Preliminary report

PIXEL

Simulations & Games

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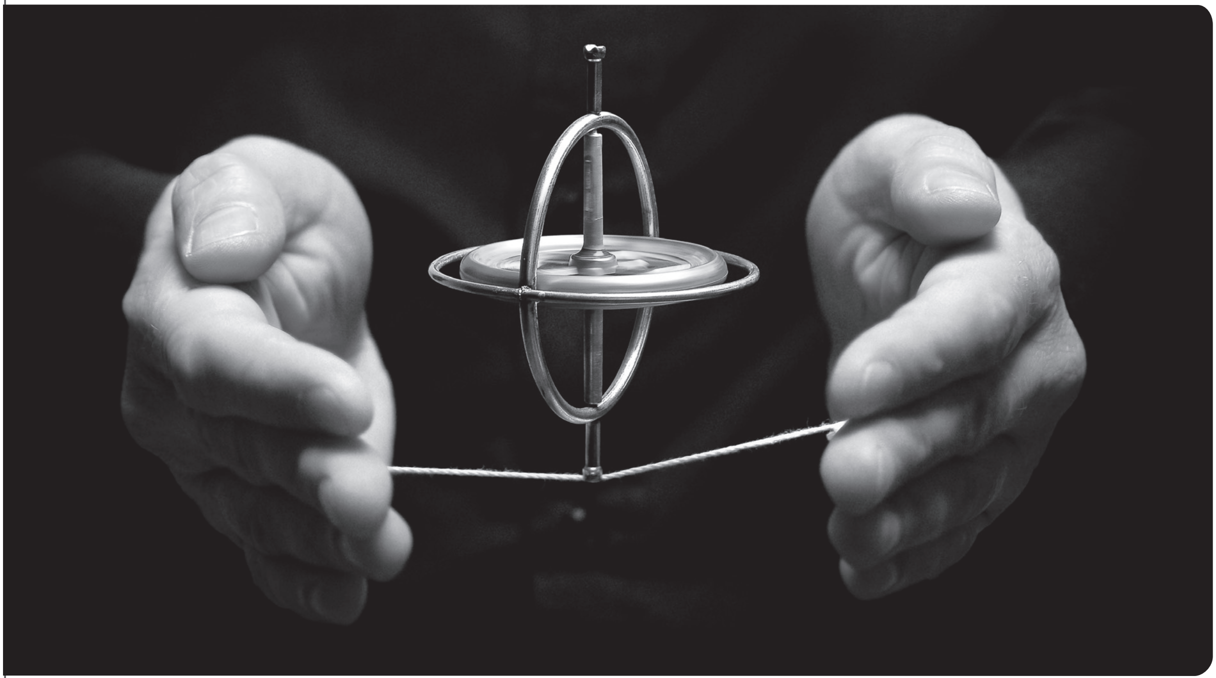



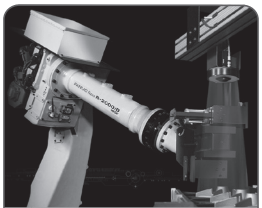

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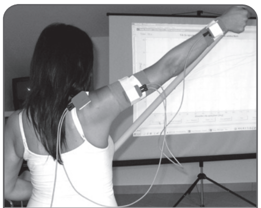


Movement Science

# Prefece by president of Inter-*Actief*

When I was young I was a big fan of Lucky Luke. The cowboy who could shoot faster than his own shadow. The romance of the Wild West combined with the crazy Daltons, the dog Rataplan and Jolly Jumper provided stories that made every little boys imagination run wild. That dream image of the Wild West with all its cowboy stories was lost when I grew up and saw the United States as shown in the movies.

The Wild West of the United States may have lost some of its saloons, sheriffs and trigger happy cowboys, but for a true Computer Science student it has not become less interesting. In the 50s and 60s Fairchild Semiconductor and a small company called Intel were formed. That small part of dessert later became Silicon Valley, the centre of information technology development. With Stanford University and companies like Google, Apple, Oracle, Cisco, Intel and nVidia; Silicon Valley still is the centre of most IT industry related fields.

When more and more details about the study tours tour program became available, that Lucky Luke feeling came back to me. Not only will the students visit the Wild West, but the Inter-Actief members will also visit the East coast. Again it's an adventure that -with a bit of imagination- will make your head spin! In all likelihood I would have experienced this U.S. adventure myself, but I had my eyes out for a board position in our beautiful association. When that came up I could not say no, but from time to time I am a bit jealous of those students who will make their own adventures and have researched this subject for many hours.

This preliminary report publishes the results of all research aspects carried out prior to study tour Pixel. I compliment all participants who carried out the research, and the committee who made all this possible. On behalf of Inter-Actief I wish all participants a beautiful educational tour and adventures no participant will forget for the rest of his life.

Enjoy the ride,

**Rick van Galen**
Chairman
Study Association Inter-*Actief*

# Preface

## Three weeks we will never forget

Study tour Pixel 2010 is an initiative of study association I.C.T.S.V. Inter-Actief and is highly supported by the University of Twente. Not only do teachers participate in the tour but all student participants have to research Macro, Meso and Micro economic aspects. Next to that all students have to research one track of the study tour theme Simulations and Games. Professors guide them in this process to produce optimal results.

The tour is one of the most serious international opportunities University of Twente students have. It allows them to research both cultural, economic and in-depth aspects of a country and IT related theme. Their work becomes very tangible when they visit U.S. based companies to verify their research results. The three week tour is not a vacation and the days are filled with company tours, business cases, interesting presentations, sightseeing, travelling between cities and more. What could we expect to see in this country, with all the stereotypes we know from the movies, from television and thanks to all the books we read about America? Without a doubt we will be surprised when visiting the United States ourselves.

A study tour is a quite unique project: The project has a turnover of more than 100.000 dollars and it is organized by students in their spare time. The organizing committee is highly motivated and invests every spare moment in making the tour better. Adding that last touch to every activity. In practice only a small percentage of students add this extracurricular experience to their programme.

Besides visiting companies we will also visit many cultural hotspots and taste the culture. This gives the students more insight in the culture of the United States and the mindset of the U.S. citizen. We can be certain a participant will never forget the three weeks of study tour Pixel.

**Niels Boom**
Chairman
Inter-*Actief* study tour committee Pixel 2010

# Contents

# Chapter 1

# About the study tour

## 1.1 Introduction

Most people are unfamiliar with the concept study tour therefore an explanation is in place. Because the first part of the name reads ‘study’ it implies that it is not just a vacation. An extensive research of several months on a specific topic is preformed prior to the tour itself. The participants will also follow several courses which concern the research topics. The topic of this year’s study tour is *Simulations and games*. The title of the tour is Pixel. To verify the results found in the research several companies and universities in the United States will be visited.

The duration of the tour is three weeks. In this time we will not only visit companies and universities, but there will be also plenty of time to explore and enjoy the United States.

## 1.2 Inter-*Actief*

Study tour Pixel is an initiative from the study association Inter-*Actief*. Inter-*Actief* represents about 900 Bachelor- and Master students from the studies Computer Science, Telematics, Business & IT. The study association is the largest study association for IT related studies in the Netherlands and organises all kinds of activities for students. Most of these are professional activities for example meetings with companies, symposia or workshops. Other activities are just for fun to let students socialize. The largest project organised by Inter-*Actief* is the study tour. A committee of six motivated students is formed every one and a half year. These students take on the challenge of organising a study tour. The first study tour organised by Inter-*Actief* was in 1987. Pixel will be the 17th tour that is organised. Previous tours went to India (International Cooperation & IT), the USA (IT security) and Japan (Ambient intelligence).

Figure 1.1: The Inter-*Actief* logo

For more information about the study association visit the website:
http://www.inter-actief.net

## 1.3 University of Twente

During the research and the tour itself the group will be guided by professors from the faculties *Electrical Engineering, Mathematics and Computer Science* (EEMCS) and the *School of Management and Governance* (SMG). The faculties will set up a mandatory course for all participants to make sure everyone has the same basic level of knowledge about the theme. Both of the faculties are part of the University of Twente which is located in the east of the Netherlands. The University of Twente is an entrepreneurial research university and provides academic education and research in a wide variety of fields and was founded in 1961, making it one of the youngest universities in the Netherlands. It is the only campus University in the Netherlands and has about 8000 students and 1500 academic personnel.

The University of Twente is a member of the 3TU.Federation which is a co-operation between the three technological universities in the Netherlands. The 3TU.Federation consists of the Delft University of Technology, the Eindhoven University of Technology and the University of Twente. This federation was founded with the aim of improving the national and international position of the technological universities in the Netherlands. The University of Twente is also a member of the European Consortium of Innovative Universities which was founded to create a network of European universities to exchange experience and knowledge.

## 1.4 PIXEL study tour

### 1.4.1 Organization

In May 2009 a committee was formed to organise the tour. First the time span was determined, taking all kind of factors like holidays, exams etc into account it was decided that October was the most suitable time for the tour. Then several brainstorms were performed and the theme *simulations and games* was chosen with the help of a few faculty members. The next step was to decide the country that was best suited. After a few weeks of research the United States of America was chosen.

When a name and logo were given to the theme promotion began. Posters, informational meetings and promotion at lectures were used to interest as many people as possible so that they would join the group.

During this promotion time the outlines for the first research were set up. A travel agency was contacted and the planning of the tour took place. Different companies in the Netherlands were contacted to fund the project and companies in the USA were contacted to arrange visits.

In the final stages, more than a year has gone by, there are 22 participants, the preliminary research is finished, the financial part of the tour is clear and the schedule is filled with different companies and universities.

### 1.4.2 Destination and Research

Study tours characterize itself as being long-distance destinations of which Japan, the U.S. and India are the most recent ones. Main focus of last two tours was state of the art development in esearch and try to find out more on these subjects Security in the U.S. and Smart Surroundings in Japan.

When looking for a research subject for this tour, we came with several recent developments like Games and Simulations, Cloud Computing and Mobile devices. From these possibilities we chose Gaming and Simulation as the main research subject for this study tour.

The Gaming and Simulation industry is a special one in these research subjects. The market for gaming and simulations exists for years already, but only lately its full potential for business opportunities is found out. Not only are Games and Simulations used for entertainment purposes anymore, but also many business like opportunities. In order to emphasize this, the research subject is dividided in six research tracks.

- Artificial Intelligence
- Augmented Reality Business
- Augmented Reality IT
- Engines and Hardware
- New Media Input Devices
- Serious Games

Currently main developments of the Games and Simulations industry are happening in the U.S., which is the reason the Pixel 2010 studytour will visit the U.S.

### 1.4.3 Name and Logo

Simulations and games have a lot in common. The most important similarity is that they both need some sort of projection to be visible. Most projection is done by using screens in all sizes and shapes. But all screens are made out of pixels. These pixels are small dots of light that might seem unimportant but combining millions of them can create endless possibilities. A similarity can be seen comparing the study tour with a pixel. A single student might feel insignificant in a small country like the Netherlands, together we manage to cross half the world to immerse in the most advanced and overwhelming techniques the world of simulations and games has to offer.

Figure 1.2: The study tour Pixel logo

The American dream is closely related to this ideal. The Statue of Liberty also symbolizes the U.S.A. in general, that is why we used it's torch in our logo.

### 1.4.4 Board of Recommendation

The following people support our study tour and are therefore members of the board of recommendation:

**Prof. dr. H. Brinksma**
*Rector Magnificus of University of Twente*

**Prof. dr. A.J. Mouthaan**
*Dean of the faculty of Electrical Engineering, Mathematics & Computer Science at the University of Twente*

**Dr. V.A.M. Peters**
*Chairman of ISAGA*

**Mr. P.E.J. den Oudsten**
*Mayor of Enschede*
The University of Twente is located in Enschede.

### 1.4.5 Organizing committee

The following six students organized the study tour. They helped participants with their research, searched for funding and searched for U.S. based companies to visit during the three week study tour:

**Niels Boom**
*BSc. student Business Information Technology*
President

**Martin Haitsma**
*MSc. student Business Information Technology*
External affairs

**Mark Kazemier**
*MSc. student Business Information Technology*
Research

**Ronald Meijer**
*BSc. student Computer Science*
Travel coordinator

**Wytse Jan Posthumus**
*MSc. student Computer Science*
Finances

**Niels Visser**
*BSc. student Computer Science*
External affairs

### 1.4.6 Participants

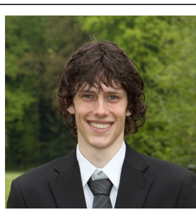
The following 22 students of the University of Twente are attending the study tour:

**Cecill Etheredge**
*BSc. student Computer Science*
Engines and Hardware

**Ernst Fluttert**
*MSc. student Computer Science*
New Media Input Devices

**Albert de Graaf**
*BSc. student Computer Science*
New Media Input Devices

**Marije de Heus**
*BSc. student Computer Science*
Artificial Intelligence



**Yme Joustra**
*BSc. student Computer Science*
Serious Games

**Nils van Kleef**
*BSc. student Computer Science*
Augmented Reality Business

**Ties de Kock**
*BSc. student Computer Science*
Augmented Reality IT

**Joeri van der Lei**
*BSc. student Computer Science*
Engines and Hardware

**Oğuz Meteer**
*BSc. student Computer Science*
Engines and Hardware

**Jordy Molenaar**
*BSc. student Computer Science*
Engines and Hardware

**Johan Noltes**
*MSc. student Computer Science*
Augmented Reality Business

**Mark Oude Veldhuis**
*MSc. student Computer Science & Human Media Interaction*
New Media Input Devices

**Sjoerd van der Spoel**
*MSc. student Business Information Technology*
Augmented Reality Business

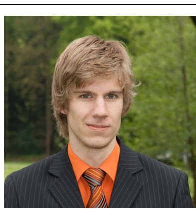
**Thomas Stols**
*BSc. student Telematics*
Serious Games

**Jasper Stoop**
*MSc. student Computer Science*
Serious Games

**Steven Sybenga**
*BSc. student Computer Science*
Augmented Reality IT

**Mattijs Ugen**
*MSc. student Computer Science*
Augmented Reality IT

**Gijs van Veen**
*MSc. student Human Media Interaction*
New Media Input Devices



**Steven van der Vegt**
*BSc. student Computer Science*
Engines and Hardware

**Thomas Visser**
*MSc. student Human Media Interaction*
Augmented Reality IT

**Stefan Weijers**
*BSc. student Computer Science*
Artificial Intelligence

**Ruud Welling**
*MSc. student Computer Science*
Artificial Intelligence

### 1.4.7 Funding

The Financial part of the study tour consists of a few parts. The grand total is more than 100.000 Euros. Most of this money is spent on travelling, residing and meals (roughly 75 percent). Other costs include representation, organisation of the study tour and putting together and publishing the research reports.

The income of the study tour is mostly generated by contract research of the participants. Each participant works 120 hours for a company, this can be any type of work. Mostly programming, but as the name contract research implies, also research. The study tour charges the companies for that work, and so more than half of the budget is filled. Besides that, each student contributes 1000 Euros to the tour himself. Also, we are being subsidized by the university because of the tour its educational value. The total of all these incomes reaches more than one hundred thousand Euros.

## 1.5 Schedule

We will travel the US according to the plan displayed in Figure 1.3 on page 22.


Figure 1.3: The tour

## 1.6 Partners

To complete the financial picture of the study tour, Pixel cooperates with a number of partners that are either close or in some cases far away settled from the University of Twente. Mostly, participants of the tour work their contract research at these partners.

### 1.6.1 University of Twente, Inorganic Material Science Group

The group of IMS at the university of Twente is a group of the faculty of TNW (English: faculty of Science and Technology). The groups occupation is to research the area of inorganic materials and their behaviour.

### 1.6.2 Vrest Medical

Vrest medical is a company that develops software that is used for training n the medical industry.

### 1.6.3 CRM Resultants

CRM Resultants fully focuses on Microsoft Dynamics CRM. It has implemented CRM solutions at roughly 60 organisations at the moment, and is a Microsoft Gold Certified partner.

### 1.6.4 Xsens

Xsens is a leading global supplier of 3D motion tracking products based upon miniature MEMS inertial sensor technology. The company is headquartered in Enschede, The Netherlands and has a subsidiary, Xsens North America Inc. in Los Angeles, California, US.

### 1.6.5 Dactique

Dactique is a company that specializes in educational E-technology. It develops software to support education and designs solutions on-demand.

### 1.6.6 Fortes

Fortes focuses on management software that shorten durations and reduces risks and costs of projects. This software is completely web-based.

### 1.6.7 Oxilion

Oxilion is a company that supplies internet services and solutions. Their services include webhosting and dedicated server hosting, partly on green servers.

### 1.6.8 Better.be

Better.be specializes in implementing all sorts of internet technology in companies. Their main target groups are big companies that are stock exchange registered, non-profit companies and regional small and medium enterprises.

### 1.6.9 Quality Online

Quality Online is a leader in Enterprise Process Management applications. For over 14 years it works successfully with partners and customers on solutions for quality, safety, risk management and compliance.

### 1.6.10 Sigmax

igmax is a company that develops mobile applications on demand, to integrate into a companys structure. Since the beginning of 2010, there are 80 professionals working at Sigmax.

### 1.6.11 Presenter

Presenter is a webdevelopment company, it develops web sites and web applications on demand.

### 1.6.12 Say Yeah

Say Yeah designs visual products like movies for profiling purposes and commercials.

### 1.6.13 Raedthuys

Raedthuys is a company that focuses on green energy solutions. It manages and monitors the flows of green electricity.

### 1.6.14 Echelon

Echelon is a full-service ICT-service provider that focuses on hosting, Internet and office-automation.

### 1.6.15 BizzDesign

BizzDesign develops customized business solutions that help improve business management.

# Chapter 2

# Research project

This book contains the results of the preliminary research of the Pixel 2010 Study tour project. This project is the preparation of our visit of different companies and research institutions in the U.S.

The main objective of the Pixel 2010 Study tour project is to give insight into the current and future trends in new technology and application of Gaming and Simulations and what implications this has on the U.S. and the Netherlands.

The overall research question of the tour is:

> *Which current and future trends in new technology and application of Games and Simulations can be perceived and what may be the implications for organizations in the U.S. and the Netherlands?*

Organizations are defined as government, enterprises and universities.

In order to answer this research question, four sub studies are conducted. Starting in this preliminary report with a Macro, Meso and In-depth research and followed up by a Micro study during the visit of the U.S. The Macro, Meso and Micro research are tied together in a way as described in Figure 2.1.

First, there is the Macro research which investigates the Macro characteristics of the U.S., using the GHPEST-model addressing the geographical, Historical, Economical, Social-cultural, political and technological aspects as well as their impact on the Games and Simulations industry.

Second, there is the Meso research which investigates four economical sectors where Games and Simluations technology is used using Porter's diamond. This study gives inside into the state-of-the-art current and future developments and how different factors influence the Games and Simulations market. Sectors that are investigated are:

- Military
- Research and higher education
- Manufacturing of consumer electronics
- Healthcare

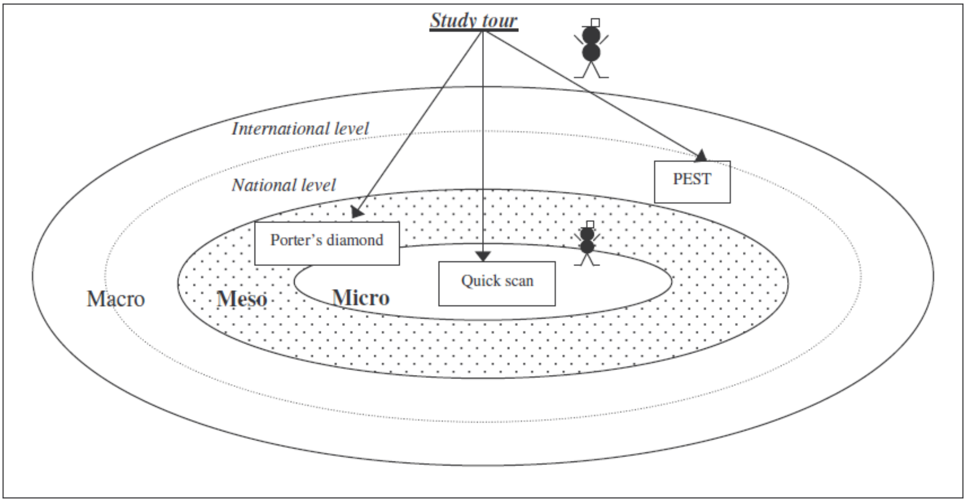



Figure 2.1: Research levels

Third, during the tour different companies within the these sectors will be visited, to obtain 'first hand' knowledge about how Games and Simulations is applied, developed and researched currently and in the future. This finishes the research on a micro level.

Finally, an In-depth research is conducted to get state-of-the-art knowledge of technologies and business models applied within the Games and Market industry. This research is divided into six research tracks and used to better understand technologies and developments found within the Macro, Meso and Micro researches. The used research tracks are:

- Artificial Intelligence
- Augmented Reality Business
- Augmented Reality IT
- Engines and Hardware
- New Media Input Devices
- Serious Games

This report contains the first two levels (Macro and Meso research) as described in Figure 2.1 and the in-depth research. More information on these studies can be found in the introduction prior to each section.

# Part I

# Macro research

# Chapter 3

# Introduction

The first sub study of the research conducted is the on the Macro level. The goal of this section is to investigate the Macro characteristics of the U.S. and compare these to the Netherlands to identify the macro level factors that may influence the development and applications in the Games and Simulations industry.

The specific research question that will be answered in this Macro analysis is:

*Which trends and technologies pertaining to the area of Games and Simulations can be perceived in the U.S., and what are the possible implications for organizations in both the U.S. and the Netherlands?*

To answer this research question, the GHPEST management science model is used. This model investigates Geographical, Historical, Political, Economical, Socio-cultural and Technological aspects of a country. This leads to the following chapters within this section:

- Socio-cultural aspects and business culture
- Economics (both National and International)
- Geographical aspects
- History of the U.S. and its relation with dutch history
- Politics (both National and International)
- Technology

# Chapter 4

# Socio-Cultural

*Section by Yme Joustra, Oğuz Meteer, Jasper Stoop and Stefan Weijers*

This chapter is about the Socio-Cultural differences between the United States and The Netherlands. The first part is about the social characteristics; social classes and demographic characteristics. The second and third section are about aesthetics and the Hofstede dimensions, mainly focusing on the masculinity differences between the countries. It also includes entrepreneurship. The last section is about the education system in both countries and the differences between them. Finally the main differences will be summed up in a list followed by a conclusion.

## 4.1 Social characteristics

### 4.1.1 Society classes

The well known American dream tells us that there is no such thing as a class in the ideal American society. Everyone should be able to reach the top. But even in this simple dream there is already a contradiction. If there are no classes, how does one reach the top, or the bottom for that matter. This is exactly why it is and always will remain a dream. Children from high-class familys are far more likely to get their efforts recognized than children born in the slums of some big city. It is however possible for some of them to reach the top. When such a thing happens the firm belief in the American dream is strengthened and it once again gives the American people some hope. [Levine, 2006]

This difference in chances results in different culture and manners in these social layers. There are a lot of individuals in each class. What would make the diversity within one class as big as the whole population. Furthermore people can ascent and descend in class by being successful and start interacting with a different class. This decreases the cultural differences between the classes. However inside classes themselves people mostly associate with people from the same class, this causes a greater gap between the different classes culture. Depending on which academic model used the classes in the USA can be split into five or six classes. We will use the William Thompson& Joseph Hickey model, since it is the most recent. This model is based with the United States in mind, so it only applies to the United States. [William Thompson, 2005] They split up the social classes into five groups;

The poor, The working, Lower Middle, the professional/upper middle class and the upper class. The working class and the lower middle class contain most of the population. The working class consists of about 32% of the population and includes all kinds of people. They all have a similar culture as a class, but they behave increasingly differently compared to higher classes. As people in the lower classes tend to favor more authority oriented values, such as respect for your superiors and strictly following rules, whereas the middle and upper classes tend to favor more self centered standards, such as being open-minded and thinking for yourself. The lower middle class is somewhat similar in culture to the working class since the line between these two classes is mostly vague and the location of this line is dependent on the model used. The main difference between these two classes is in education not in culture. This class also consist of about 32% of the population. Most of the people in this class have completed some form of high school and college and have a bachelors degree, they can associate with the lower middle-class but can also become upper-middle class if successful. The upper-middle class consist of the top 15% of the population and are mostly people with at least a college education level, many of them also have a masters degree and make quite some money. [William Thompson, 2005] They have a totally different culture compared to the lower-middle class what is shown mostly in their parental education. Kids of upper-middle class families are taught to be more self-directed and curious to the world around them. Because of the difference in upbringing most upper-middle class children dont really come in contact with the lower classes and cause the cultural difference to increase. [Levine, 2006] The top of the US society is the upper class. They consist of very successful people like celebrities or powerful business managers. They generally have multiple millions to spend. Only 1% of the population can be counted as the upper class. They have a similar culture as the upper-middle class and mostly associate with them or each other. Finally there is also the poor. The less fortunate inhabitants of the united states. They consist of the remaining 14%-20% of the population and mostly did not finish high school. They do poorly paid work if they work at all. In contrast with America for a long time the Dutch society was not divided into layers but into columns (pillars). It essentially meant splitting the Dutch society into protestant, catholic , social-democratic and liberal. The working class people essentially made up the social-democratic pillar, the more wealthy or atheists made up the liberal pillar, while the two major religions of the Netherlands made up the protestant and catholic pillars respectively. This created a more vertical culture in comparison to the American structure, but it still contained some horizontal elements since some pillars more or less consisted of the same social class. The culture in each pillar was very different, since they all have their own television broadcasts and had even special shops meant for one or two pillars. This pillarisation is mostly undone by now but there are still remnants visible in the Dutch culture.

### 4.1.2 Demographics

Demographic characteristics have a lot of influence on the culture of a population. In this section we discuss the differences in demographic characteristics between the Netherlands and the United States of America.

Table 4.1: Life Expectancy at Birth

| Rank | Country | Total | Male | Female |
|---|---|---|---|---|
| 1 | Japan | 82.6 | 79.0 | 86.1 |
| 2 | Hong Kong | 82.2 | 79.4 | 85.1 |
| 17 | Netherlands | 79.8 | 77.5 | 81.9 |
| 38 | United States | 78.2 | 75.6 | 80.8 |
| 82 | China | 73.0 | 71.3 | 74.8 |
| 194 | Mozambique | 42.1 | 41.7 | 42.4 |
| 195 | Swaziland | 39.6 | 39.8 | 39.4 |

**Life Expectancy at Birth**

[United Nations, 2006] The life expectancy is a factor in the Human Development Index as an indicator of the longevity and health of the population of a country. The Human Development Index can be used to compare the Netherlands to the United States. More on the Human Development Index can be found later on in the chapter. As you can see the relative distance between the Dutch Life expectancy and that of the United States is not that big. It is a bit in favor of the Netherlands, maybe because of the healthcare that has been available for every inhabitant. America just introduced a similar system, so maybe the life expectancy of the United states will go up a little bit in that coming few years. This is speculation on our part.

**Age Distribution**

[CIA, 2009]. The youngest group of people in America (0-14 years) make up for 20.2% of the population. The percentage of people between 15 and 65 years is 67% and the final group of people older than 65 is about 12.8%. In relation to our research subject, the population that might be interested in serious games or any of the other tracks, would be the largest group of people aged between 15 and 65 years.

In the Netherlands the percentage of people between aged 0-14 is quite a bit lower with 17.4%. The group between 15-65 has relatively the same size with 67.7%. The oldest group is a bit larger than America and has a percentage of 14.9%. All in all there might be a little more reason to focus more on the oldest group in the Netherlands than in America, where its percentage is smaller. The other way around, in America it might be smarter to focus your efforts with the youngest group in mind. However the total amount of people in America is much higher than in the Netherlands, so it is probably also worth it to design things for the eldest group.

**Religion**

[CIA, 2009] The major religions in the united states are Protestant with 51.3%, Roman Catholic with 23.9% and Mormon 1.7%. There are also unaffiliated with 12.1% and 4% dont have a religion. The rest is composed of small (¡1%) religions that we ignore for now. Comparing that to the Netherlands where there are 30% Roman Catholic, 11% Dutch Reformed, 6% Calvinist and 5.8% Muslim. But the biggest difference is in the atheists as 42% has no religion in the Netherlands. Big cultural differences can be explained by this difference. The Dutch have a much lower amount of religious people than America. As only about 50% can be considered Christian while in America that number is over 75%. Both cultures are however christen based. So the law system and general values that civilizations get from religion should be similar. When developing games for the population of America or the Netherlands we might have to consider making games that are acceptable for Christians to play, this of course depends on the target and type of game.

**Ethnic groups**

According to the CIA factbook [CIA, 2009] about 79% is white, 13% is black and 5% is Asian. The rest are minorities such as the natives of Alaska, Hawaii or America itself. Hispanics are not listed separately but fall under multiple other ethnic groups. The total percentage of Hispanics is about 15%. According to the Bureau of Labor Statistics [Bureau of Labor Statistics, 2008a] Black or African American employees are doing relatively good. With a 23% bachelor degree or higher. If you look at the statistics it seems favorable to hire African Americans because they on average spent more time on work, and less sleeping. It does seem however that there are more unemployed African Americans than there are in Hispanic or Asian groups [Bureau of Labor Statistics, 2003]. Asians are doing practically well in that field, with only 4% unemployment rate. Hispanics are worse with 14%. African Americans have up to 24% unemployment rate though. The Asians in America are highly educated with more than 50% Bachelors degree or higher. Hispanics are the least educated minority group with only 15% with a bachelors degree and almost 33% without a high school diploma.

According to the factbook the the Netherlands have a much higher percentage of white ethnic people compared to the United States. About 80% is classified in the Dutch ethnic group. And 5% are from other parts of the European Union. About 2.4% is Indonesian, 2.2% Turkish, 2% Surinamese and also 2% Moroccan. According to the Central Bureau of Statistics (2008) (Centraal Bureau voor de Statistiek) [Centraal Bureau voor de statistiek, 2008]there is also a big difference in heritage in the unemployment rate. The Dutch themselves only have a 3.2% unemployment rate, while the non-Dutch have 7.1%. If we even split that into the western and non-western non-Dutch. We get to 5.1% and 9.0% unemployment rate respectively. The numbers of 2008 are considerably better than that of 2006 though. [CIA, 2009]

Even though Americans and Dutch can be considered somewhat similar. The non- native (as in not born in or from the United States) ethic groups are totally different. In the United States Hispanics make up for a big part of their culture, while there are almost none in the Netherlands. The same can be said about Islamic culture in the Netherlands. The percentage Islamic people is quite a bit smaller than the Hispanics in America though so they might not have as much influence. And thats not even counting the fact that Turkish and Maroccan have quite different cultures themselves.

**Languages**

According to the CIA factbook about 82 % of the American population natively speaks English and about 11% Spanish. Of the non-English speaking population about 2/3 claim to be able to speak English good or very good. So the total English speaking population should come at about 94%. All other languages are not really worth noting since they are only spoken by very small parts of the population. [CIA, 2009] [Shin and Bruno, 2000]

In the Netherlands more than 95% of the population speaks Dutch. According to the study by eurobarometer, a commission by the European union, about 87% of the Dutch population claim to be proficient in English. There shouldnt be too much of a language problem on our study tour. But we can encounter native Spanish speaking people, that might not be too proficient in English. When developing games for America it might be useful to include a Spanish version. [ Eurobarometer , 2005]

### 4.1.3 Gender Inequality

In America there are more males born than females, 1.05 male/female, but as the population gets older the amount of males decreases faster than the amount of females. So at age 15-65 the ratio has become 1:1. For people older than 65 the ratio is even 0.75:1. This means there are a lot more older woman in America than there are men. What might have to be taken in consideration when developing applications.

In the Netherlands similar ratios exist. However males tend to survive a little longer there. As at 15-65 the ratio is still 1.02:1 and at 65 and above it is 0.76:1. So at least in the biggest group the gender ratio is in favor for men in the Netherlands where it was equal in America. In work there has always been an inequality in amount of pay to woman. Jessica Arons (2008), Director of the Womens Health & Rights Program at the Center for American Progress Action Fund, states that women lose vast amounts of money because of the career wage gap .[Arons, 2008] As education increases so does the pay gap. The largest pay gap seems to exist at the jobs that require the highest education. This research was done however with inequality of women in mind, and tries to show us how bad it is. So it might be a bit biased, and in my opinion she should use percentages instead of cumulative wages in a lifetime, because a woman who makes 1% less than a male in a job that makes 1 million a year, now gets a larger cumulative pay gap was a woman who only makes 80% of a man in a job that earns 10.000 dollar in a year, while relatively doing a lot better. Francine D. Blau et. al (1994) tells us that the wage gap is decreasing slowly and that women in some kind of professions are more wanted then men. The total women/men wages come to 0.78/1 in America. [Blau and Kahn, 1994] In the Netherlands we have a similar wage gap, Catherine Chubb et. al (2008) give a pay gap of about 18% in 2006. This would concur with a ratio of 0.82:1 . This is a bit less than in the United States. But it is relatively high in comparison with the rest of Europe. This is probably caused by the high part-time labor degree of women in the Netherlands. [Chubb et al., 2008]

### 4.1.4 Sports and Leisure

There are a lot of team sports played in the united states but he most popular are American football, Baseball, Basketball and Ice Hockey.[Harris Interactive, 2009] According to the American Time Use Survey on average an American spends about 20 minutes on sports a day. American between 15-24 spend much more time on sport. On average 36 minutes per day. [CARTER et al., 2009]

Hunting and fishing are also favorite leisures of the American people. The favorite team sports in the Netherlands are Football (also known as Soccer in the United States), Field hockey and Volleyball. Very popular individual sports include tennis and Ice skating. [spo, 2010]

Nowadays the television and the internet are one of the biggest time consuming activities. The Bureau of Labor Statistics did a survey about time spend on leisure activities in the USA. [Bureau of Labor Statistics, 2008b] An average American spends 2.51 hours on television or movies every day. Where the Dutch according to Maurice Vergeer et al. (2009) spend less time on television. About 2.25 hours per average Dutch inhabitant. But this is still one of the highest in Europe. [Maurice Vergeer and Scheepers, unknown] It appears that the time spend on television is related to the education of that certain person. A highly educated individual is less likely to spend a lot of time watching television than someone with a lower education. This pattern seems to be universal in a lot of countries.

### 4.1.5 Conclusion

The culture of the inhabitants of the United States is partly because of their social characteristics. One of these characteristics is their social class. The class in which a certain inhabitant resides generally contains most of his friends and family. Minor cultural differences can be seen in different social classes.

When compared to the Netherlands we can conclude that the United states have:

- a lower life expectancy.
- relatively more young people and less old people.
- more religious people
- a higher percentage of non-English native speaking inhabitants. Compared to the percentage of Dutch native speaking inhabitants of the Netherlands.
- a lower percentage of men at higher age.
- a bigger wage gap between men and woman.
- inhabitants that spend more time on television than inhabitants of the Netherlands do.

The most popular sports in the United States are not the same as in the Netherlands and the ethnic composition of the inhabitants is also different. Most notable demographic differences are the religion and the age distribution, these show a significant difference or a different trent compared to each other.

## 4.2 Aesthetics

The United States culture has a huge global influence through fashion, art, cinema, music and architecture. In next couple of sections these topics will be covered.

### 4.2.1 Fashion

The progress of fashion in the United States rapidly increased in the 20th century, when Americans started to express themselves through clothing. In the 1950s, teenagers dictated what was "cool" to wear (but they are more the trend followers today). It was around that time when the rebelion of the youth began and jeans became popular among teenagers and young adults [Sullivan, 2006]. In the 1960s which was the era of hippies, people wore clothes with bright colors and decorated their jeans with flowers and other designs.

Later in the second half of the 20th century, musical preference started influencing clothing. Since the United States is a melting pot of different cultures spread over one of the largest countries in the world, they can be divided into subcultures. These subcultures together with musical preference have a huge influence on fashion which has led to many different wear styles such as grunge (ripped jeans and t-shirts), urban/hip hop (bandanas, long, loose t-shirts and jerseys, "bling bling" jewelry), punk (t-shirts with logos, wallet chains, heavy and combat boots), gothic (plain black shirts, heavy and dark pants with belts) and Californian/West Coast (relaxed, classy and conservative styles, t-shirts, shorts, slippers) among others. Many regions have their own version of a particular style.

Today, there are a lot of fashion designers in the US, that have a significant influence on the fashion in the world. The famous American fashion designers are *Calvin Klein*, *Karl Kani*, *Tommy Hilfiger* as well as musicians who are also fashion designers like *Jennifer Lopez*, *Gwen Stefani* and *Will Smith*.

The Netherlands, being a much smaller country, does not have as many fashion designers and labels as the United Stated. The most famous Dutch fashion label is *10Feet*, and the most known Dutch brands are *WE* and *Mexx*.

### 4.2.2 Cinema

Eadweard Muybridge, an English photographer known for his contributions to photography and motion-picture, revealed the zoopraxiscope at the World's Columbian Exposition in 1893, which caused a sensation [Encyclopedia Brittanica, 2010]. Since then, the United States has been at the forefront of global cinema. Hollywood, a district in Los Angeles, California, has been the home of several of the largest film companies of the US (Paramount, Warner Bros., RKO and Columbia) since the beginning of the 20th century [Wikipedia, 2010c], having produced many globally known and acclaimed movies [IMDb, 2010a].

The 1950s, with the increasing technological possibilities and the usage of widescreen processes, marked a division of American cinema into two categories: *Blockbusters* and *independent films*. Blockbusters are movies starring famous actors, have a high production value, and deliver spectacle. They cost a great deal of money and carry a risk of failure, so studios release only a few movies each year and rely on their successes the stay profitable. To attract a large audience needed to make a profit, a lot of advertising takes place [Wikipedia, 2010b]. A couple of examples are *The Titanic* (budget $200 million and gross revenue $1,843,201,268 [Box Office Mojo, 2010d]) and *Avatar* (budget $387 million [The Wrap, 2010] and gross revenue $2,671,408,000 [Box Office Mojo, 2010a]).

In contrast to blockbusters, some (mostly small) studios in the United States also produce independent films, which have small budgets so that even if such a film were to be unsuccessful, it would not have an impact as great as the failure of a blockbuster. For a film to be considered independent, less than half its financing should be subsidized by a major film studio. These types of movies emphasize on creativity and innovation expressed through high quality production in terms of acting, and because of their low budget nature, they are not backup up by advertisements as is done with blockbusters. Therefore these movies rely far more on critical praise to attract an audience. Independent films can have a very high profit-to-cost ratio since many of them are low budget, and are therefore produced much more than blockbusters [Wikipedia, 2010b]. A couple of examples are *Reservoir Dogs* (budget $1.2 million and gross revenue $2,832,029 [Box Office Mojo, 2010c]) and Fahrenheit 9/11 (budget $6 million and gross revenue $222,446,882 [Box Office Mojo, 2010b]).

The Dutch cinema started in the late 19th century with the "De Brandweer" in 1895 followed by "De Jongen met de bal" in 1904 and "Een Jongmensch..." in 1907 [Wikipedia, 2010e]. The Dutch film industry is most famous for its documentaries, but since 1970 there has be a decline in documentaries [Wikipedia, 2010a]. Again the effects of the Netherlands being a small country can be seen in its film industry. Up till 2005, film studios in the Netherlands relied mostly on funding from the government, because of the lack of international market for Dutch films [Wikipedia, 2010a][Beerekamp, 2003]. This resulted in Dutch films having a much smaller budget than blockbusters from Hollywood and is more comparable the budgets of indie films in the U.S. Most members of the parliament agreed that film studios should try to attract private investors [Beerekamp, 2003], which resulted in an increase in budget for Dutch films [Beerekamp, 2003]. One of the most famous Dutch movies is *Turks fruit* (Turkish Delight) release in 1973 and has won the award for best Dutch film of the century in 1999 [IMDb, 2010b].

The influences of cinema on gaming can be seen in the form of cinematic cutscenes found in many games. On of the most famous game series known for its cinematic cutscenes is the *Metal Gear* series (especially in the *Metal Gear Solid* series) with *Metal Gear Solid 2* having 45 minutes of cutscenes and *Metal Gear Solid 4* having 90 minutes [can, 2008].

### 4.2.3 Music

The role that music plays in the American society is a complex one. It influences not only the musical taste of people, but also their culture and brings together people of different geography, religion, language, gender and sexuality and perhaps most importantly, ethnicity [Wikipedia, 2010d]. African American music has been a big part of the musical culture of the US and comprises of styles like blues, jazz, R&B and later rock and roll, soul and hip hop, which have evolved from spiritual, minstrel shows and slave songs [Wikipedia, 2010d]. There are also other styles of music like pop, country, heavy metal, punk rock which are all evolutions of older styles, but the cultural melting pot of the Unites States also takes all sorts of global musical influences as well. A couple of examples are classical, Latin, Irish music and also asian music.

The US, housing the four biggest major record companies in the world, has a huge music industry with a revenue of about $12 billion [Richard, 2000]. These four companies are *Universal Music Group*, *Sony BMG Music Entertainment*, *EMI Group* and *Warner Music Group* and are called the "Big Four" [Lamb, 2010]. They are represented, supported and promoted by the *Recording Industry Association of America (RIAA)* [RIAA, 2010]. Sony BGM Music Entertainment, Universal Music Group and EMI Group are also operational in the Netherlands, bringing American music to the Dutch. They also have contracts with some popular Dutch musicians like *Anouk* (EMI) [EMI, 1993], *Kane* (Universal \Sony), *Acda en de Munnik* (Universal), *Ilse DeLange* (Universal), *De Jeugd van Tegenwoordig* (Universal) [Universal Music, 2010], *Krezip* (Sony) and *Within Temptation* (Sony) [Sony Music Entertainment Netherlands, 2010].

Some record companies work closely with other media companies to produce music related products. A good example are games with musical themes like the *Guitar Hero* and *Rock Band* series, where you play on a game controller in the shape of a guitar. These games are very popular (the Guitar Hero franchise reached $2 billion in sales [Carless, 2009]) and has a great cultural influence in the US [Zezima, 2007][Levy, 2007]. Another example is Audiourf, in which you race across a track where the song you choose determines its shape and speed [aud, 2009], receiving many positive reviews [met, 2010]. Games with a musical theme are common these days.

### 4.2.4 Architecture

Just like with fashion and music, the architecture of the United States is very diverse. It it different in every region due to influences of the multicultural society. Keyword here is *modernity*, because the history of the country does not go as far back as for instance European or Asian countries and therefore has not had much historical influences on national architecture.

One aspect of modern architecture in the U.S. can be seen in the center of larger cities in the form of skyscrapers. The invention of the safety elevator by Elisha Otis in 1853 [They Made America, 2010] is one the several architectural innovations that made building skyscrapers possible. The most famous skyscraper in the United States is the *Empire State Building* built in 1931 and located in New York. It has 102 floors and its height is 1454 feet (or 443 meters), making it one of the highest buildings buildings in the world [Empire State Building Company, 2010]. The tallest skyscraper of the Netherlands is the *Maastoren* with a height of 541 feet (or 164 meters) [SkyscraperCity, 2005]. A couple of similarities in American and Dutch buildings can be seen. For instance, the *Wells Fargo Plaza* has a glass exterior making it look like the building was made entirely of glass. The Netherlands has *Gebouw Delftse Poort* (Gate of Delft Building), which also has a glass exterior.

Just as the Americans are famous for their skyscrapers, the Dutch are famous for their bridges. This is because the Dutch have always been in constant struggle with water, around 50% of the land being below sea level. The most famous is the *Erasmusbrug* (Erasmus bridge), also nicknamed "The Swan" [Glass, Steel and Stone, 2010]. It is located in Rotterdam and has a length of 2,600 feet (or 792 meters) and a height of 456 feet (or 139 meters). A famous American bridge is the *Golden Gate Bridge*, located in San Francisco, California. Its length is 8981 feet (or 2737 meters) and its height is 746 feet (or 227 meters) [gol, 2010].

### 4.2.5 Conclusion

The United States has a very dynamic culture. This can be seen in topics like music, fashion and cinema among others. The influences in these areas are not only local, but have a global impact as well, making the US one of the most influential countries in the world. But since the US is a relatively young country with many historic aspects originating from Europe, it also has been influenced by other countries, adding to its dynamic culture.

Some American influences have made an impact on the gaming industry. Games like Guitar Hero and Audiosurf are influenced by music and cinematic influences can be seen in Metal Gear Solid.

## 4.3 Hofstede

A widely used approach to compare differences in national cultures is the work by the Dutch organizational sociologist Geert Hofstede. In his book Cultures Consequences[Hofstede, 1980] he reports the results of an extensive study he conducted at IBM during from 1973 to 1978 to define the concept of national culture. In this survey questionnaires were taking from 116,000 employees across 40 different countries and based on the results of these questionnaires he formulated a set of measurable cultural variables in support off his theory that societies confront four fundamental problem[[Westwood and Everett, 1987]:

- the distribution of power and the concomitant relationships of equality and inequality;
- the role and place of the individual in relation to the collectivity and the implications of this for the maintenance of order and the balance between individual and collective interest;
- sexual differentiation and its implications for social roles, role behavior patterns and role management;
- how societies can best cope with change and the uncertainties that it engenders.

To examine the differences in coping with these four problems he defined four cultural dimensions[hof, 1980b]:

**Power distance** the extent to which less powerful members of organizations and institutions accept and expect that power is distributed unequally.

**Uncertainty avoidance** the extent to which a culture programs its members to feel either uncomfortable or comfortable in unstructured situations. Unstructured situations are novel, unknown, surprising, different from usual.

**Individualism** on the one side versus its opposite, collectivism, is the degree to which individuals are supposed to look after themselves or remain integrated into groups, usually around the family.

**Masculinity** versus its opposite, femininity, refers to the distribution of emotional roles between the genders it opposes tough masculine to tender feminine societies.

A fifth cultural dimension was found in collaboration with Michael bond[hof, 1988], confusion dynamism, which was incorporated by Hofstede as long-term versus short-term orientation, which emphasizes on the concern for future rewards versus concern for consequences of past and present actions.

### 4.3.1 Hofstede's Cultural Dimensions

Before the actual numbers of the dimensions will be examined, we will first elucidate the given cultural dimensions.

In [hof, 1980b] Hofstede defines power distance as:

> ...the extent to which a society accepts the fact that power in institutions and organizations is distributed unequally. Its reflected in the values of the less powerful members of society as well as in those of the more powerful ones.

Cultures that are high in power distance are illustrated by decisions being made by superiors without consultation with subordinates (and subordinates preferring this practice) and employees being fearful of disagreeing with their superiors; whereas cultures that are low in power distance will have a more participative and egalitarian relationship between superiors and subordinates[Ford et al., 2003]. Hofstede[hof, 1980b] adds that in cultures that are high in power distance, the members generally feel that most people should be dependent while a few people should be independent. Superiors are thought to be different (physically and psychologically) from subordinates and hierarchy legitimates inequality. There is also a degree of distrust between those who have power and those who have less power. In cultures that are low in power distance, members have a tendency to blame the system for problems. Equality is desirable and subordinates view superiors as being similar to them. There is also a greater degree of trust among the societys members regardless of power status. Thus, unlike members of high power distance cultures, members of low power distance cultures do not readily accept inequality or an unequal system[Conner, 2003]. Vitell, Nwachukwu and Barnes[Vitell et al., 1993] provide the following propositions on differences in power distance:

> Business practtioners in countries with a small power distance (e.g., the U.S. or Canada) are more likely than business practitioners in countries with a large power distance (e.g., France) to take their ethical cues from fellow employees, whereas practitioners in countries with a large power distance are more likely than business practitioners in countries with a small power distance to take their ethical cues from superiors.
>
> Business practitioners in countries with a small power distance are likely to consider informal professional, industry and organizational norms as

> more important than formal codes of ethics when forming their own deontological norms.

Hofstede[hof, 1980b] defines uncertainty avoidance as:

> ...the extent to which a society feels threatened by uncertain and ambiguous situations and tries to avoid these situations by providing greater career stability, establishing more formal rules, not tolerating deviant ideas and behaviors, and believing in absolute truths and the attainment of expertise. Nevertheless, societies in which uncertainty avoidance is strong are also characterized by a higher level of anxiety and aggressiveness that creates among other things, a strong inner urge in people to work hard.

Uncertainty avoidance is related to anxiety, need for security and dependence upon experts. A culture that is high in uncertainty avoidance would exhibit a rule orientation, prefer employment stability and exhibit stress as the members of the culture try to explain, mitigate and minimize the uncertainty that is inherent to life[Hofstede, 1980; Ford et al., 2003]. [Vitell et al., 1993] provides us with the following propositions on uncertainty avoidance:

> Business practitioners in countries that are high in uncertainty avoidance (e.g., Japan) will be more likely to consider formal professional, industry and organizational codes of ethics when forming their own deontological norms than business practitioners in countries that are low in uncertainty avoidance (e.g., the U.S. or Canada).

Hofstede[hof, 1980b] describes the individualism versus collectivism dimension as follows:

> Individualism implies a loosely knit social framework in which people are supposed to take care of themselves and of their immediate families only, while collectivism is characterized by a tight social framework in which people distinguish between in-groups and out-groups; they expect their in-group (relatives, clan, organizations) to look after them, and in exchange for that they feel they owe absolute loyalty to it.

An individualist culture is one in which the ties between individuals are loose. On the other hand, a collectivist society finds people integrated into strong, cohesive groups. Cultures high in individualism will value personal time and personal accomplishments. Whereas cultures high in collectivism will value the groups well-being more than individual desires; the belief is that it is best for the individual if the group is cohesive[Hofstede, 1980]. Members of collectivist cultures are motivated by the objectives of fitting-in and accomplishing group goals. Also, members of collectivistic cultures are said to expect the in-group and the organization to treat them fairly and to take care of them. Moreover, as noted by Hofstede[hof, 1980a], there are certain key differences between the expectancies of collectivistic and individualist in-work situations. For example, members of individualistic cultures take more of a universalistic approach to work-related decisions such as reward allocation, hiring, and promotions. That is to say, individualists expect such decisions to be based on skills and rules. On the other hand, members of collectivist cultures take more of a particularistic approach to work-related decisions. Namely, exceptions are expected on the basis of the situation or even on in-group/outgroup membership[Conner, 2003]. In [Vitell et al., 1993], the following propositions on individualism vs. collectivism are given:

> Business practitioners in countries that are high on individualism (e.g., the U.S. or Canada) will be less likely to take into consideration informal professional, industry and organizational norms when forming their own deontological norms than business practitioners in countries that are high on collectivism (e.g., Japan).
>
> Business practitioners in countries that are high on individualism will be likely to consider themselves as a more important stakeholder than owners/stockholders and other employees, whereas business practitioners in countries that are high on collectivism will be likely to consider the owners/stockholders and other employees as more important stakeholders than themselves.

Masculinity versus femininity is described by Hofstede[hof, 1980b] as:

> Measurements in terms of this dimension express the extent to which the dominant values in society are masculinethat is, assertiveness, the acquisition of money and things, and not caring for others, the quality of life, or people. These values were labeled masculine because, within nearly all societies, men scored higher in terms of the values positive sense than of their negative sense (in terms of assertiveness, for example, rather than its lack) even though the society as a whole may veer toward the feminine pole. Interestingly, the more an entire society scores to the masculine side, the wider the gap between its mens and womens values.

The propositions in [Vitell et al., 1993] concerning masculinity versus femininity are:

> Business practitioners (both males and females) in countries high in "masculinity" (e.g., the U.S. or Japan) will be less likely to perceive ethical problems or to be influenced by professional, industry- and organizational codes of ethics than business practitioners (both males and females) in countries characterized as high in "femininity" (e.g., Sweden).

### 4.3.2 United States' Cultural Dimensions

We will now take a look at the respective values[hof, 2009] of Hofstede's cultural dimensions.

| Country | PDI | IDV | MAS | UAI | LTO |
|---|---|---|---|---|---|
| US: | 40 | 91 | 62 | 46 | 29 |
| average: | 55 | 43 | 50 | 64 | 45 |
| NL: | 38 | 80 | 14 | 53 | 44 |

The high Individualism (IDV) ranking for the United States indicates a society with a more individualistic attitude and relatively loose bonds with others. The populace is more self-reliant and looks out for themselves and their close family members.

The next highest Hofstede Dimension is Masculinity (MAS) with a ranking of 62, compared with a world average of 50. This indicates the country experiences a higher degree of gender differentiation of roles. The male dominates a significant portion of the society and power structure. This situation generates a female population that becomes more assertive and competitive, with women shifting toward the male role model and away from their female role.

The United States was included in the group of countries that had the Long Term Orientation (LTO) Dimension added. The LTO is the lowest Dimension for the United States at 29, compared to the world average of 45. This low LTO ranking is indicative of the societies' belief in meeting its obligations and tends to reflect an appreciation for cultural traditions.

The next lowest ranking Dimension for the United States is Power Distance (PDI) at 40, compared to the world average of 55. This is indicative of a greater equality between societal levels, including government, organizations, and even within families. This orientation reinforces a cooperative interaction across power levels and creates a more stable cultural environment.

The last Geert Hofstede Dimension for the United States is Uncertainty Avoidance (UAI), with a ranking of 46, compared to the world average of 64. A low ranking in the Uncertainty Avoidance Dimension is indicative of a society that has fewer rules and does not attempt to control all outcomes and results. It also has a greater level of tolerance for a variety of ideas, thoughts, and beliefs.

### 4.3.3 conclusion

The United States' Hofstede dimensions are manifested in all aspects of everyday life; they can be used to explain different phenomenons in the American culture, of which two examples will be discussed now:

- a well-known phenomenon in the United States is concerned with the many lawsuits. There is a tendency to sue anyone for any reason, whenever there is the slightest possibility for financial compensation. This can be explained by the high individualism ranking; despite the likely negative consequences for the opposing party, the personal gain is considered more important. This is highly related to individualism.

- another phenomenon in the United States is that of credit card debt. A substantial part of the United States' population has one or more credit cards which are used to buy goods by instalment, with very little consideration for the obvious negative effects. This phenomenon can be partly explained by analyzing the United States' Hofstede dimensions: a high individualism index combined with an above average masculinity index can lead to the need to buy luxury goods, either to raise one's status or as a general sense of self valuation. The low long term orientation can be used to explain the disregard for the negative effects of buying on instalment.

## 4.4 Entrepreneurship

This section will give some insight into general behavioral aspects as well as aspects of business culture of the United States. First the American Dream will be addressed, followed by general/individual business culture, major work topics, business etiquette. Lastly the influences of American entrepreneurship on the gaming industry will be discussed.

### 4.4.1 American Dream

The American Dream is the idea that every individual has the potential to attain a better and fulfilling life, success and a state of happiness by working to their fullest potential towards that goal. It was first expressed by James Truslow Adams [Adams, 1931] and finds its roots in the second sentence of the United States Declaration of Independence [Jefferson, 1776]:

”We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness.”

### 4.4.2 General business culture

The American Dream is of great influence in business culture in the United States. Fueled by the idea that hard work is highly rewarded, Americans work long and hard and contribute to one of the biggest economies in the world. The working hours between 1990 and 2000 have increased in the form of and extra 40-hour work week [str, 2010]. Americans work 1800 hours per year on average compared to the Dutch, who work 1300 hours per year [van den Brand, 2006]. This hard work can manifest itself in the form of job related stress [str, 2010]. Since the United States is such a large country, it has many subcultures with geological, topographical, historical and political differences among different regions. For instance, the Southern part of the U.S. is known for its hospitality [Berardo, 2006a] while the East Coast is formal and has a conservative approach concerning clothing and conduct. In contrast, businesses in the West Coast are less formal than their Eastern counterparts [Berardo, 2006a].

### 4.4.3 Individual business culture

Although businesses in the same region can have a lot of similar characteristics, they can still differ greatly from each other because of individual business factors like type of industry, business structure, management and business mission. It is therefore advised to spend time researching the region, as well as the individual companies in that region. Many companies offer information about their approach to doing business on their web site [Berardo, 2006a].

### 4.4.4 Major work topics

The workplace in the United Stated offers employees certain rights that are protected by law. Businesses hold these rights in high regard and comply with the labor laws by investing a considerable amount of time and money. The major topics of today's workplace are [Berardo, 2006b]:

- Affirmative action
- Discrimination based on age, race, ethnicity, and sexual orientation
- Diversity
- Disabled workers
- Equal employment opportunities
- Safety in the workplace (including preventing workplace violence, drug use, and sexual harassment)
- Privacy rights
- Religious protection

There are two main ideas on the U.S. workplace, and the influence of the American Dream can be clearly seen in them [Berardo, 2006b]:

1. Individuals have the same right to be employed in a workplace, and they cannot be discriminated against because of factors like race, age, religion, sexual orientation, disabilities, or gender.
2. Individuals have certain rights regarding basic pay standards, safety, and treatment in the workplace that must be met by employers.

There are many laws that deal with these two ideas. A couple of them are

**Immigration and Nationality Act** (INA), which determines conditions for temporary or permanent employment of foreigners in the United States

**Fair Labor Standards Act** (FLSA), which established a national minimum wage, prohibits most forms of child labor, and guarantees that employees are paid one and a half times their normal wage for overtime

**Family and Medical Leave Act** (FMLA), which grants employees up to 12 weeks of unpaid leave for certain medical reasons. Among these are giving birth and taking care of the newborn child of the employee, taking care of immediate family members, and taking medical leave due to a serious health condition among others

More laws dealing with the main ideas can be found in the section *Laws*. Again, it is a good idea to study the rules and guidelines that many businesses in the U.S. use to deal with certain procedures [Berardo, 2006b].

### 4.4.5 Business etiquette

Like in every other country there is a certain behavior which you are expected to conform to. Although the etiquette can vary between different regions and companies, there are still some general behavioral aspects common in the United States. Here we will discuss a couple of them. [Roberts and Taylor, 2008] and [Today Translations, 2010] list a couple of aspects of business etiquette, which will be discussed next.

### Meeting and greeting

First impressions are important so, when introducing yourself, offer a firm handshake that lasts 3-5 seconds, upon greeting and leaving. Maintain good eye contact during your handshake as this leaves an impression that you have confidence [Wilkes, 2008], which is also true for smiling. If you are meeting several people at once, maintain eye contact with the person you are shaking hands with, until you are moving on the next person. Be aware that you may be greeted with a "hello" rather than a handshake in rural areas. Americans usually do not appreciate hugging and close physical contact, though this depends on the region and the how close you are with the other.

The exchange of business cards can vary. You can exchange business cards at this point, but also when one party is leaving, however the former is often more usual. You can always give your card, but do not expect to always receive one from your partner, because this depends on wanting to contact the person later. It is also very normal for the recipient of your card to place your card into his/her wallet or in the back pocket of his/her trousers.

Lastly, when it comes to clothing, you may want to dress conservatively for the first meeting and after that, you can just follow your host's clothing (in)formality in subsequent meetings.

### Conversations

The most often used language will be English, but the importance of Spanish keeps increasing with the U.S. being neighbors with Mexico and having a large population of Spanish-speaking citizens living in the United States. So in the future being able to speak Spanish will be more and more important. Americans usually dislike periods of silence during negotiations and may continue to speak simply to avoid silence. They also like to laugh and enjoy talking with people with a sense of humor. Also of importance is to keep good eye contact during conversations because it shows interest, sincerity and confidence. Lastly, since Americans usually do not like too much physical contact, it is advised to keep about two feet of distance between you and your partner to avoid uncomfortable situations (again, this can differ in every region).

### Doing business

As the North American culture stresses the individual initiative and achievements, American businessmen are very punctual, persistent, direct and to-the-point, being able to make decisions quickly and decisively based on as much information as they can gather. They are very opportunistic, future oriented and are not afraid of disagreeing and taking risks to make as much profit as possible. When negotiations are in a deadlock, they will try to find more ways of coming to a positive conclusion, but always within company policy. Keep in mind that money is of highest priority and will be used to win arguments.

In general, working weeks are Monday to Friday, 8:30/9:00 am to 5:00/6:00 pm and long working hours are common. Little business is conducted on Sundays, since this is the usual day of worship for many religions.

Businessmen tend to be busy with work related things on many occasions. Examples are having lunch/dinner (although social conversations will also take place during them) and playing golf, which a very popular sport among business executives and also a venue for business deals. The saying ”time is money” is not just a saying; it is the way Americans do business and therefore business is usually conducted at a fast pace. Also, sports terms are very popular and often you will hear terms like ”touch base”, ”call the shots”, ”ballpark figures” and ”game plan” among others.

If you are invited for a business meal, the host will usually pay, but in case he doesn’t, be prepared to pay for your own meal. Inviting business partner to your home is common and is a gesture to show goodwill between you and your business partners.

**Gifts**

Giving gifts are very common in some cultures while being unacceptable in others. Many companies in the U.S. discourage or limit exchange of gifts, but can be common practice in some companies. If you do give a gift, modest gifts are preferred like a gracious written note, which is always appropriate and acceptable. A lunch/dinner invitation can also be acceptable, just make sure it does not look like a bribe. The exchange of business gifts usually happen after the deal is closed and in most situations, gifts are unwrapped immediately and shown to all.

When you visit a home, you don’t need to bring a gift, although it is always appreciated. Flowers, a potted plant, or a bottle of wine are good choices, unlike personal gifts for women like perfumes or clothing, which are usually inadequate.

### 4.4.6 Consequences for the gaming industry

Businessmen in the U.S. are not afraid to try new ways to make more profit. Effects of this can be seen in new methods of game distribution like *Steam*, which allows gamers to buy games online and download the games to their computer, by creating an account and logging into Steam. This approach has benefits like not having to go to a store to buy the game and not having to worry about losing the original medium because it can always be re-downloaded. *Valve*, the makers of Steam, also have ported their games to the growing Macintosh platform [MacNN, 2010], that has relatively few games, so they can acquire new customers.

Another effect is charging for non-complete games or ”premium downloadable content” (PDLC), which are essentially very long demos [Graft, 2010]. This is an effect of the gaming industry adapting in order to try to lower development costs for new games. Since games are becoming more and more complex, this results in higher costs (GTA4 cost approximately $100 million [Bowditch, 2008]). Electronic Arts wants to use the PDLC payment model, and Crytek is also considering this model [Crossley, 2010], so they can generate more revenue, but also deliver higher quality games by incorporating suggestions of gamers who play the PDLC games [Graft, 2010]. It is also very important that this model can also be utilized as a cheaper marketing tool, because marketing is essential for achieving high sales.

The drive to make more profit can force companies tp make employees work hard and long, which can cause discontent among employees and their families. An example of this is when the wives of the employees at Rockstar Games sent the company a letter in which they express their concerns and discontent, and threatened to take legal action against the company [Rockstar Spouse, 2010]. This was done by an anonymous person using the alias "Rockstar Spouse". Electronic Arts had to deal with the same treatment when they received an letter from a user "EA_Spouse" [Hoffman, 2004], who was later revealed as Erin Hoffman [Jenkins, 2006].

### 4.4.7 Laws

- Civil Rights Act of 1964
- Americans with Disabilities Act
- Child Labor Laws
- Consolidated Omnibus Reconciliation Act (COBRA)
- Health Insurance Portability and Accountability Act (HIPAA)
- Family and Medical Leave Act (FMLA)
- Occupational Safety and Health Administration Act (OSHA)
- Unemployment Compensation
- Worker's Compensation

### 4.4.8 Conclusion

Future oriented, fast-paced businessmen that are not afraid to take risks are a common sight in the United States. When comparing the US to other countries, the United States appears to be very work related [str, 2010], with a lot of its employees working hard and long. A lot of laws exist to protect employees on the work floor, and many companies do their best to adapt standard procedures so they comply with these laws. The drive for more profit causes companies to think differently about how to reach new customers, make it easier to serve existing customers and lower the costs of development. This can sometimes lead to companies demanding too much of their employees as can be seen in the examples above.

## 4.5 Education

### 4.5.1 Introduction

In this part of socio-cultural we discuss the section Education. Before we can say anything about the results of education and development we first need to know how the United States and the Dutch education systems work exactly and what the differences are between them. Then we will research the education levels of both countries and analyze them. After the education levels we will research the human development over the years and compare them with the education levels. We will close this section with a view on the future and a conclusion, but we will first explain both education systems starting with the United States education system.

### 4.5.2 United States education system

The United States education system consist of a few different levels. In this section we will explain how the United States education system works exactly.

Children of four or five years old start in pre-primary school. Their first year at school is called kindergarten. When the children reach the age of six they join elementary school or also called primary school. This will be their second year at school. At this point the United States education system refers years to grades starting from one. The second year will be the first grade and the third year at school will be the second grade. We will use the term grade from now on. The word grade has two meanings: firstly, the score achieved on an exam or in a course, and secondly, a year of education in primary or secondary school.[EuroEducation.net, 2006b]

The primary school consists of five years. Most of the children starting primary school, are five or six years old. When leaving primary school they are about ten or eleven years old. After the primary school the secondary school follows.

The secondary school can be split in middle school and high school and starts with sixth grade and ends at grade twelve. The first three years are mostly called the middle school. Middle school is sometimes called junior high school and functions as a bridge between the elementary school and high school.[Math and Reading Help, 2010]

The ninth to twelfth grades are called the high school. The students can choose for a public or private high school. Public high schools are operated by the government and financed by public funds. However private schools are not operated by the government and not financed by public funds. These schools are operated by private individuals and are financed by private funds. The only thing public and private schools have in common is that the students have to meet the minimum graduation requirement set by the state. Private schools are more favorite by students because these schools have more options than public schools. These more options can be a broader selection of foreign languages or more advanced math and science and so on.[USA Study Guide, 2007]

After high school college or the university follows. The difference between college and the university is that college offers a collection of degrees in one specified area. A university is a collection of all these colleges. The student has the possibility to choose for a public or a private university. The difference between these kinds of universities are the same as at public and private high schools.[T.E., 2010]

When the students have achieved their high school diploma they can go to college or the university. If foreign students want to go to college or university they have to know what a United States student at high school knows. The students will attend the undergraduate school. These schools offer the students a two-year degree called an associate degree or a four-year degree called a bachelor degree in a specific course or study, which is called a major.

An associate degree is given in two types of colleges for the completion. There are three kinds of student groups who would follow the associate degree. Firstly, students who do not want to pursue a bachelor degree, but want to attend a U.S. community college, enroll in an associate degree program, and pursue an associate degree. Secondly, students who want to pursue a bachelor degree, but who want to complete the first two years of their undergraduate education by enrolling in one of the many associate degree programs at a U.S. community college and then transfer to a four-year U.S. college for the last two years. Thirdly, members of the local community want to attend associate degree program classes in various subjects at U.S. community colleges without pursuing any type of degree or enrolling in formal associate degree programs (this is called "continuing education").[USA Study Guide, 2007]

A bachelor degree takes four years. The most common two classes of bachelor degrees are the bachelor of science degree (BSc) and the bachelor of arts degree (BA). Many students follow a bachelor degree, because it provides more job opportunities and the graduate will earn more money than a student with a high school diploma or a student that has followed an associate degree.

At the end of the second year of the bachelor degree students have to select a major. Students have to complete a number of courses within their major or complete several courses in closely related fields to satisfy the requirements for graduating their bachelor degree. A few courses have to be completed by all the students. These courses are writing, foreign language, communications and American history. If one of these courses does not meet the requirements a student cannot graduate.[USA Study Guide, 2007]

When students have finished their bachelor degree, they can continue their study at a higher level. This level consist of two different types of degrees. The first degree is the master degree which is a two-year degree that is highly specialized in a specific field. The second degree is a doctor degree which is also called a Doctor of Philosophy (PhD). It takes three to six years to complete this type of study and you have the possibility to teach at a university.

### 4.5.3 Dutch education system

The Dutch education system works differently from the United States education system. In this section we will explain how the Dutch education system works.

When children reach the age of four they go to a basic or elementary school. This school can vary in three different types namely, public school, private school or a special school (religion) and has a duration of eight years. The choice of type of school depends on the parents. When the children join the basic school their first two years are called the nursery. At their third year at school they learn how to read, write and do math. In the eighth year the children have to do a test called the Cito test. This test will determine which level of higher education the children can do.

Now we will give some information about the different levels a Dutch student can reach and how they can get there.

After the elementary school the children will go to VMBO or high school. The children mostly are then twelfth years old. High school consist of three different levels called HAVO, VWO and Gymnasium.

Voorbereidend middelbaar beroepsonderwijs (VMBO, 'preparatory middle-level applied education') is the lowest level of the three. This kind of education has a duration of four years from the age of twelve to sixteen.

Hoger algemeen voortgezet onderwijs (HAVO, 'senior general education') is the middle level of the three. This kind of education has a duration of five years long and prepares the student for higher professional education.

Voorgezet wetenschappelijk onderwijs (VWO, 'pre-university education') is the highest level of the high school. This kind of education has a duration of six years and consists of two different types, namely, athenaeum and gymnasium. The difference between those two is that gymnasium has two extra languages, Latin and Greek.

The kind of level a student will follow is determined by the score of the Cito test and the advice of the elementary school. It is possible for the children to grow to a higher level if the current level is to easy for them.

In the last two years of VMBO, the pupils can choose between technology, health and personal care and welfare, economics and agriculture. In the last two years of HAVO and the last three years of VWO, the pupils can choose between Science and Technology, Science and Health, Economic and Society and Culture and Society.[EuroEducation.net, 2006a][Van Dale, 2009]

When the students reach their last year of VMVO or high school they have to do an exam. If they pass the exam they get a diploma and have the possibilities to grow to tertiary education, which consist of MBO, HBO and WO. With a VMBO diploma you can go to MBO or to HAVO. With a HAVO diploma you can go to HBO or to VWO and with a VWO diploma you can go to the university.

Middelbaar beroepsonderwijs (MBO, 'intermediate vocational education') is oriented on vocational training. The studies have a duration of four years. When the pupils have completed their MBO, they have the possibility to enroll in HBO or they search for a job.

Hoger beroepsonderwijs (HBO, 'higher vocational education') is oriented on higher professional training and the studies consist of a bachelor with a duration of four years and a master of two years. Each year the student can obtain credits from completed courses. After four years the student needs enough credits to graduate for the bachelor degree. After the bachelor they can choose for a longer study and obtain a master degree at a university.

Wetenschappelijk onderwijs (WO, 'higher education') is taught at a university. It is only possible to enroll in WO if you have a VWO diploma or a HBO propedeuse. A propedeuse is a diploma you get when you have completed the first year of the study. When you have enough credits after three years you graduate for your bachelor degree. After the bachelor you have the possibility to longer your study to complete also your master degree in one or two years or become a Doctor of Philosophy.

### 4.5.4 Differences between the United States and Dutch education systems

In this subtopic we discuss the differences between The United States and Dutch education system.

***Study life career***

All the United States students follow the same education system. They all start at elementary school and all students join secondary school up to the university. In

The Netherlands students participate at the level of education that fits best with their intelligence. This will be determined by making the Cito test. This means that not all the students will take the same level of education.

***Public and private schools***
In the Netherlands you will see almost no private schools. This is because the Dutch believe that the government should fund the schools and companies should not. In the United States this is different; there you see more private schools, because the inhabitants believe that private schools provide a better education, which leads to better job opportunities.[Fulbright Center, 2007][Council for American Private Education, 2007]

***Tuition***
There is an amazing difference between the tuition a United States student has to pay and a Dutch student has to pay. An United States student has to pay more for a private school than for a public school. For a four-year public school a United States student has to pay more than 13,000 dollar and for a four-year private school more than 30,000 dollar. The difference between the amount a student has to pay for a public school and a private school is, because public schools are funded by the government and private schools are not. These amounts are much higher than a Dutch student has to pay annually. Dutch students pay an annual amount of about 1,600 euro, with roughly equals 2,136 dollar.[National Center for Educational Statistics, 2009b][Project America Beta, 2008][VU University Amsterdam, 2010]

***Home schooling***
Home schooling is possible in the United States. The reasons why people choose for home schooling are because they want to teach their child religion besides the official courses or they see negativity in schools, like bullying, drugs, crime and sex that can influence the development of their child. In the Netherlands home schooling is not allowed. However, there is one exception and that is when the child is seriously ill or incapable to physically attend the school.[National Center for Education Statistics, 2003]

### 4.5.5 Education results

Now we know how both education systems work. In this section we will discuss education results of fourth, eighth grades and fifteen-year-old students between United States students and Dutch students. These results are published by the National Center for Education Statistics (NCES) and by the Dutch Ministry of Education, Culture and Science. NCES participates in several international assessments to measure how the performance of United States students and adults compares with that of their counterparts in other countries. Students have participated in three different studies, Progress in International Reading Literacy Study (PIRLS), the Program for International Student Assessment (PISA) and the Trend in International Mathematics and Science Study (TIMMS). Those three studies are organized by subject area in three different parts: reading, mathematics and science. They compare United States students with other countries, including the Netherlands.[National Center for Educational Statistics, 2009c][National Center for

Educational Statistics, 2009a]

PIRLS focuses on the aspects of reading skills. TIMMS focuses on the aspects of mathematics and science skills and PISA focuses on fifteen-year-old students on all three subjects. The most recent results are from the year 2006 and for TIMMS the most recent results are from the year 2007. We will first list the kind of levels we will discuss between The United States and The Netherlands. After the list, three tables will follow with the results represented. The results are coming from the website of National Center for Education Statistics.[National Center for Educational Statistics, 2009d][National Center for Educational Statistics, 2009e]

The levels that will be discussed are:

- Reading fourth-grade;
- Mathematics fourth-grade;
- Mathematics eight-grade;
- Science fourth-grade;
- Science eight-grade;
- Reading fifteen-year-old;
- Mathematics fifteen-year-old;
- Science fifteen-year-old.

***Tables:***
We will start with reading (first table), followed by mathematics and science (second table) and at last the fifteen-year-old on all the three - reading, mathematics and science - subjects (third table). In each table we will inform, the to be discussed subject, followed by the country and the years with the scores. Almost all results are based on an average of 500, but if this differs, the new average is mentioned.

### 4.5.6 Analyze results

Here we will analyze the results of the three tables shown in the previous subsection *Education results*. If we look at the scores of both countries we see that The Netherlands has almost on every area better scores, but over the years the scores of The Netherlands decreases and the scores of The United States increases almost on all areas except on the areas of Reading fifteen-year-old, Mathematics fifteen-year-old and Science. It is remarkable that the scores of the United States in science fourth-grade are higher than the scores of The Netherlands but the scores of science eight-grade are lower than the scores of The Netherlands. Further, the scores of The Netherlands are far above the average and the scores of The Netherlands in the areas Reading fifteen-year-old, Mathematics fifteen-year-old and Science fifteen-year-old are all higher than the scores of the United States.

| Subject | Country | 2001 | 2006 |
|---|---|---|---|
| Reading fourth-grade | The United States | 542 | 540 |
| | The Netherlands | 554 | 547 |

Table 4.2: Analyzed by PIRLS - general average: 500

| Subject | Country | 1995 | 1999 | 2003 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Mathematics 4th-grade | U.S. | 518 | - | 518 | 529 | - |
| | NL | 549 | - | 540 | 535 | - |
| Mathematics 8th-grade | U.S. | 492 | 502 | 504 | - | 508 |
| | NL | 529 | 540 | 536 | - | - |
| Science 4th-grade | U.S. | 542 | - | 536 | 539 | - |
| | NL | 530 | - | 525 | 523 | - |
| Sciene 8th-grade | U.S. | 513 | 515 | 527 | - | 520 |
| | NL | 541 | 545 | 536 | - | - |

Table 4.3: Analyzed by TIMMS - general average: 500

| Subject | Country | 2000 | 2003 | 2006 |
|---|---|---|---|---|
| Reading 15-year-old, averages: | | 500 | 494 | 492 |
| | The United States | 504 | 495 | - |
| | The Netherlands | - | 513 | 507 |
| Mathematics 15-year-old, averages: | | 500 | 500 | 498 |
| | The United States | 493 | 483 | 474 |
| | The Netherlands | - | 538 | 531 |
| Science 15-year-old, averages: | | 500 | 500 | 500 |
| | The United States | 499 | 491 | 489 |
| | The Netherlands | - | 524 | 525 |

Table 4.4: Analyzed by PISA - general average is given.

### 4.5.7 Human Development

Over the years human development has increased in many countries. Also in the countries the United States and The Netherlands human development has increased. The increase is expressed in an index called the Human Development Index (HDI). This index measures the Education, Life expectancy and GDP. In this section we will take a look at the human development over the years between The United States and The Netherlands. The indices are published on the website of 'Human Development Reports'.

A table showing the indices of the human development of both countries over the years:

| | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| U.S. | 0.894 | 0.909 | 0.923 | 0.939 | 0.949 | 0.955 | 0.955 | 0.956 |
| NL | 0.889 | 0.903 | 0.917 | 0.938 | 0.950 | 0.958 | 0.961 | 0.964 |

In 1980 the development of the United States was higher than the development of The Netherlands. From 2000 and later the development of The Netherlands is higher than the development of the United States. This is remarkable because this is also visible in the education results. The results that have been published are mostly from 2000 and later and in the most cases we analyzed that the results in The Netherlands were higher than the results from the United States.[Human Development Reports, 2009a]

***Health and Education Report***
In this part we will show a table with indices of both countries about the percentage adults of twenty five years and older at three different educational levels in 2009.

Low: stands for Low educational attainment level.
Medium: stands for Medium educational attainment level.
High: stands for High educational attainment level.

| | Low | Medium | High |
|---|---|---|---|
| The United States | 14.8 | 49.0 | 36.2 |
| The Netherlands | 34.8 | 38.6 | 26.0 |

These indices show that the United States has a higher educational level than The Netherlands. But you have to know that these indices are based on adults from twenty five years old and older. If you look at the first table you can see that in 1980 to 1995 the development of the United States was better than the development of The Netherlands. This will explain why The Netherlands has a high rate at low educational and medium educational level, because many people above the twenty five years old have studied in those years or earlier.[Human Development Reports, 2009b]

***Gross enrolment***
These percentages show the results of male and female in 2007.

| | Male | Female |
|---|---|---|
| The United States | 88.1 | 96.9 |
| The Netherlands | 97.9 | 97.1 |

Based on these results you can see that the percentage of gross enrolment in The Netherlands is for male and female higher is than for the United States. The gross enrolment is calculated by expressing the number of students enrolled in primary, secondary and tertiary education as a percentage of the total population of official school age for all three levels.[Human Development Reports, 2009b]

### 4.5.8 Future

Looking at the development indices of Human Development we expect that the difference between both countries will grow. It is possible that the development of the United States will stay constant or may decrease, because in 2008 and 2009 an economic crisis existed, which resulted in many inhabitants with large debts. If the inhabitants have no money to spend, students have less money for studying, which will results in choosing for a public school instead of private school. This will result in students learning less, because public schools have less options than private schools and so the level of education will decrease. After graduating at school, students will start working earlier, because there is no money to attend college at a university.

### 4.5.9 Conclusion

Based on all this information we can conclude that both education systems are very good, but looking at the results in the section 'Education results', we see that the scores of the Dutch students are higher than of the United States. The United States Students are better on the area science fourth-grade but as we look at the results of the areas science eight-grade and science fifteen-year-old we see that the results of the Dutch students are higher than the results of the United States Students.

Looking at the tables in the section 'Human Development' we see that the development of The Netherlands has passed the development of the United States over the years. Also the gross enrolment of the Dutch students both male and female is higher than the gross enrolment of the United States.

The only thing the United States has better scores on (higher percentage of education level), is the Health and Education report based on twenty-five years old and older people. This is not a surprise since the results of the United States showing in the section 'Human Development' from 1995 and before are higher than the results of The Netherlands. A great percentage of inhabitants have had education in those years.

Based on these facts we can conclude that the development of education in The Netherlands has grown over the years and slightly passed the average United States education development.

## 4.6 Differences

In this section we will list the main differences between The United States and The Netherlands.

| The United States | The Netherlands |
| --- | --- |
| High Percentage Christianity | Higher Percentage Atheists |
| Younger generation increasing in number | Younger generation decreasing in number |
| All the students follow the same education levels | All the students follow the level of education that fits best with their intelligence |
| Many private schools | Many public schools |
| Homeschooling possible | Homeschooling only possible when a valid reason is given |
| Very work related | Much less work related |
| Long working hours are common | Working hours are short |
| Individualistic attitude | Long term oriented |
| Score of 62 on masculinity | Score of 14 on masculinity |

## 4.7 Conclusion

From the given information in this chapter we can conclude that there are many differences between The United States and The Netherlands. Most notable demographic differences are religion and age distribution. The United States have younger population, while in the Netherlands older people are gaining in numbers. It might also be important to note the high number of Spanish-native speaking inhabitants in the United States.

Also because of the difference between the amount of inhabitants of both countries, we can preceive that there are more fashion labels and designers, musicians, actors in The United States. The influence of this is visible in The Netherlands as we listen to music made in The United States, watch American movies, wear jeans and other clothes inspired by U.S. fashion among others.

Americans are very work related. They work hard and long, because they have faith in the American Dream, which basically means that that everyone has the right for employment and that hard work should be rewarded in the context of doing business. The U.S. has a lot of laws that support and protect employees, but sometimes companies break the rules to make more profit.

There are some notable differences as well when we look at the mindset in the United States compared to The Netherlands. Based on the Hofstede dimensions we can conclude that the biggest difference between the American and Dutch population is the masculinity; while The Netherlands scores only 14 on masculinity, the United States scores above the average with 62. The Dutch appear to be a little more long term oriented, while Americans appear to have a more individualistic attitude. Power distance and uncertainty avoidance score about the same.

Finally both countries have a different education system, which results in different levels and results. The influence of the government plays a role in the education system. The amount of funding the government of The United States gives is much lower than the amount of the government of The Netherlands. This results in a difference between the amount of private and public schools, the amount of money a student has to pay annually and a difference in the results of the students.

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# Chapter 5

# Economics of the United States of America

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## Introduction

This chapter discusses the economy of the United States of America, the biggest economy in the world, according to the International Monetary Fund's World Economic Outlook [Fund, 2010b]. The main focus is on how the U.S. economy influences the emergence of new technologies such as gaming and simulations, as is stated in the research question for the macro research in general:

*Which macro factors and/or actors can be distinguished that could support or inhibit the development and application of simulations and games in the US?*

The issue now is, how can this chapter contribute to answering the research question. What needs to be established is the link between economics and games & simulations. Because any new development requires investments, at least some link can be made between the subject of this chapter and the overall research subject. In an economy that is not doing well, investments will be few and conservative, as people will be hesitant to spend what money they have on what is essentially a gamble: a new technology such as augmented reality or serious gaming. This is the question this chapter should answer:

*Does the U.S. economy provide a climate in which new technologies, such as games & simulations, can prosper?*

This chapter answers this question by looking at:

**Trade** What do Americans trade with whom? What does this say about the economy as a whole?

**Finance** What are the key figures for the U.S. economy? Who invests in the U.S.? Is the economy financially stable?

**Labor** What are the most important sectors in the U.S. job market?

**Comparison with the Netherlands** How does the U.S. economy compare to the Dutch economy

**Trends** Which major trends can be distinguished in the U.S. economy, and what influence do they have on investments in new technologies?

## 5.1 International Trade

The United States has quite some trade partners with which they have different trade agreements that serve specific purposes, such as free trade agreements or bilateral investment treaties. This section discusses facts about trading with the United States; how this has evolved over time and how trading with the United States is done now. We will discuss several subjects such as trade agreements that are valuable to the U.S., as well as trade barriers that make it more difficult to trade. A look on firms that are active in international trade is also provided although we will not go into too much detail, since the chapter Import & Export elaborates more on that subject.

### 5.1.1 U.S. Trade Agreements

The Office of the United States Trade Representative (USTR) is responsible for developing and coordinating U.S. international trade and its agreements and policies. The USTR monitors the implementation of trade agreements of its trading partners, enforcing rights of the U.S. under those agreements. The USTR distincts four different types of agreements [Representative, 2010b]:

- World Trade Organization agreements
- Free Trade Agreements
- Trade and Investment Framework Agreement (TIFA)
- Bilateral Investment Treaties (BITs)

Each of these agreements will be handled in more detail in the following sections.

#### World Trade Organization agreements

The United States is a member of the World Trade Organization [Organization, 2010c]. The World Trade Organization (WTO) is an organization in which its member governments try to sort out the trade problems they face with each other [Organization, 2010b]. The organization was created on 1 January 1995 and can be seen as the replacement for the General Agreement on Tariffs and Trade (GATT) that existed from 1948 to 1994. By the 1980s the system needed a thorough overhaul, which led to the negotiations round of 1982, also known as the Uruguay Round, and ultimately to the WTO. It is also the WTO's responsibility to monitor its members and make sure they comply to the WTO agreements. The United States has been a member since the WTO's creation date.

WTO agreements cover goods, services and intellectual property. The agreements include every country its commitments to lower custom tariffs and other trade barriers. They also require governments to make their trade policies transparent by notifying the WTO about laws in force, adopted measures, and through periodic reports by the secretariat on trade policies of WTO members.

The current round of negotiations is called the Doha Development Agenda (DDA or Doha Round), and has been carried out since November 2001. It is the ninth round of multilateral trade negotations to be carried out since the end of World War II. The negotiations include those on agriculture and services, which begain in early 2000 [Organization, 2010a].

### Free Trade Agreements

A free trade agreement, also referred to as free trade area, is a pact between two countries or areas that agree on lifting most or all tariffs, quotas, special fees, taxes and other trade barries, to trade between the two parties. The purpose of free trade agremeents is to allow more, faster and easier trade in goods or services between two parties. Free trade agreements have shown to be one of the better ways to open up foreign markets to U.S. exporters. In 2006, FTA countries comprised 7.5% of global GDP (not including the U.S. itself), and were responsible for 42.6% of total U.S. exports [International Trade Administration, 2010].

Currently the U.S. has free trade agreements with 17 countries: Australia, Bahrain, Canada, Chile, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Israel, Jordan, Mexico, Morocco, Nicaragua, Oman, Peru and Singapore. Also Colombia, Korea and Panama have signed free trade agreements with the United States, but Congress must enact legislation to approve each of the agreements, before they can go in effect. The United States does not have a free trade agreement with The Netherlands. Since the U.S. and Netherlands are members of the World Trade Organization, both can profit from that membership.

An important free trade agreement in which the U.S. plays an important role, is the North American Free Trade Agreement, NAFTA. The NAFTA was created on 1 January 1994 and is an FTA between the United States, Canada and Mexico. By connecting 444 million people producing $ 17 trillion worth of goods and services, the NAFTA is the largest free trade agreement in the world. In 2008 the United States traded $ 967 billion worth of goods and $ 106.8 billion worth of services with its NAFTA partner countries, summing up to a total worth of $ 1.07 trillion.

### Trade and Investment Framework Agreement (TIFA)

A Trade and Investment Framework Agreement, abbreviated TIFA, is a trade pact between two countries that establishes a framework for expanding trade and resolving outstanding disputes. The framework is also known in other flavours, such as the Trade, Investment and Development Agreement, abbreviated TIDCA. The agreements however all serve as a forum for the United States and other countries, where they can meet and discuss issues of mutual interest. The objective is to improve cooperation on both sides and to increase opportunities for trade and investment for both parties. A TIFA can be seen as an important step towards a free trade agreement, since it starts the process of discussion and defines the first agreements for both parties in order for them to solve disputes, and start better collaboration.

#### Bilateral Investment Treaties (BITs)

A U.S. bilateral investment treaty (BIT) is an agreement between the U.S. and another country to encourage, promote and protect investment in each other's countries by nationals and companies based in either country. A BIT is mostly signed between developing countries and more developed countries by by policy makers in developing countries, because they believe that signing them will attract more foreign direct investment (FDI).

BITs require that investors and their investments in the territory of the other party are treated in the same way as the host party would treat its own investors and their investments. Also, a BIT provides a good transferability of investment related funds in and out of either country, without delay and a market rate of exchange. If there is an investment dispute, a BIT gives investors from either party the right to submit the dispute to international arbitration, without the requirement to use the other country's courts.

The United States currently has signed bilateral investment treaties with 40 different countries [Service, 2010].

### 5.1.2 Trade barriers

A trade barrier is any government policy or regulation that restricts international trade. Barriers can take many forms, such as import and export tarrifs, licenses, quotas, etcetera. Trade barriers are believed to have a negative impact on a country's economy since it is more difficult to trade with other countries, resulting in an economy that does not grow as fast as it would when goods and services would be shipped abroad [Commission, 2007].

#### Tariff bariers

Although during the last round of negotiations by the World Trade Organization its members agreed on substantially reducing and eliminating tariff barriers, the U.S. retains a number of significant duties and tariffs in various sectors, including but not limited to food products, textiles, footwear and leather goods. When the U.S. Bureau of Customs and Border Protection changed classifications, this led to higher tariffs. Tariffs on optical optical fibre cables were eliminated under the Information Technology Agreement (abbreviated ITA, in which participants completely eliminate duties on IT products covered by the agreement), but the U.S. does not wish to do the same for other technology related products that are not classified under the ITA. Attempts to broaden the scope and coverage of products in the form of an ITA II have failed [Commission, 2007].

#### Non-tariff barriers

Now that tariff barriers are succesfully being reduced and eliminated, the focus moves away from tariff barriers and towards non-tariff barriers. European Union and other exporters to the United States face strict regulatory barriers. Products exported to the U.S. must conform to more and more technical regulations concerning consumer health and safety, and environmental protection. As an example, documentary and labelling requirements for textiles must comply to certain U.S. labelling requirements. Pressure equipment and other equipment for use in the workplace must often be certified by the U.S. Department of Labor. In the United States insurance companies determine product safety requirements and producers of goods must comply them [Commission, 2007].

With these kinds of non-tariff barriers, any company that wants to sell goods in the United States must comply to these strict regulations. Especially non-U.S. companies find assessing product conformity and testing requirements very difficult. As an extra factor of difficulty, these regulations that companies are used to can be subject to change overnight. Although it is farely rare that this happens on such a short notica, insurance markets can change regulations that are in effect when they find it neccesary [Commission, 2007].

An interesting barrier is the Trade Expansion Act of 1962. The act dictates that industries in the United States can set up a petition to restrict import from third countries to ensure national security [Commission, 2007]. The problem with this act is that the decision made by the majority does not need any proof from the industries. The industries can thus misuse the act by arguing that a reduction of trade done between the U.S. and a third country would improve or ensure national security, while it may actually just be to reduce foreign competition.

**Intellectual property rights**

Since the World Trade Organization's Uruguay Round in the 1980s a number of positive changes have been made in U.S. legislation. However, copyright issues are still problematic such as authors' moral rights and music licensing exemptions due to the 1976 U.S. Copyright Act, which most importantly defines the basic rights of copyright holders and defines *fair use*. Although the U.S. lost a WTO case on the Copyright Act, the U.S. still not brought its Copyright Act into compliance with the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs) as defined by the World Trade Organization.

Article 31 of the TRIPs Agreement requires that governments using patented products must inform the legal holders of the patent of its use. Despite the fact that U.S. authorities extensively make use of patented goods, they seem to frequently fail to comply with this article [Commission, 2007]. It seems that the United States perform well when it comes to restricting trade (see non-tariff barriers for example) and defining rules, but not so much when it comes to complying to them.

### 5.1.3 The relation between the U.S. and Saudi Arabia

The relationship between the U.S. and Saudi Arabia has been one of America's most complex connections in the Middle East, especially since the attacks on September 11$^{th}$, 2001 on the World Trade Center. In these attacks, 15 of the in total 19 hijackers are believed to be Saudi. The kingdom of Saudi Arabia is being treated in a special way by international community because of its Islamic relegion and, of course, oil wealth [Prados, A.B., Blanchard, C.M., 2007] [Pollack, 2002]. In this chapter we will look at the aspects of why Saudi Arabia is an important partner of the United States, as well as a brief history of this relation.

### History

In 1931 Chigago millionaire and associate of U.S. presidents Charles R. Crane was invited to the kingdom of Saudi Arabia by Abd al-Aziz. It was the king's hope that Crane might explore assets beneath the kingdom its soil. Water would be the first step. There was however a more interesting product in the ground than water: oil. In 1933 the Saudi Arabian minister of finance was convinced to sign a 60-year contract delivering exclusive rights to a single U.S. oil company for exploration and extraction in the Hasa region. The later to be called Aramco (the Arabian American Oil Company) first found oil in 1938 [Pollack, 2002].

As of 1946 the United States occupied a newly built airbase at Dhahran, near the Hasa oil fields, in order to support the flow of men and material to Burma during the Cold War. In the beginning of the 1950s the United States was in the middle of complications between Saudi Arabia and its rivals in Iraq and Jordan. Because of the rivals' proximity to the oil fields, Saudi Arabia signed a defense pact with the United States in 1951 [Pollack, 2002].

On August 4, 1990, just hours after Iraq invaded Kuwait, president George H.W. Bush told King Fahd bin Abd al-Aziz that the security of Saudi Arabia is of utmost important to the United States and other Western countries. Many United States administrations have emphasized their commitment to the security of Saudi Arabia [Prados, A.B., Blanchard, C.M., 2007].

In Saudi Arabia there is a growing anti-U.S. climate, which is believed to be caused by domestic and foreign policies of Saudi Arabia. By mutual agreement, the United States withdrew all its military forces from Saudi Arabia at the end of August 2003 [Pollack, 2002]. The relationship the U.S. currently has with Saudi Arabia is of course very valuable for the U.S., since Saudi Arabia has huge oil reserves and America is a huge consumer of oil.

### Oil

Saudi Arabia holds the world's larges oil reserves which is estimated at 261.7 billion barrals in 2001 and produces 9.5 million barrels per day as of 2005. It is estimated that 11.4% of total oil imports of the United States and 7.4% of total oil consumption originated from Saudi Arabia in 2004. In June of 2000, members of the Organization of Petroleum Exporting Countries, a cartel of 12 oil-producing countries including Saudi Arabia, agreed on changing the oil production by 500,000 barrels per day if the 20-day average price of a single barrel over would fall out of the price range of $ 22 to $ 28. In 2005 Crown Prince Abdullah's foreign policy advisor mentioned during a meeting between President Bush and the Crown Prince that this price range had become unrealistic, since the price of barrels had been going up towards $ 50 per barrel. Saudi Arabia proposed a plan in 2005 to deal with the ongoing supply and demand issues, by increasing its production of oil with approximately 1.3 million up to 12.5 million barrels per day in 2010, increasing the supply to the Western countries [Prados, A.B., Blanchard, C.M., 2007].

## 5.2 Comparison with the European Union

In the context of this report, it is only logical to make an economical comparison between the United States and the Netherlands. Fortunately, this is not the only interesting comparison to be made. Vast differences in aspects such as geographical scale and nation-wide structure call for an alternative, perhaps fairer point-of-view. One option to be considered is the comparison of individual European countries with the individual states of the United States. At the same time and at an even higher level, a comparison can be made between the United States and the European Union as a whole.

The first and foremost measure of a nation's economy is the GDP (gross domestic product). In simple terms, the GDP is a flow variable that measures the value of a nation's total annual output. The output is that which is produced by all the individuals in the course of a single year and represents the resources that are available for consumption and investment in that year. Since countries vary in scale, the GDP is divided by the number of inhabitants resulting in the per capita GDP.

It is important to note that valuing an economy and its prosperity by per capita GDP comes with a number of shortcomings. In the first place, the GDP only measures the production that is statistically recorded within the market. This excludes the production of household and black (illegal) markets, while this may be a significant and extensive economical factor even in modern industrial nations. Another issue with GDP is that it is strictly material; in other words, intangible factors such as leisure, good environment and happiness are not taken into account. As an extreme example, production processes that destroy the environment may improve GDP without the cost of environmental destruction being factored into the equation. Despite these shortcomings, GDP still remains an important international measurement unit at macro level.

### 5.2.1 EU versus US according to GDP

We begin by comparing individual European countries against the United States. When looking at the GDP per capita (in 2000) of the countries as depicted in figure 5.1, big differences can be seen between the European countries and the United States. The per capita GDP is considerably higher in the United States: 17% in comparison to the second "richest" country, Switzerland, and even lower for the rest of Europe. In 2008, the US per capita GDP was about 40% higher than the EU15 average Institute [2010].

Again, it is important to remember that the United States is an entire continent consisting of geographically defined regions with highly varying factors such as prosperity, growth and environment. Therefore, the comparison between Europe and the United States can be extended by comparing individual US states against European countries.

Figure 5.2 shows a comparison with interesting results. Out of all the European countries, there is really just one country that rivals with the individual states: Luxembourg. All other countries, including the Netherlands, can be found at the lower end of the scale. Only four US states score below the EU15 average GDP, but the differences are only small, while there is a very wide gap (of at least 100%) between the majority of the European countries and the more affluent US states. For example, Connecticut has almost twice the material prosperity of great European nations (and former great empires) such as France and the United Kingdom. Other countries, such as Portugal and Greece have a per capita GDP that is far below even the poorest state of the United States (Mississippi).

### 5.2.2 Private consumption

Another important welfare indicator is the private consumption: the choice of deciding where to spend your money on, whether it be food, a luxury car or electronic products. Individual access to products of technical progress, such as computers or the Internet, is an important aspect of welfare in today's economy.

From figure 5.3 it is clear that the per capita private consumption in the United States is far higher than in most European countries. The US private consumption is 29% higher than the country with the highest private consumption in Europe, namely Luxembourg. When comparing the United States to the European Union (EU15 average), a difference of 77% can be seen. All in all, the average American consumes nearly twice as much as the average EU citizen, which can be explained by the higher GDP as well as the difference in taxation policy between the United States and the European Union.

### 5.2.3 Gini coefficient

The Gini coefficient is a method that is commonly used to measure the inequality of income or wealth within a nation. The coefficient ranges from 0 to 1, with 0 corresponding to complete equality and 1 to complete inequality. A completely unequal society is considered to be one where a single person receives 100% of the total income, whereas an equal society would be one in which every person receives the same percentage of the total income.

Figure 5.4 shows that the Gini coefficient of the United States is the highest among the depicted western countries. It is no surprise that the wealth within the European Union appears to be spread more evenly among its inhabitants in comparison to the United States, where big differences exist between the rich and poor.

### 5.2.4 Why is Europe lagging behind?

Looking at the above measurements and additional studies on the economic development of the United States and Europe Institute [2010]Gidehag and Bergström [2004], one can only conclude that the United States is in fact richer than the European Union. The European Union is seemingly lagging behind in terms of economic growth, and so trying to understand these causes of growth (or lack thereof) has long been an important aspect of economic science. As it appears, politics seem to play a crucial role in the process of economic growth.

For one, the differences in political views on taxation are believed to be connected to the economical growth. With higher tax burdens and a larger public sector comes more power for political decision-makers and public bureaucracy. And as the public sector becomes larger, the portion of the economy that is open for competition shrinks.

Figure 5.4 shows that the tax burden (total tax revenue per GDP) in the United States is dramatically lower than any other European countries. In these European countries, high taxes are used as a means to finance a comprehensive welfare system that is targetted at redistributing income and wealth among its inhabitants (e.g. from the rich to the poor). This is reflected in the aforementioned Gini coefficient. And although redistribution may be ethically justified, it has an economical drawback: at an individual level, good behaviour is no longer rewarded while bad behaviour goes unpunished. In other words, the difference between the economically efficient and inefficient is minimized and the incentives for choosing behaviour to sustain economic growth are just not big enough.

Another point is the lack of competitiveness in the public sector, which compromises a relatively large part of the market in European countries. In the business sector, companies grow and lose market share all the time, whereas the public sector misses this degree of dynamic freedom. Start-ups and bankruptcies, although very common in the business sector, are virtually unknown in the public sector.

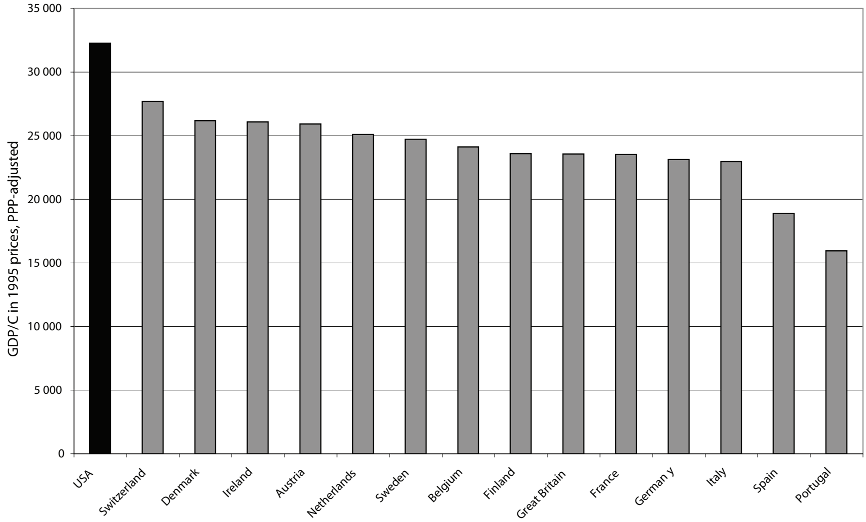


Figure 5.1: Per capita GDP in European countries (EU15) and in the United States, 2000, current prices and PPP-adjusted. Source: Timbro/Eurostat Gidehag and Bergström [2004].

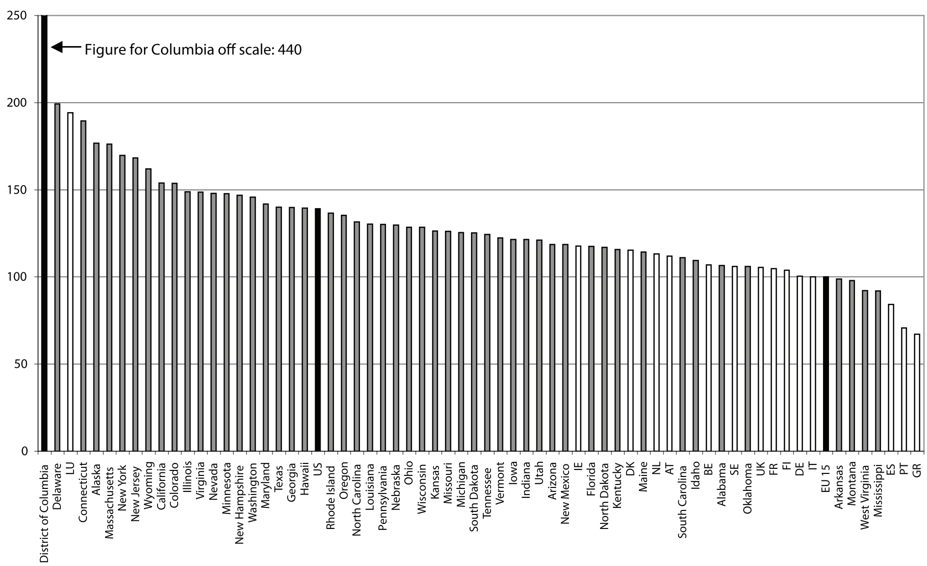


Figure 5.2: Per capita GDP in European countries (EU15) and in the states of the United States, 2001, PPP-adjusted, index EU15 = 100. Source: Timbro/BEA/Eurostat Gidehag and Bergström [2004].

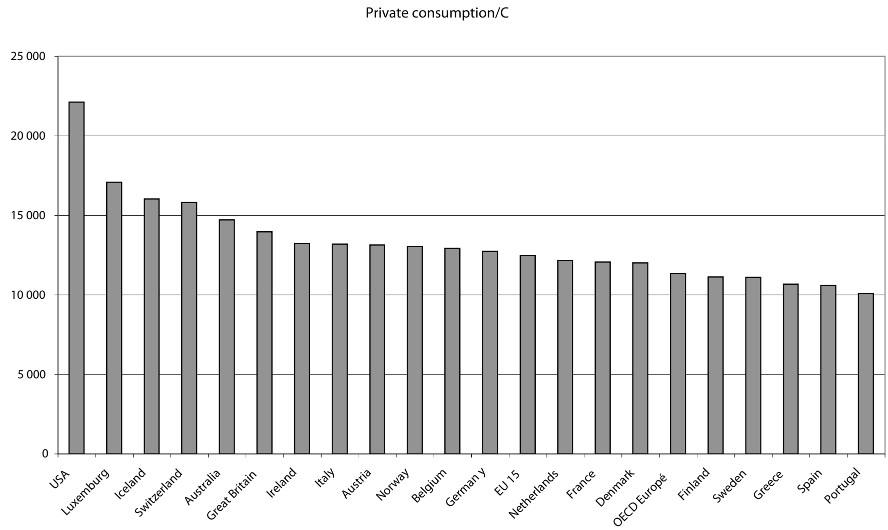


Figure 5.3: Private consumption in fixed money terms in the European countries (EU15) and in the United States, 2000, PPP-adjusted. Source: Timbro/Statistics Sweden Gidehag and Bergström [2004].

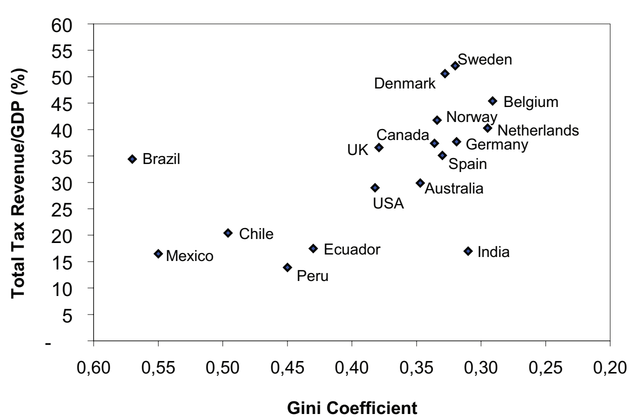


Figure 5.4: Tax burden and Gini coefficient of various countries, 2003. Source: Siqueira de Siqueira et al. [2003].

## 5.3 Import and Export

The United States is considered to be the largest economical nation in the world. Next to a gross domestic product (GDP) of $14,26 trillion, U.S. factories are also producing a total goods worth of $1,49 trillion, making it the world's top manufacturing nation Agency [2010]Bureau of International Information Programs [2007]. Given these facts, it is no surprise that the United States belongs to the world's largest trading nations in the world. In 2009, U.S. exports summed up to $1,056.9 billion and U.S. imports was accounted for $1,558.1 billion, summing up to a total of $2,615 billion in international trade. The major part of this grand total is due to the United States' top 15 trading partners; they are responsible for 71.8% of total trade, as can be seen in figure 5.5.

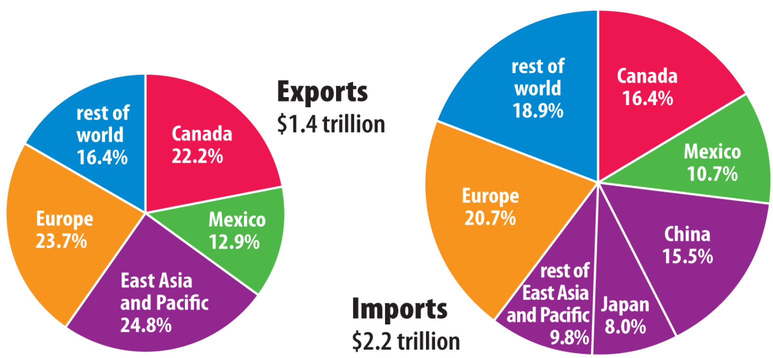


Figure 5.5: 2006 U.S. export and import countries. Source: U.S. Dept. of State Bureau of International Information Programs [2007].

### 5.3.1 Overview of trading trends and foreign partners

Over the last 50 years, the United States has shown an overall increasing trend in import and export, as can be seen in the historical trade data in figure 5.6. Since the 1960's, the United States along with most other first world countries have worked towards eliminating protectionism by encouraging free trade through policies, treaties and international organizations, as outlined in section 5.1. With the removal of trade barriers and improvement of political relationships between nations, global trade has dramatically increased. Table 5.1 gives an overview of U.S. trade with its top partners.

Canada is currently the largest U.S. goods trading nation with $600,6 billion in total goods trade during 2008, of which 56.5% were exported and 43.5% were imported goods. The total export of $261,1 billion consisted of top export categories machinery and transport (45%), manufactured goods (14%) and chemicals (11%). Another important export area are the agricultural goods (6%), Canada being the biggest U.S. export market for agricultural products such as fresh vegetables, fruit, snacks and red meat. U.S. import of Canadian goods constituted a total of $339,5 billion in 2008, with top import categories being mineral fuels (34%), machinery and

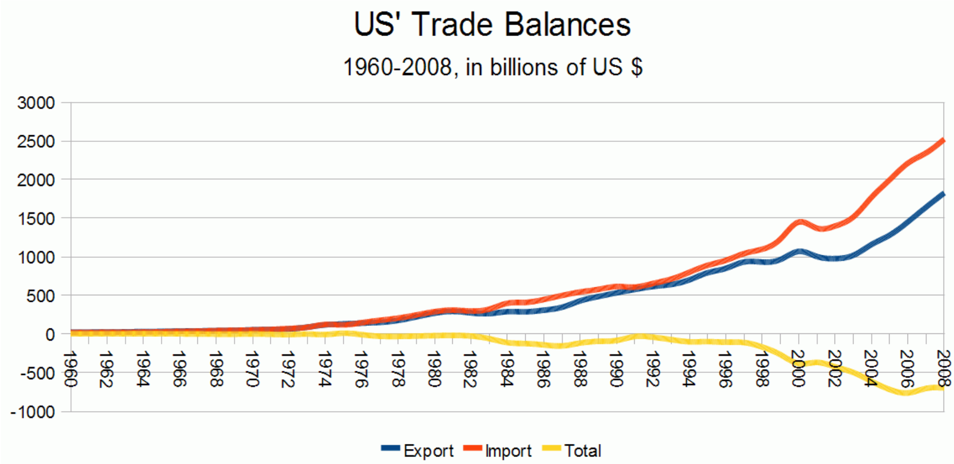


Figure 5.6: Historical data on U.S. exports and imports between 1960 and 2009. Source: U.S. Census Bureau U.S. Census Bureau [2010].

transport (25%) and chemicals (8%) Representative [2010a]. The U.S. is clearly a major oil supplier for Canada.

The European Union is currently the largest U.S. trading partner. The relationship between these two powers is considered to be the most complex trading relationship in the world due to the sheer volume of transatlantic trade and investment, with an average flow of about $2,7 billion a day and a total goods trade of $641,7 billion in 2008. Total export was $273,8 billion, with top categories being machinery (40%), chemicals (18%) and manufactured goods (7%). Import of European goods totaled $367,9 billion in top categories machinery and transport (40%), chemicals (22%) and manufactured goods (10%) Commission [2009].

China is another interesting trading partner, with a total goods trade of $406.7 billion but a remarkably low export total of $69.7 billion. Top export categories include machinery and transport (36%), chemicals (13%) and manufactured goods (7%). The U.S. import of Chinese goods is characterized by high trade values in machinery and transport (45%) and miscellaneous manufactured articles (35%) such as household and other daily products that are mass-produced in China U.S. Census Bureau [2008].

### 5.3.2 Balance of trade and the weakening of the U.S. economy

In the above trade facts and figures, one of the things to be noted is the discrepancy between the U.S. import and export values. This relationship between import and export is also known as the *balance of trade* and describes the difference between the domestic demand (buying) and the output of a nation (selling). When a nation exports more than is imported, a generally favorable balance of trade exists that is otherwise known as a *trade surplus*. Vice versa, when a nation is importing more than is exported, a *trade deficit* (or trade gap) exists. The balance of trade is a

| Rank | Trade commodity | Export | Export % | Import | Import % |
|---|---|---|---|---|---|
| 1 | European Union | 273,8 | 100 | 367,9 | 100 |
| | - Machinery and transport | | 40 | | 40 |
| | - Chemicals | | 18 | | 22 |
| | - Manufactured goods | | 7 | | 10 |
| | - Misc. manufactured art. | | 13 | | 11 |
| 2 | Canada | 261,1 | 100 | 339,5 | 100 |
| | - Machinery and transport | | 45 | | 25 |
| | - Chemicals | | 11 | | 8 |
| | - Manufactured goods | | 14 | | |
| | - Mineral fuels | | | | 34 |
| 3 | China | 69,7 | 100 | 337,0 | 100 |
| | - Machinery and transport | | 36 | | 45 |
| | - Chemicals | | 13 | | 3 |
| | - Manufactured goods | | 7 | | 13 |
| | - Misc. manufactured art. | | 7 | | 35 |

Table 5.1: U.S. export and import goods for 2008 by country and Standard International Trade Classification (SITC) categories, in billions of U.S. dollars.

delicate issue in any economy, as a trade surplus may indicate a lack of domestic demand while the existence of a trade gap has to be accounted for with external capital funding, e.g. through the purchase of government securities, resulting in an increase in debt.

In the case of the United States, trade values were more or less in balance during the 1960s and 1970s. It was not until 1982 when the U.S. economy saw a sudden increase in trade deficit, starting at 0.6% GDP and eventually growing to 5.8% GDP in 2006 as can be seen in figure 5.7A. Since the early 1980s, the increase in imports relative to GDP has outpaced the increase in exports, specifically in the area of imported consumer goods Newton [2009]. Although determining the exact cause of the trade deficit trend in this period is a complex process, research has shown a correlation with several changes in the U.S. economy due to both domestic and foreign factors:

**Fluctuation of the U.S. dollar exchange rate** As the dollar rose in the late 1990s, the U.S. demand for imports was stimulated by falling import prices while foreign demand for U.S. exports stagnated due to rising export prices. When the dollar eventually fell back down in the early 2000s, the trade nevertheless remained out of balance Bivens [2004].

**Accumulation of U.S. dollar reserves by foreign governments** Foreign exchange (Forex) reserves are foreign currency deposits held by authorities to back liabilities such as local currencies and bank reserves. The U.S. dollar is the most widely held reserve currency in the world, with China ($2.27 trillion) and Japan ($1.07 trillion) holding the two largest International [2009]. A key aspect here is that countries such as China are capable of keeping the value of their own currency relative to the dollar down (this is also known as currency appreciation), thus making Chinese exports relatively less expensive for foreign markets such as the U.S. In order to do so, China's central bank must purchase vast amounts of U.S. dollars, leading to huge Forex reserves W.M. and Labonte [2009].

**Increase in relative domestic consumption of goods** The black line in panel B of figure 5.7 shows the pattern of household consumption as a share of personal income or the average percentage of income that was spent on consumption. An upward trend can be seen that started in the early 1980's, with 87.5 percent in 1980 compared to 95.8 percent in 2006. This consumption boom is virtually identical to the increase in revolving credit (consisting primarily of household credit card debt) as indicated by the blue line in panel B Wen and Shimek [2007].

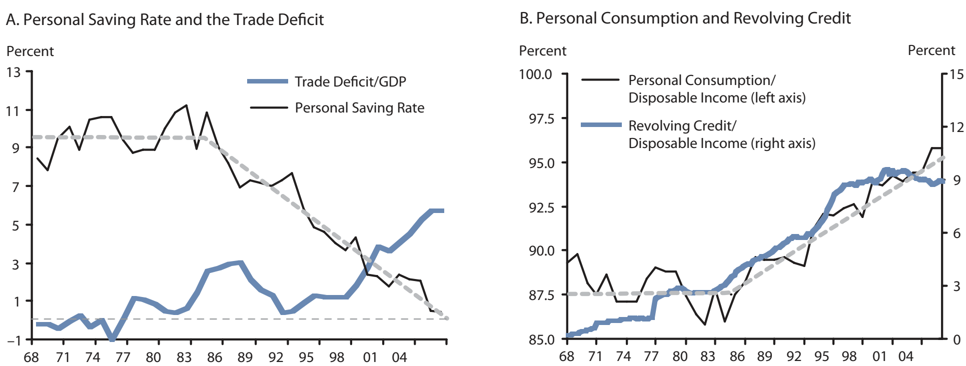


Figure 5.7: U.S. trade deficit per GDP and the correlation with personal savings between 1968 and 2007. Source: Federal Reserve Bank of St. Louis Wen and Shimek [2007].

## 5.4 Banks

### 5.4.1 Introduction

In this section we will discuss central banking, the reason it exists and the effects of central banking. At the end, we compare the central banking structure in the US with the banking structure in The Netherlands. Since The Netherlands take part in the Eurozone, NL does not have full control over it's currency. Because of that, most of the discussion in this section will compare the Eurozone/European Central Bank to the Dollar/Federal Reserve.

### 5.4.2 Central banking and reserve banking

Before the advent of the reserve banking system, banks stored Gold bullion. Storing bullion was costly, but the storage costs could be mitigated by interest on gold that the bank loaned out.

| | | | |
|---|---|---|---|
| Original deposit | = | \$ 100.0 | |
| First National lending | = | \$ 90.00 | [= .9 x \$100.00] |
| Second National lending | = | \$ 81.00 | [= .9 x \$90.00] |
| Third National lending | = | \$ 72.90 | [= .9 x \$81.00] |
| Total money supply | = | \$1000.00 | |

Table 5.2: Amount of money eventually created

Since most deposits are in the bank, and most money stays in the bank, banks can loan out part of their deposits. Since all money that's loaned out can be redeposited (and reloaned, ad inf), money is created. Table **??** shows the total amount of money loaned out when each bank keeps 10% of it's deposits as reserve. This is called fractional-reserve banking. The total amount of money in circulation is upper bounded by the geometric series $\sum_{k=1}^{\infty} ar^{k-1} = \frac{a}{1-r}$, with $a$ substituted by the begin amount, and $r$ the reserve percentage.

According to mainstream economic theory, fractional-reserve banking enables (central)banks to create money when needed, and gives government regulators strong control over the money supply and thus inflation.Mankiw [2008]

This follows from the interest paid on loans. All money that is loaned out bears interest, and a slight increase or drop in the interest rates set by the central bank, has a strong influence on how attractive loaning is.

Furthermore, reserve banking enables banks to create money when needed. Most mainstream economists argue that this mechanism enables the economy to generate the needed liquidity.

The big risk of reserve banking is also it's main benefit. Under a reserve banking system, there is more money in circulation than there is available in total. The reserve ratio has a direct influence on the number of creditors that can withdraw their deposits.

When a ĺargeámount of depositors withdraws their deposits, a bank does not have enough liquidity to pay out itś loans. This is called a bank run.

To prevent bank runs, the *central banking system* was created.

### 5.4.3 Central Banking and International Finance

Most western countries have a central bank. Most of these were created after bank failures. For example, the Federal Reserve was created after a series of bank failures in 1907. Customers need to trust banks and the failures had a massive indirect impact on the economy, because lack of consumer trust.

Central banks provide loans to banks against a certain interest rate. However, the bank needs to provide suitable collateral. This collateral provided to the central bank is likely of lower quality than collateral used when loaning money from other banks. However, the central bank always provide loans.Carney [2009]

This primary lending rate/discount rate, offers bank a last reserve action when facing a liquidity crisis.Cecchetti [2009]

**United States - The Federal Reserve**

In 1914, the US congress decided that the US needed a central bank to prevent further bank failures. The federal reserve has a Board of Governors with seven members, with the chairman being appointed by the US President in four-year terms.

The Federal Reserve System consists of the Federal Reserve Board in Washington, D.C., and 12 regional Federal Reserve Banks around the US. The Federal Reserve Board's duties fall into four categories:

- conducting the nation's monetary policy by influencing the monetary and credit conditions in the economy in pursuit of maximum employment, stable prices, and moderate long-term interest rates.
- supervising and regulating banking institutions to ensure the safety and soundness of the nation's banking and financial system and to protect the credit rights of consumers
- maintaining the stability of the financial system and containing systemic risk that may arise in financial markets
- providing financial services to depository institutions, the U.S. government, and foreign official institutions, including playing a major role in operating the nation's payments system

Board [2009]

The federal reserve is the only entity in the US allowed to introduce US paper currency into circulation.

You should note that the FED is not owned by the US government, nor by private parties. The FED also does not pay interest on invested capital, but however, pays a 6% dividend over those investments. More details on what the FED is, and is not can be found in Board [2007].

### 5.4.4 The Netherlands - De Nederlandsche Bank/European System of Central Banks

In 1998 The Netherlands decided to join the Economic and Monetary Union, starting on 2009-01-01. The biggest impact of this was that The Netherlands would join the Euro zone and that most of the functions of De Nederlandse Bank merged into the European System of Central Banks.

On the first of Januari, 1999 11 countries joined the Eurozone. Greece joined in 2001. Exchanges rates between those countries their currency and the Euro were fixed. The Euro was introduced as legal tender on the first of Januari, 2002.

Upon joining the Euro zone the twelve countries currently in the Eurozone gave up partial control of their state finances. Most important of these is that since 1999, the European Central Bank controls the interest rates.

The objectives of the European Central Bank are:

- "The primary objective of the ESCB shall be to maintain price stability"

- "without prejudice to the objective of price stability, the ESCB shall support the general economic policies in the Community with a view to contributing to the achievement of the objectives of the Community as laid down in Article 2 (high level of employment and sustainable- and non-inflationary growth)." (Treaty article 105.1)

Further more, the ECB performs the following Basic tasks:

- the definition and implementation of monetary policy for the euro area;
- the conduct of foreign exchange operations;
- the holding and management of the official foreign reserves of the euro area countries (portfolio management).
- the promotion of the smooth operation of payment systems.

Bank [2010a]

The ECB tries to reach a 2% inflation target, and imposes rules on the economies of itś member countries, to prevent inflation in member states.

Some say that the crisis in Greece is due to sloppy adherence to ECB rules. Others argue that Greece should never have joined a monetary union with states with different types of economies.Boone and Johnson [2010]

In contrast to the FED, the ECB pays interest on deposits. Because of this interest, the reserves of the ECB are much higher then that of the FED.Cecchetti [2009])

### 5.4.5 Reserve banking and Bank-to-Bank loans

As discussed earlier, only a part of deposited money is kept in reserve. The resulting multiplication is controlled by the interest ratio set by the central banks.

In a reserve banking system, the money that comes from the central bank is sometimes called *high powered money*. This is the initial source of money, which is then multiplied through loans.

Most of the assets of a bank are non-liquid. Data from Hahn [2009] shows that some major European banks have a leverage ratio of around %3.

The interest value on loans differs with the risk for each loan. In trade, the insurance costs for loans vary according to the type of loan.

When using loaned out money, or loan based products as collateral, the risk of the investment has a big impact. The rating of a loan should directly reflect it's risk. Historically, only a very small percentage of loans defaulted. This meant that even though some loans defaulted, the risk was mitigated by the effect of large numbers.

With the advancement of complex products, like Cash Collatorized Debt Obligations, rating agencyś becme more important. The value of a derived is much harder to calculate. The market for rating agencyś is split up between three big parties. During the credit crunch, it became obvious that a lot of products had been too highly rated.

There are perverse rewards for rating agencies. Their income is dependent on the amount of products rated and some products are very complex.

During the 00's there was a trend towards higher ratings. Furthermore, products that were rated by multiple agencyś had a higher chance at the higher ratings.Barnett-Hart [2009]

When the banks realised a lot of products had been rated too high, they could not know the real value of their asseets. The FED and ESCB provided a lot of short term loans to keep the markets liquid on the long term.Cecchetti [2009]

Large government injections prevented a collapse of the monetary system. Still, the current system with a loose money supply and focus on bank profit is under discussion. Under the current system, government intervention/t́oo big to failḿake risky behaviour a positive-sum game for banks.

Both Europe and the US are looking at reforms that move the risks towards the bank.

At the moment, the proposed measures by the International Monetary Fund is that the financial services industry would be subject to a Financial activities Tax, to pay for the large costs of the financial meltdown. However, the proposed taxes, that splits the tax between banks and bankers, would take more then ten years to pay for the current crisis.

Afterwards, the fund would be used to prevent upcoming crisises.IMF [2010]

### 5.4.6 Control & Stability

The evolution of the banking system has led to a more stable financial system. Even though the credit crunch had a big effect, it did not lead to a longterm recession.

Previous banking- and exchange rate systems were not able to do this.Ball et al. [2010]

The control over money creation, via the central banks is very powerful, both in periods with strong economic growth and when close to a recession. However, the low interest rate targets in good times give the central banks little flexibility to intervene in crisis situations.

The other option, a higher inflation target would worsen the budget deficits and trade position of the US and Europe. This is not an option either.

More openness by the banks and stronger capital requirements should decrease the likelyhood of a credit crisis.

### 5.4.7 Impact of the choices

#### European Central Bank

The European System of Central Banks has as itś main disadvantage that the member state are not as heterogenous as wishes. It will be tested during the Greek recovery.

The ESCB has less control then the FED.

#### Federal Reserve

The FED has control over a bigger part of the world economy then the ESCB. The US economy is more heterogenous then European.

Furthermore, the US has, and probably is able to keep a large long-term budget deficit as long as the Dollar is being used a lot in international trade.

### 5.4.8 Comparison

We think that the FED has more possibilities for control then the ESCB. However, the FED is slower with the adoption of supervision, and government intervention is less likely in the US.

In our opinion, neither structure has a big advantage over the other. The interlocking influences of the European and US economy means that neither can perform well when the other is in a crisis.

## 5.5 International Finance

An important factor, if not the most important factor when discussing economics is money and how that money is exchanged. This chapter discusses the financial position of the United States on the international market. That means that all aspects pertaining to cash and how it flows in and from the U.S.A. are presented. When talking about cash flows, the following (non-exhaustive) list of factors is important:

- Cash in & out flows (the balance of payments), describing where cash comes from and goes to
- Foreign investments & Foreign investors, treating what countries invest the most in U.S. companies, but also which countries are most popular as an investment for the U.S.
- National debt, focusing on how much money the U.S. owes, and how that debt is built up.
- The dollar, because when talking about cash the vehicle (currency) can‘t be omitted. For this paragraph the focus is on the dollars steady devaluation compared to the euro, and what underlies this phenomenon.

Of course, at the moment of writing, no financial analysis of the United States would be complete without some mention of the financial crisis. Most of this crisis causes and effects might be in the banking sector and financial governance, but it is still a financial crisis. For this part, the focus is on how the crisis affects the U.S. international financial position.

### 5.5.1 Cash flows: The U.S.A. Balance of Payments

The first aspect of the United States financial position is the cash that flows in and out of the country. The sum of cash inflows and outflows is called the balance of payments. In essence, the balance of payments is a nations checkbook, showing the incoming and outgoing transaction. The Balance of Payments is part of a broader framework of tools for statistical analysis of a nation's economy, another part being the International Investment Position. The two elements together give an indication of how the nation is performing economically.

More formally, the International Monetary Funds (IMF) Balance of Payments Manual [Fund, 2010a] provides the following definition:

*The balance of payments is a statistical statement that summarizes transactions between residents and nonresidents during a period. It consists of the goods and services account, the primary income account, the secondary income account, the capital account, and the financial account.*

This statement can be broken down into smaller parts, providing more clarity on what the Balance of Payments (or BOP) actually is:

- *...a statistical statement...*
  This means the BOP is not the sum of all transactions between the U.S. and other countries, but rather a representation of those transactions.

- *...between residents and nonresidents...*
  As mentioned before, the BOP shows how monetary value flows in and out of the country, where residents can be anything from individuals to multinational companies.

- *...during a period...*
  The Balance of Payments as a tool is used to describe the nations cash flows, given information on the state of the economy. Of course, such a description is like a snapshot.

**Balance of Payments accounts**

The BOP shows five separate accounts, or groups of cash flows. As the name suggest, these accounts balance each other out, or at least that is what they should do. In that sense, the Balance of Payments is comparable to a standard balanced as used in accounting, showing assets and equity on one side and liabilities on the other. Were the BOP differs from a balance as used in companies, is to start with the scale. The figures in the BOP are usually in the billions and trillions of dollars. Another major difference is that it does not show equity, as a nation has no such thing. This is because equity is defined as everything that is left after all liabilities have been paid. Liabilities are all the claims non-residents have on residents assets. Obviously, there could never be a case where all liabilities are paid, but furthermore, what is left would not represent the nations equity, but a sum of the equity held by residents. For a resident, his or hers equity may be of interest, as it provides information on their solvability (in other words, their risk of going bankrupt), for a nation solvability is no issue, as it can by definition not go bankrupt. Another statistic that is of importance to the cash flowing in and out of the country, the International Investment Position, does show information on national equity, in the form of gold bullion. This is disccused in the next section, Investments. Also, the chapter on the financial crisis will delve deeper into the subject of a nation going bankrupt.

The accounts on the Balance of Payments are defined by the IMF as follows:

| | |
|---|---|
| The Goods and Services account (part of current account) | This account shows the transactions that have been made in the form of goods (products) or services over the period. |
| The Primary Income account (part of current account) | Primary income consists of the transactions made in return for the use of goods (which is a service), lending financial assets (money) or so-called non-financial non-produced assets (for instance renting land, fishing or forestry rights) |
| The Secondary Income account (part of current account) | Secondary income consists of services of goods for which no economic value is returned, for example international aid |
| The Capital Account | This consists of non-produced non-financial assets sold, such as land for embassies, as well as exchanges of capital without direct economic value returned (for instance insurance payouts or inheritances) |
| The Financial Account | This shows the net total of traded financial assets and liabilities and shows how much the nation is borrowing from or lending to other economies |

**The United States Balance of Payments**

With all elements of the BOP now clear, it is time to look at the Balance of Payments of the United States of America, and what it tells. The balance was obtained from the United States Bureau of Economic Analysis, or BEA [Department of Commerce and international, 2010]. It can be seen in table 5.3.

The table shows a number of interesting facts. What immediately becomes clear is the impact the financial crisis has had: the export and import of goods have gone down. This indicates economical downturn. Furthermore, capital is flowing out of the country: the capital account shows a $ 2 billion flow to non-residents. Also, the assets owned in foreign countries have gone down. In other words, Americans have invested less for the second year in a row. Finally, foreigners appear to be less interested in investing in the United States and U.S. currency.

**Impact on Games & Simulations**

The Balance of Payments shows, as mentioned above, that the U.S. economy was on a low “heat” in 2008 and 2009. This is not a climate where innovations such as augmented reality, new HR solutions such as Serious Gaming et cetera thrive. However, the BOP shows only macro-economical statistics, that is, all U.S. industries' figures are combined into a single figure. It is therefore still very much possible that innovative business and business innovation is still being done in some sectors. Considering Serious Gaming is for instance not directly applicable to the mass production environment of the automobile industry, one of the largest victims of the financial crisis, there is still more to be investigated as to the impact of the financial climate on gaming & simulations. The following section looks at how much is being

| *Credits and debits* | 2008 | 2009 |
|---|---|---|
| *Current account* | | |
| Export of goods and services and income receipts | 2,591,233 | 2,115,929 |
| Import of goods and services and income payments | -3,168,938 | -2,405,555 |
| Unilateral current transfers, net | -128,363 | -130,243 |
| *Capital account* | | |
| Capital account transations, net | 953 | -2,859 |
| *Financial account* | | |
| U.S owned assets abroad, excluding financial derivatives (increase/financial outflow (-)) | -106 | -237,454 |
| Foreign-owned assets in the United States, excluding financial derivatives (increase/financial inflow (+)) | 534,071 | 435,236 |

Table 5.3: The United States Balance of Payments, in millions of dollars

invested in the U.S. by non-residents. This will provide more information on the financial climate.

### 5.5.2 Investments

An important indicator as to how a nation's economy is performing is the extent to which foreigners are willing and able to invest in companies in that nation. It is a sign of confidence if a non-resident is willing to invest. Also, the amount residents of a nation invest in companies in other nations gives information on the financial power of a nation's residents. The IMF uses a statistic called the International Investment Position (or IIP) [Fund, 2010a] to assess the two points mentioned. The IIP is defined as:

*a statistical statement that shows at a point in time the value of: financial assets of residents of an economy that are claims on nonresidents or are gold bullion held as reserve assets; and the liabilities of residents of an economy to nonresidents.*

This statement is build up from the following three interesting elements, excluding those already explained in the discussion of the balance of payments above:

- *...financial assets of residents...that are claims on nonresidents...*This means investments from U.S. citizens in non-U.S. companies.
- *...gold bullion held as reserve assets...* This is what can be considered the nation's savings, actual gold held in safes. It could be considered, as mentioned in the discussion of the BOP as equity.
- *...liabilities of residents...to nonresidents* This means investments from non-U.S. residents in U.S companies.

| *Type of investment* | *Position 2007* | *Change* | *Position 2008* |
|---|---|---|---|
| U.S.-owned assets abroad | 18,278,842 | 1,609,316 | 19,888,158 |
| Foreign-owned assets in the United States | 20,418,758 | 2,938,646 | 23,357,404 |
| Net international investment position of the United States | -2,139,916 | -1,329,330 | -3,469,246 |

Table 5.4: The United States International Investment Position 2007 vs. 2008, in millions of dollars

Combined the difference between what people invest in the U.S and what is invested in the U.S. describes the U.S. investment position. It is either a claim on the rest of the world, or a liability. The first is a situation where more people invest in the U.S than the other way round, the latter is the opposite. Table 5.4 shows the United States' Investment Position for 2008, which was obtained from the United States Bureau of Economic Analysis [Department of Commerce, 2010].

Sadly, these provide little information on the effect of the financial crisis on the investment position, as no figures are available for 2009. As the crisis already started in 2008, at least something can be said on the effect of the crisis on investments. Remarkably, the difference between what U.S. residents invest and what is invested by non-U.S. residents has never been greater than it was in 2008. This indicates that investments in the U.S. have never been more popular. This at least gives some indication that the investment and therefore innovation climate in the U.S. is not suffering too much from the crisis.

A different statistic interesting for the comparison is where the foreign investments come from, in other words, which countries' residents are the largest investors in the U.S.? Another related question, that is even more interesting, is why people invest in the United States. The question is interesting, because the IIP shows more people invest in the U.S. than vice versa.Table 5.5 shows the major foreign holdings of U.S. securities, a type of investment, obtained from the U.S Treasury [of the Treasury Federal Reserve Bank of New York, 2009].

The table offers few surprises. Japan is the second largest economy, it is therefore no surprise that they are a major investor in U.S. securities. A similar statement applies to China. More surprising is the presence of Luxembourg, since it's the 90th largest country by Gross Domestic Product, according to the IMF's World Economic Outlook [Fund, 2010b]. The explanation is that Luxembourg is a financial center, just as the Cayman Islands and Switzerland, and options held by a bank from a certain country are considered to be held by residents from that nation. With the question now answered (to some extent, the above only discusses *securities* issued by the U.S. ) *who* invests in the U.S., the focus shifts to *why* people invest. Hopefully, the answer will shed light on the changes new developments like gaming and simulation have for attracting investors.

| *Country* | *Total investment in U.S securities* |
|---|---|
| Japan | 1,250 |
| China, mainland | 1,205 |
| United Kingdom | 864 |
| Cayman Islands | 832 |
| Luxembourg | 656 |
| Belgium | 456 |
| Canada | 441 |
| Ireland | 400 |
| Middle East oil exporters | 391 |
| Switzerland | 314 |
| Netherlands | 312 |

Table 5.5: Major foreign investors in U.S. securities, in billions of dollars

**Why non-U.S. residents invest in the States**

According to research by Kristin Forbes [Forbes, 2009], a major reason for investing in the U.S. are the scale, liquidity and efficiency of the U.S. financial market. This mainly holds for countries that don't have such markets themselves, mostly less developed countries. She does suggest that the U.S. worthiness of investment based on what revenue can be made is lower than for investments in other countries. However, the conclusion is that as long as the U.S. provides a stable, large, liquid and efficient financial market, the climate for investment will remain. This also means that new developments have a chance, as long as they are properly presented on those markets. The question is, how long will those financial markets remain prosperous, as the United States' national debt is towering above the market ominously. The next section discusses how much life is left in the U.S. economy, as seen from a national debt point of view.

### 5.5.3 The U.S. National Debt

This section will discuss how the U.S. accrued their debt, and how it affects the economy as a whole. At the moment of writing the debt is $ 12,660,168,000,000. That means more than 12 thousand billion dollars, or $ 40,000 per citizen, and rising. In the few minutes it took to look up the National Debt Clock [USDebtClock.org, 2010] and type the two sentences above it has risen by 10 million dollars. Of course, the U.S. economy is considered the largest in the world, making it less of a problem to have a large debt. Table 5.6 shows a comparison of total national debt (obtained from [Group, 2010]) divided by Gross Domestic Product (obtained from [Fund, 2010b]) for some of the largest economies: Japan, the U.K. and U.S..

The figures in the table can be considered quite shocking, as they mean for instance the entire U.S. economy, when geared towards resolving national debt, would need almost a year to pay it off. For the U.K. this is even worse, but the figures may be misleading, as every country uses their own measurement of debt. The figures for the U.S. however have been obtained from both the U.S. Treasury

| *Country* | *# largest economy by GDP* | *GDP, in billions of $* | *External national debt, in billions of $* |
|---|---|---|---|
| U.S.A | 1 | 14,441 | 12,660 |
| Japan | 2 | 4,910 | 2,330 |
| U.K. | 5 | 2,680 | 9,106 |

Table 5.6: Comparison of major economies by GDP and national debt

and the World Bank, and were found to be equal. The confusing differences in national debt calculation come from a categorization of different types of debt:

**Public debt** The total amount of securities and bonds isssued by a nation's government. It is a sum of the debt of the public and the debt held by government accounts.

**Debt held by the public** The total amount of securities and bonds issued minus those held by government accounts

**Debt held by government accounts** Public debt securities plus securities issued by governmental departments.

These categories are not only poorly distinguishable due to the similar names, but the division of debt into different types is not untrivial. What however is clear, is that the majority of debt is held by government, and only a small portion by the public. The latter is considered in some reports as the national debt, in others the total national debt (that is, including governmental debt) is used.

### 5.5.4 Why is the national debt this high?

As could be seen in the table above (table 5.6), the U.S. debt is not only high in comparison to the nation's Gross Domestic Product, it is also in absolute figures the highest in the world. And it keeps getting higher. The question than is, where does all this debt come from? This section tries to provide an answer, by looking at major historic events and their impact on national debt. Of course, politics also come into view at this point. The section concludes with some estimates of where the debt figure is going, and what impact that could have on the U.S. economy.

#### National debt over time

Over the last few years, the national debt is seemingly rising without control, partially caused by the financial crisis and all measures associated. But figures are only meaningful when put into context. Here, that context would be:

**a.)** the total state of the economy, found through the Gross Domestic Product.

**b.)** major historical events such as wars,

**c.)** government policies (such as the famous New Deal),

**d.)** economic events, such as stock market crashes.

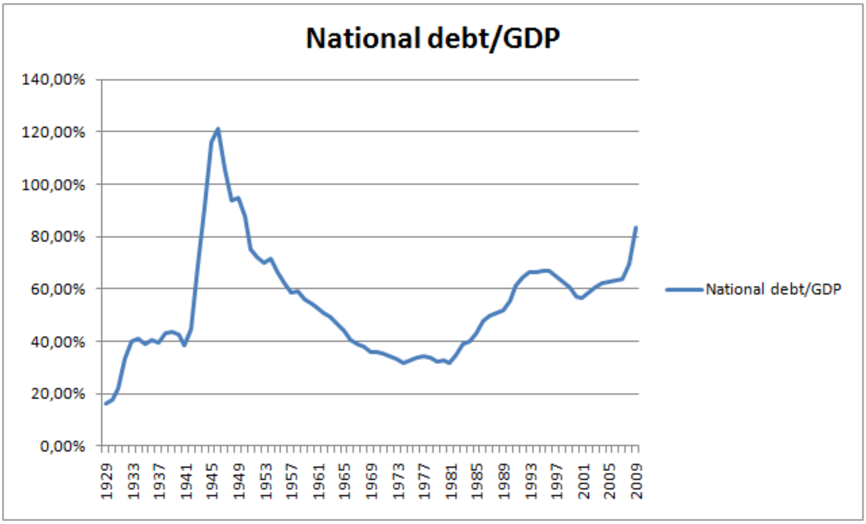


Figure 5.8: National debt divided by GDP, 1929-2009

To start with the first, figure 5.8 shows the ratio between the gross domestic product and national debt from 1929 onwards. Figure 5.9 shows a comparison of the Gross Domestic Product and national debt from 1910 onwards.

Interestingly, the comparison between GDP and national debt (fig. 5.9) shows that both have risen steeply but steadily since roughly the mid-1970s. The ratio between the two does however show large fluctuations. Roughly, the debt as percentage of GDP has been rising since the early 1980s, with a period of decline between 1997 and 2001. This decline is the result of the GDP steadily rising on, whilst the debt stabilized over a couple of years, most likely a result of the economic prosperity of that time (the internet bubble). Below, some interesting changes in both charts associated to major historical events or periods are discussed in more detail.

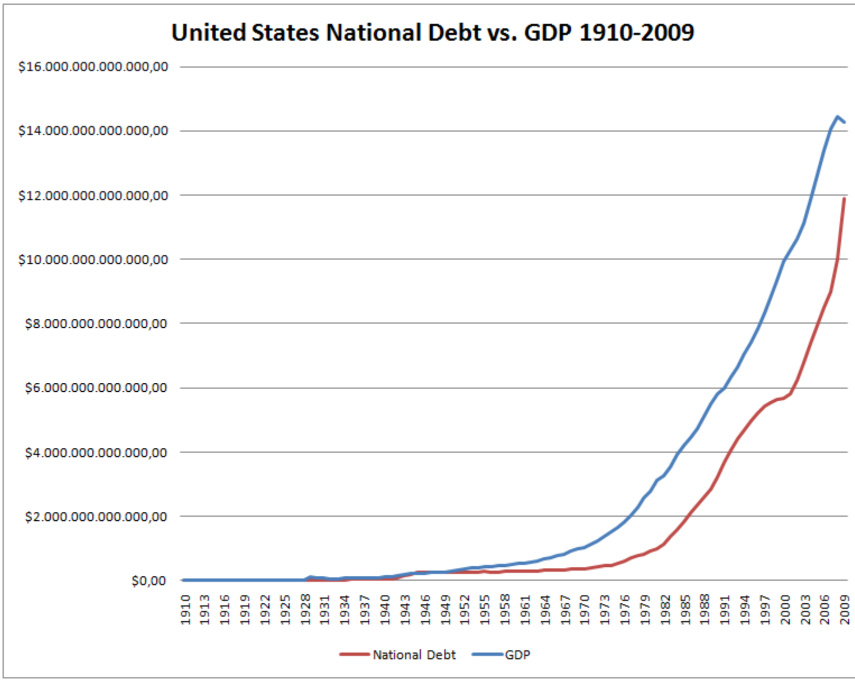


Figure 5.9: National debt compared to GDP, 1910-2009

**1929-40** *Great Depression*
On first hand, one would expect the economic downturn of the Great Depression to lead to higher national debt. The figures do not, however, show an increase, the exact opposite is the case. The debt remained the same over the entire period ('29-~40), even decreased from 1929 to 1933. As the Great Depression is the largest recession in modern times, by definition the Gross Domestic Product did decrease.

**1940-45** *World War II*
In order to finance their participation, including the building of military material, training of soldier and so on, the United States needed to issue war bonds, a type of security. Between 1940 and 1945 the total national debt skyrocketed to over 260 billion dollars, an increase of 500 percent. The gross domestic product increased just 120 percent over the same period, leading to the only period in recent history where the national debt exceeded the GDP.

**1945-60** *After the war*
The period after World War II is marked by a substantial decrease in the ratio between national debt and GDP. It did however take until halfway past the 1960s for the ratio to reach its pre-war value. As can be seen from figure **??**, the economic growth of the post-war era is the cause for the decrease in national debt to GDP ratio. The debt caught up with the increase in GDP in the early 80s, a period of economical difficulties.

| | | |
|---|---|---|
| **1997-2001** | *Internet bubble*<br>The period from 1997 to 2001 is marked by the so-called dotcom or internet bubble, a period of economic prosperity. During this period, the debt stabilized, but the GDP kept on rising. |
| **2008-present** | *Financial Crisis*<br><br>The most recent financial crisis shows a significant increase in national debt, but more remarkably perhaps in light of earlier years, an actual decrease in GDP. The rise in national debt is explained by the bank bailouts the U.S. government needed to finance. |

**Where will the increasing debt lead?**

At the start of the discussion of the international financial aspects of the United States the statement was made that a nation cannot go bankrupt. This is true, at least in the common interpretation of bankrupcy: the liabilities outweighing the assets, or being unable to pay of creditors. A country can always create more value by issueing securities or printing more currency, resulting in their technically not going bankrupt. There is of course a point where the financial power of a nation is too low to attract investors on one end to buy the securities issued, another risk is hyperinflation. Such developments could lead to the de facto bankrupcy of a nation, bringing it's financial system to it's knees. In his paper for the Federal Reserve Bank of St. Louis [Kotlikoff, 2006], Kotlikoff suggests the term *broke* for such a situation. The paper puts questions on the U.S. economy's future. The author provides the following arguments in favor and against the idea that the United States are going "broke".

| *Arguments in favor* | *Arguments against* |
|---|---|
| The national debt is massive | Ratio of national debt to GDP is better than for most developed countries, such as Japan. |
| Taxes are too low to support the economy | Interest rates are historically low. |
| | The dollar is the world's reserve currency. |
| Countries could sell their U.S. securities in an instant | Countries such as China and Japan have a large demand for U.S. securities. |

The author concludes that due mainly to the large group of baby boomers, who will soon be eligible to retirement, the financial gap of the United States will only increase. He states:

*Countries can and do go bankrupt. The United States, with its $65.9 trillion fiscal gap, seems clearly headed down that path.*

With this statement, it needs to be considered that it was made in 2006, two years before the start of the financial crisis we're facing today. The fiscal gap has only broadened, plus new legislation concerning healthcare threatens the gap becoming even greater. At the moment, their is still no real problem, as long as the Chinese, Japanese and others keep buying U.S. securities. The question is, for how long.

### 5.5.5 The United States Dollar

The final element for consideration when talking about the U.S. economy is the best-known currency in the world, the dollar. A national economy's backbone is it's currency, this section will discuss the dollar's current and future worth and how inflation has influenced it. Also, factors influencing the value of the American currency are discussed. Figure 5.10 shows the dollar's worth compared to the euro, from 1999 onwards. The data was obtained from the European Central Bank [Bank, 2010b].

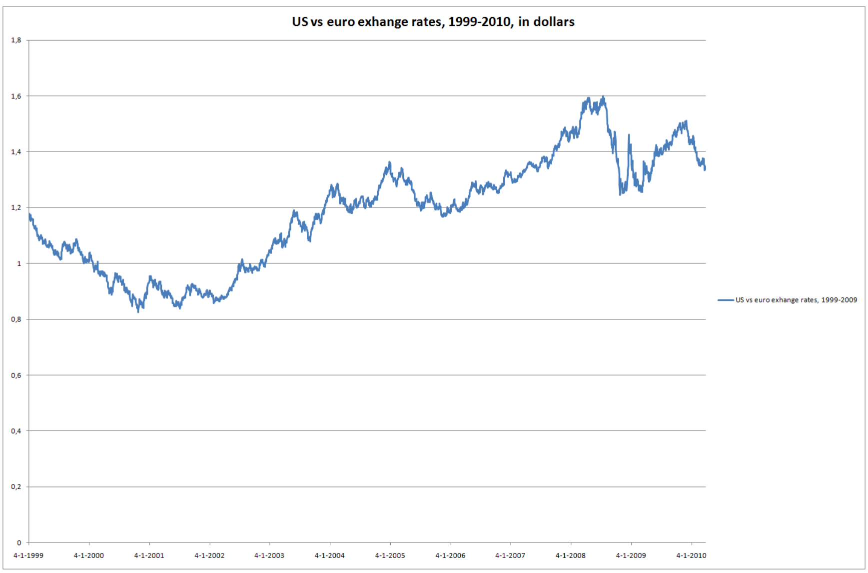


Figure 5.10: The U.S. dollar to euro exchange rate, 1999 to 2010

What the figure shows is an initial drop in value from the (then fictuous) euro. On January 1st, 1999, the euro was set at $1.18. The value of the euro only started to rise, or appreciate after the euro coins and bills were introduced on January 1st, 2002. It took until 2004 for the euro to exceed its initial set dollar worth, but it has since then not fallen below the $1.18 mark. The result of the financial crisis can clearly be seen in this graph, showing a volatile period of depreciation, appreciation and then depreciation once again, all in the period of a few months. These fluctuations seem linked to the U.S. dollar deflating over 2009, as can be seen in figure 5.11, which shows the inflation percentage of the dollar from 1980 to 2009. These statistics obtained from the IMF World Economic Outlook [Fund, 2010b]. In 2009, the dollar showed a sharp deflation, where inflation had fluctuated between the 2 and 4 percent mark practically from the 1990s onward. This deflation seems to have attracted buyers for U.S. dollars, unsurprisingly because a more valuable dollar by definition brings revenue to the owner upon sale. The euro also showed lower inflation, but no deflation, as can be seen in figure 5.12.

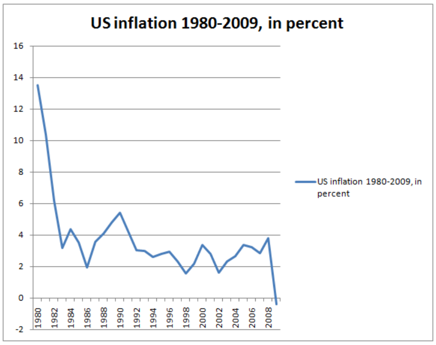


Figure 5.11: The U.S. inflation rate, 1980 to 2009

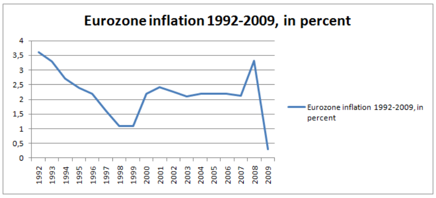


Figure 5.12: The euro inflation rate, 1992 to 2009

### 5.5.6 Consumer purchasing power

The previous sections on international finance have focused on the investment side of the U.S. economy. This plays a major role in new developments such as games. An other side to consider is the consumer, and whether or not they have the power to buy, or *consume* new games. This subsection discusses the Big Mac Index and Purchasing Power Parity (PPP) to evaluate the U.S. consumer purchasing power.

#### The Big Mac™ Index & Purchasing Power Parity

A theory of consumer purchasing power is the purchasing power parity, which basically states that price levels in any two countries should be identical after converting prices into a common currency. One way of measuring whether or not PPP exists, is buy comparing the price of a group of goods, a so-called basket in different countries. A popular tongue-in-cheek indicator of PPP is comparing the price of a McDonalds's Big Mac™[Pakko and Pollard, 2003]. The method does have some scientific value, as the sandwich has similar ingredients everywhere it's served. Below (table 5.7) is a comparison of Big Mac™prices, converted to U.S. dollar for different countries.

What this shows is that the U.S. sandwich is somewhat undervalued, compared to the European Economies. It is however overvalued compared to Japan and China, suggesting that the U.S. purchasing power is lower than the euro and pound purchasing power, but still higher than the majority of other countries. The purchasing power of consumers will therefore not likely be a restriction on the amount of games that will be bought by U.S. consumers.

| *Country* | *Big Mac™price, U.S. $* |
|---|---|
| Argentina | 1.42 |
| Australia | 1.86 |
| Britain | 3.14 |
| China | 1.20 |
| Japan | 2.18 |
| Netherlands (=euro area) | 2.98 |
| United States | 2.71 |

Table 5.7: The Big Mac Index of Purchasing Power Parity, 2003 figures

## 5.6 Market Sectors

The United States is often described as a *capitalist* economy, a term that was introduced by Karl Marx to describe a situation in which a small group of people that control large amounts of capital make the most important decisions, focussing om making as much profit as possible. The counter-part of a capitalist economy can be seen as a more *socialist* economy in which it is more likely that a country's gouvernment has more control, aiming at a more equal distribution of resources, for instance.

Nowadays however, people argue that a capitalist or socialist economy is not as relevant as it used to be. Governments in the United States, and also in other countries, have tried to find a best-practice economy in which the government plays an important role along with private enterprises [of State, 2001].

### 5.6.1 The basic concepts of the U.S. economy

According to a document that was published by the U.S. Department of State in 2001, two basic concepts of the United States economy can be distinguished. In this section we will discuss the two basic concepts that are of importance for the U.S. economy.

The first part of the economy are the natural resources. The United States has a very rich collection of mineral resources and fertile farm soil and its climate is moderate, making it suitable for many different applications. A country's economy begins with its natural resources. You need natural resources before you can produce goods to sell.

Another important concept of the economy is its labor. This part of the economy provides the transformation process from natural resources into goods. The number of workers and their productivity is of utmost importance for a country's economy.

### 5.6.2 North American Industry Classification System

The North American Industry Classification System, abbreviated NAICS, was adopted in 1997 to replace the Standard Industrial Classification system that was used then. The standard is used by U.S. Federal statistical agencies for classifying business establishments. The classifications are used for the purpose of collecting, analyzing and publishing statistical data related to the U.S. economy [Bureau, 2008]. The current classifications were adopted in 2007 and define 20 main economic sectors. In the statistics of this chapter the NAICS classifications are used.

### 5.6.3 Three-sector hypothesis in the United States

In modern economies one can distinguish three distinct economic sectors [Newman, 2009]. In this section we will refer to them as the primary, secondary and tertiary sector but they are also known to be the agriculture, industry and service industries, respectively.

**Primary sector** Extraction and production of raw and natural materials

**Secondary sector** Transforming raw or intermediate materials into goods

**Tertiary sector** Involves the delivery of consumer and business services

#### Primary sector

Every industry that involves the processing of natural resources into primary products belongs to the primary sector of an economy. Everything we create and do eventually has its roots in natural resources. Without them, we would not know what to do. Industries that belong to this sector include but are not limited to fishing, mining and farming.

In the United States the primary sector is far from the largest sector; in fact, it is a very small sector. Its GDP only counts for 1.2% of the nations GDP, which is slightly less than the Netherlands where 1.9% of the nation its GDP is produced by the primary sector [Agency, 2009].

#### Secondary sector

The secondary sector of an economy includes industries that processes products produced by the primary sector into products that are usuable. Whereas products from the primary sector can be seen as building blocks, the secondary sector uses these blocks to create products that can be used. Industries in this sector include but not limited to the production of cars, textiles or shoes, or construction work.

In the United States the secondary sector is a medium sector. The secondary sector in the U.S. produces 21.9% of the total GDP, which is just like the primary sector slightly less than in the Netherlands, in which 24.4% of the total GDP is produced by the secondary sector.

#### Tertiary sector

As the final sector, the tertiary sector is recognized by delivering services rather than physical products. The tertiary sector is also needed to sell products that have been produced by the primary and secondary sectors. Industries that belong to the tertiary sector are for example software services, banking, cinemas or taxis.

The tertiary sector is by far the largest sector in the United States. 76.9% of U.S. GDP comes from the tertiary sector, which is a bit more than the Netherlands; there the tertiary sector is responsible for 73.7% of the nation's GDP.

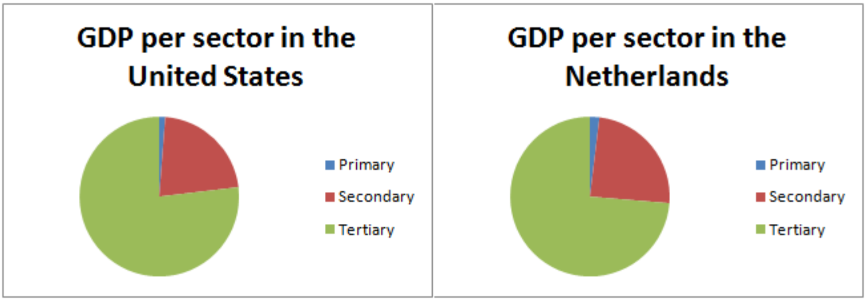


Figure 5.13: GDP distribution per sector in the United States and the Netherlands [Agency, 2009]

#### U.S. economic sectors compared to the Netherlands

In figure 5.13 the GDP's of the United States and the Netherlands are shown, distributed over the three economic sectors. The GDP of the United States comes a bit more from the tertiary sector compared to the Netherlands, whereas in the Netherlands the secondary sector is a little bigger compared to the United States.

### 5.6.4 Market sectors in the United States

The United States Census Bureau provides a detailed statistical analysis of the U.S. economy based on the latest NAICS classifications. The Bureau conducts the economic census every five years. The most recent census is measured over business year 2007 and was first released in the first quarter of 2008. However, it takes three years before the U.S. Census Bureau has published all statistics.

In figure 5.14 market sectors of the U.S. are displayed, ranked by the number of sales, shipments, receipts, revenues or business they have done. The wholesale trade sector is the most successful sector when it comes to making money. It is however not the sector with the most establishments or paid employees. The wholesale trade sector is the 8$^{th}$ sector with 432,094 establishments. And with almost 6.3 million paid employees the wholesale trade sector is number 9 on the list of total paid employees. Figure 5.15 shows that sector is also not the most profitable one for its employees. It is ranked 5$^{th}$ on the list of best paid sectors, with an average payroll of $ 53,400. [Bureau, 2007]

#### Computer system design and related

The sector *professional, scientific, and technical services* consists of establishments that require a high degree of expertise and training. The subsector *computer systems design and related services* consists of establishments that are related not only to computer software design and development, but also publishing. This specific subsector is more applicable to us than others, since our industries and research have are also in relation with computer related companies that are probably classified in this sector.

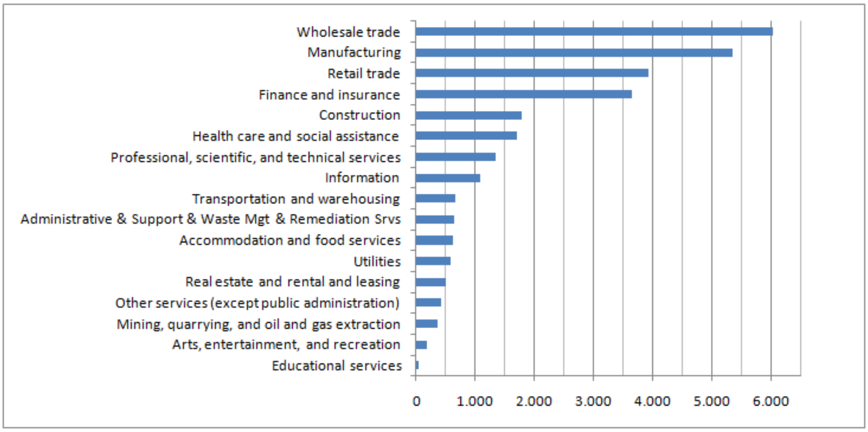


Figure 5.14: Sales, revenues, business done by market sectors in the U.S., billions of dollars (2007)

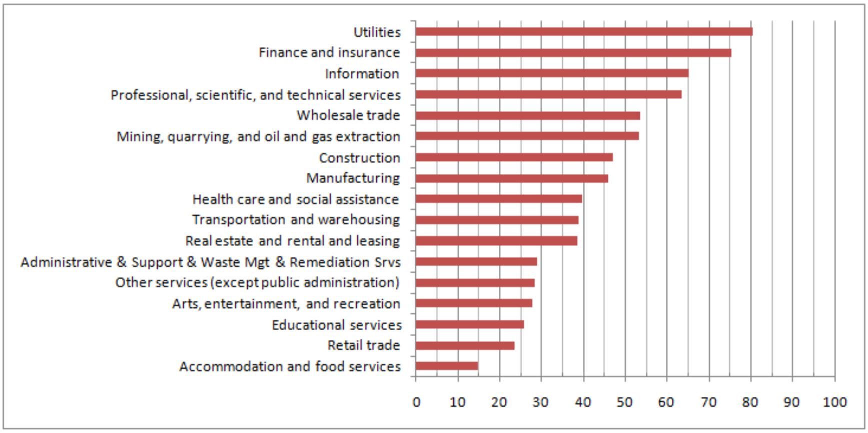


Figure 5.15: Average payroll per paid employee in U.S. market sectors, thousands of dollars (2007)

| | amount | compared to sector | compared to total |
|---|---|---|---|
| Establishments | 117,909 | 13.96 % | 1.63 % |
| Paid employees | 1,339,508 | 16.58 % | 1.18 % |
| Receipts/revenue | $ 273.5 billion | 20.33 % | 0.95 % |
| Total annual payroll | $ 102.2 billion | 19.97 % | 2.25 % |
| Average annual employee payroll | $ 76,338 | 120.6 % | 173 % |

Table 5.8: Statistics and comparison of the *computer systems design and related services* sector

In table 5.8 exact numbers of the *computer systems design and related services* subsector are presented. While the subsector provides almost 14% of the main sector its establishments, it is responsible for more than 20% of its revenue meaning that establishments in this subsector produce more revenue than establishments in its sibling subsectors. It is also interesting to see that this specific subsector pays better than the other subsectors. The average annual payroll in the susector is a little over $ 76 thousand dollars (approximately 56,800 euro on April 6, 2010), which is 1.2 times the average payroll of the sector and a little more than 1.7 times the average over all sectors.

## 5.7 Labor and (Un)employment

This section focuses on labor and (un)employment in the United States. Amongst other things the next items will be discussed in this section:

- Historical figures for labor, describing how unemployment has risen and fallen over the years, combined with associated economic and historic events.
- Major employment sectors, showing where most are employed.
- (Minimum) Wages, showing average pay per sector
- IT employment, showing the total size of the IT workforce in the U.S.

### 5.7.1 (Un)employment over the years

Figure 5.16 shows the unemployment rates in the United States, from 1947-2009. The graph shows a fluctuation around the 8 percent unemployment mark, never exceeding 10 percent until 2009, a result of the financial crisis.
Obtained from [Department of Labor, 2010]

### 5.7.2 Major employment sectors

The major employment sectors in the United States are the service industries. Over 75 percent of Americans works in either a managerial position, a service occupation or in some other form of sales occupation, as shown in figure 5.17.

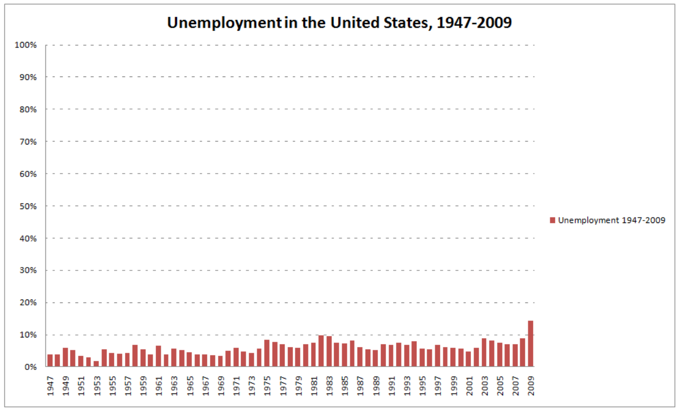


Figure 5.16: Unemployment in the United States, 1947-2009

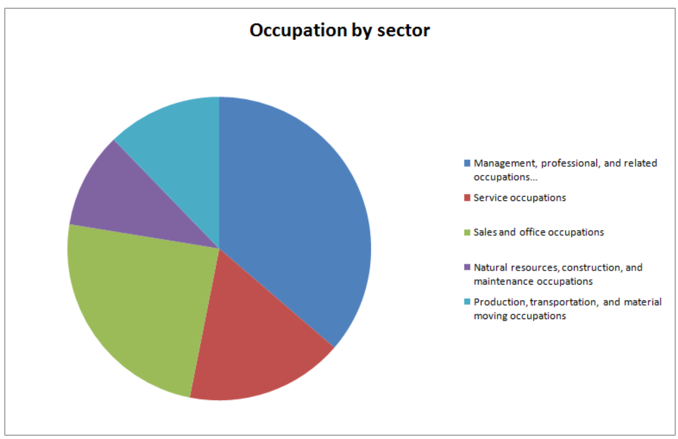


Figure 5.17: Occupation by sector

### 5.7.3 (Minimum) wages per sector

Table 5.9 shows per major employment sector how many of the workers are paid at or below federal minimum wage ($6.55 per hour).

### 5.7.4 IT workforce

Figure 5.18 shows the IT workforce and how it's divided into sectors. It must be noted that this also includes consulting services, although a consultant wouldn't have to be in IT.

| *Sector* | *Percentage of workers at or below minum wage* |
|---|---|
| Management, professional and related occupations | 1.0 |
| Service occupations | 12.7 |
| Natural resources, construction, and maintenance occupations | 1,1 |
| Production, transportation, and material moving occupations | 3 |

Table 5.9: Occupation by sector

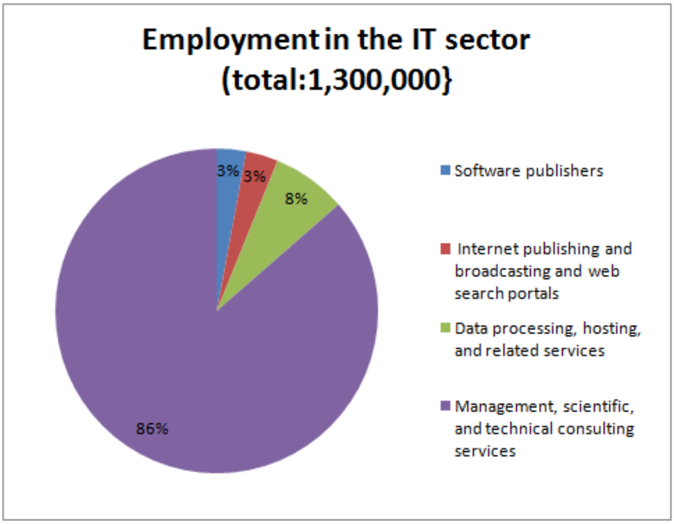


Figure 5.18: Occupation by sector, IT

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# Chapter 6

# Geography

*Section by Jordy Molenaar, Thomas Stols and Gijs van Veen*

## Introduction

In this chapter we describe the geography of the United States of America. We will start with an introduction to the topography and continue with the infrastructure, climate, nature and demography of the United States of America. Our goal here is to answer the question: *Which macro factors and/or actors can be distinguished from the geography of the United States of America that could support or inhibit the development and application of simulations and games in the US?*. To achieve this we will describe the subjects above, focusing on the facts. In the conclusion we will answer the research question, make a brief comparison between the USA and the Netherlands on the field of geography.

## 6.1 Topography

With an area of 9,826,675 square kilometers the United States of America is the third largest country in the world, right after Russia and Canada, though the People's Republic of China is bigger when not counting territorial waters. Of this area roughly 95% consists of landmass while the other 5% is water.

Apart from Hawaii and Alaska the remaining forty-eight states are located in the middle of the North American continent. When including the 2477 kilometer long border in Alaska, the north of the United States has a 8,893 kilometer long border with Canada and at the south the country has a 3141 kilometer border with Mexico. The State of Alaska is disconnected from the rest of the United States by Canada and its territorial waters also border with those of the Russian Federation.

The forty-eight connected states are further bounded by the Pacific Ocean in the west, Atlantic Ocean in the east and Gulf of Mexico in the south. The State of Alaska borders the Pacific in the south, Bering Strait in the west and Arctic Sea in the North. The state of Hawaii is an island group located in the Pacific Ocean, southwest of the North American mainland. The total coastline of the United States of America is 19,920 kilometers. A map of the United States of America can be seen in Figure 6.1 [CIA, 2009; Wolters-Noordhoff Atlasproducties, 2007].


Figure 6.1: The United States of America [Wikipedia, 2010b]

### 6.1.1 Terrain

Due to the large area it covers, the United States of America consist of multiple distinct terrains. The country has a vast central plain. In the west a major mountain range, the Rocky Mountains, can be found, while at the east there are only hills and low mountains. Alaska consists of rugged mountains and broad river valleys and Hawaii has a volcanic topography [CIA, 2009].

The United States of America have been divided into eight distinct physiographic regions, as first defined by Fenneman for both the western and eastern parts of the United states in 1931 and 1938 respectively [Fenneman, 1931, 1938]. These eight regions have been composed of a total of twenty five smaller physiographic regions called provinces. Figure 6.2 shows these different provinces in the United States.

**Laurentian Upland** (area labeled 1), part of the Canadian Shield physiographic region. Primarily made of ancient Precambrian igneous, metamorphic, and sedimentary rock. The area is slightly mountainous though not rugged due to age old erosion.

**Atlantic Plain** (2 and 3), is the flattest of the United States physiographic regions. The Atlantic plain is characterized by barriers and drowned valleys. It consists of marshes and wetlands and the ground consists mainly of sand and clay.

**Appalachian Highlands** (4-10), are a vast system of mountains located in the east of the United States. Geologically the terrain consists of sedimentary rocks, volcanic rocks and remnants of ancient ocean floors.

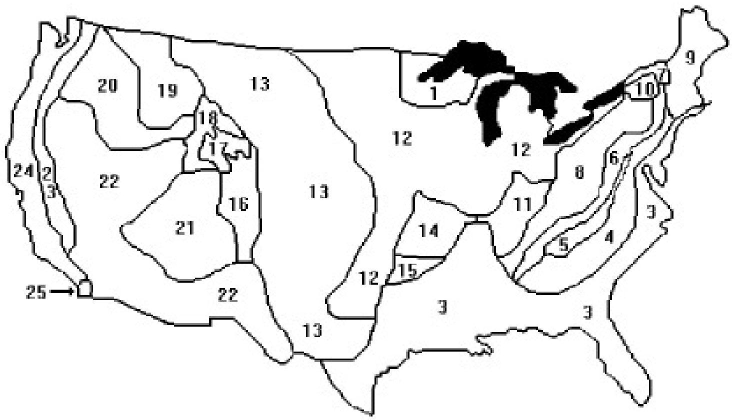


Figure 6.2: Physiographic provinces in the United States of America [Defense Advanced Research Projects Agency (DOD), 2001] after [Fenneman, 1931]

**Interior Plains** (11-13), is a large region with relatively low relief that covers a large part of both the United States and Canada. The basement of the Interior Plains consists of Precambrian metamorphic and igneous rocks but are covered with sedimentary rock as a result of the area having been an inland sea several million years ago.

**Interior Highlands** (14 and 15), is the only mountainous area in the United States between the Rocky Mountains and Appalachian Mountains.

**Rocky Mountain System** (16-19), is the largest and highest mountain system in the United States of America, except for those in Alaska. It consists mainly of igneous and metamorphic rocks, though at some places sedimentary rock can be found. The peaks of the mountains are relatively rounded and gentle as they rise from high bases.

**Intermontane Plateaus** (20-22), consists of separate mountains with broad valleys between them where plateaus, ranges, basins and gorges can be found. The ground consists mainly of sandstone and due to volcanic activity in the region remnants of lava flows can be found. In the southern parts desert like areas such as Death Valley, the lowest point of the United States, are located.

**Pacific Mountain System** (23-25), is a coastal hilly or mountainous area, though not as high as the Rocky Mountains. The area consists mainly of rocky terrain.

### 6.1.2 Rivers

The United States have several long rivers spread across the country. Though the Missisippi river system is considered the largest of all United States rivers, the Missouri river, a tributary to the Mississippi river, is actually longer. In length, the five longest rivers in the United States are [Kammerer, 1990]:

**Missouri River** with a length of 4,087 kilometers the longest river of the United States. The Missouri river has it's source in the Red Rock Creek, Montana and mouths in the state of Missouri, where the river enters the Mississippi River.

**Mississippi River** has a length of 3,765 kilometers and streams from its source in Minnesota into the Gulf of Mexico in Louissiana. The river system of the Missisippi river and all the rivers streaming into it is the largest river system in the United States of America.

**Yukon River** is the largest river of the state of Alaska. It has a length of 3,186 kilometers and though it's source can be found in Canada the river streams through Alaska into the Bering Sea.

**Rio Grande** has a length of 3,057 kilometers and has its source located in the state of Colorado. The Rio Grande forms the border between the state of Texas and Mexico and eventually mouths into the Gulf of Mexico.

**Saint Lawrence River** is as long as the Rio Grande and connects the Great American lakes with the Gulf of Saint Lawrence.

### 6.1.3 Lakes

The United States has several lakes, the most notable of them being the five Great Lakes located between the United States and Canada. These lakes, Superior, Michigan, Huron, Erie and Ontario, form the largest surface freshwater supply in the world. About 84 percent of the North American surface and twentyone percent of the world's supply of surface freshwater is found in the Great Lakes[United States Environmental Protection Agency, 2010].

### 6.1.4 Major Centers

The population of the United States is spread all over the country. Though a lot of regions exist with only few inhabitants, the United States has several densely populated areas. Table 6.1 shows the ten biggest cities in the United States.

On average, the coastal areas of the United States have more inhabitants than the inland states. With 36,961,664 inhabitants the state of California is by far the most populated state in the United States, followed by biggest state Texas and the state of New York at 24,782,302 and 19,541,453 inhabitants respectively [Census, 2010]. As can be seen in Figure 6.3, the eastern states are more populated than the states in the west.

Major centers for the technology industry, vital to the subject of simulation and gaming, are Washington, New York and most importantly Silicon Valley, an area just south of San Francisco [Market Watch, 2008]. The name of Silicon Valley is derived from the large number of companies working with silicon made computer chips. The reason the area is so densely populated is often seen as a result of Standford University and Professor Frederick Emmons Terman, who felt that the area had too little employment opportunities for the graduates. Terman started his own company and encouraged his students to do the same [Tajnai, 1985].

| Rank | City | State | Population |
|---|---|---|---|
| 1 | New York | New York | 8,363,710 |
| 2 | Los Angeles | California | 3,833,995 |
| 3 | Chicago | Illinois | 2,853,114 |
| 4 | Houston | Texas | 2,242,193 |
| 5 | Phoenix | Arizona | 1,567,924 |
| 6 | Philadelphia | Pennsylvania | 1,540,351 |
| 7 | San Antonio | Texas | 1,351,305 |
| 8 | Dallas | Texas | 1,279,910 |
| 9 | San Diego | California | 1,279,329 |
| 10 | San Jose | California | 948,279 |

Table 6.1: List of biggest cities in the United States of America by population [Census, 2010]

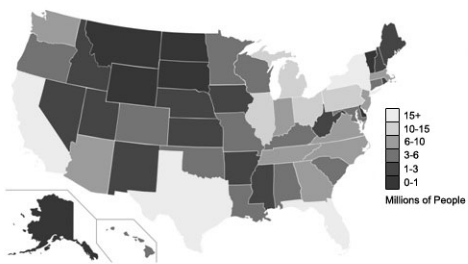


Figure 6.3: Population of US States [Census, 2010]

### 6.1.5 Natural Resources

The United States has multiple different natural resources in its soil. With 491 billion short tons of coal reserves the United States holds 27% of the world's total in coal reserves, the largest reserve in the world. Apart from coal, copper, lead, molybdenum, phosphates, uranium, bauxite, gold, iron, mercury, nickel, potash, silver, tungsten, zinc, petroleum, natural gas and timber can be found on American soil [CIA, 2009]. For gaming and simulation the mineral silicon, that can also be found in the United States, is important, as this mineral is used to produce computer chips [Siffert and Krimmel, 2004]. Table 6.2 gives an oversight of where the minerals can be found.

| **Mineral** | **Location** |
|---|---|
| Aluminium | The majority of the aluminium mining is done in the state of Washington, though there is also aluminium found in North and South Carolina, Mississippi, Missouri, Montana, New York, Kentucky, Tennessee, Texas and West-Virginia. |

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| | |
|---|---|
| Barite | Most Barite can be found in Nevada, but also in Illinois, Louissiana, Missouri, Tennessee and Texas. |
| Cadmium | Cadmium can be found in Alaska, Illinois, Penssylvania and Tennessee. |
| Coal | The majority of the coal reserves of the United States are located in the Appalachian Mountains, specifically the states Kentucky, Ohio, Pennsylvania and West-Virginia. The Rocky Mountains also have many coal mines, though not as much as the Appalachian Mountains. |
| Copper | Copper-mines in the United States are located in Arizona, Nevada and New Mexico. |
| Gemstones | Gemstones are spread across the country and are found in Arizona, Arkansas, California, Colorado, Idaho, Illinois, Montana, Nevada, New York, North Carolina, Oregon, Utah and Washington. |
| Gold | Most gold is found in the western states such as Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Washington. |
| Iron Ore | Iron Ore is found near the great lakes, mostly in Michigan, Minnesota and South Dakota. |
| Lead | Lead is found mostly in the northern states such as Alaska, Colorado, Idaho, Missouri, New York and Tennessee. |
| Mercury | Mercury is found in California and Nevada. |
| Nickel | Only found in Montana. |
| Phosphate | Mostly found in Florida, but also in North Carolina and Idaho. |
| Potash | Found in Michigan, New Mexico and Utah. |
| Salt | A lot of salt is found in the United States due to the dried out seas across the country, such as Death Valley. Located in California, Kansas, Louissiana, Michigan, Nevada, New Mexico, New York, Ohio, Texas and Utah. |
| Silicon | Even though California has a region names Silicon Valley, the mineral is not found there. Rather, silicon is found in Alabama, Georgia, Illinois, Kentucky, New York, Oregon, Washington and West-Virginia. |
| Silver | Found in Alaska, Arizona, California, Colorado, Idaho, Missouri, Montana, Nevada, New Mexico, South Carolina and Utah. |

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| | |
|---|---|
| Sulfur | Found in the most central states, but mostly in Texas. Other states include Arizona, Louisianna, Montana and Wyoming. |
| Uranium | There are only eight uranium mines in the United States, located in Louissiana, Nebraska, Texas and Wyoming. |
| Zinc | Just like lead, zinc is found in Alaska, Colorado, Idaho, Missouri, New York and Tennessee. |

Table 6.2: Minerals and their location in the United States [Kramer et al., 2010]

## 6.2 Infrastructure

Due to its large size infrastructure plays a vital role in the United States. Not only in forms of transportation but also for energy, communications and water supply.

### 6.2.1 Land Use

The roughly 9.3 million square kilometers of usable land in the United States are used for multiple purposes. In 2002 about 20 percent of the land area was cropland, 26 percent was permanent grassland pasture and range and 29 percent was forest-use land. Only three percent of the land was used for urban areas. Thirteen percent of the land was used for special uses such as roads, airports, industrial areas, wildlife refuges and areas used for national defense. The remaining ten percent was used for other purposes such as cemeteries, industrial sites in rural areas and golf courses, but rough terrain such as deserts and tundra's as well. Figure 6.4 gives an overview of the use of land [Lubowski et al., 2006].

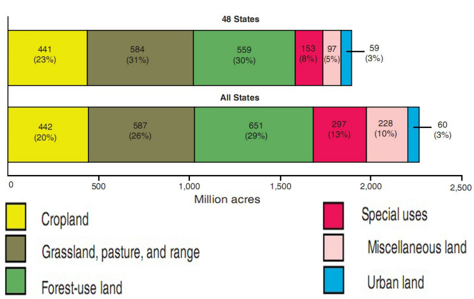


Figure 6.4: Use of land by percentage in the United States in acres (one acre is 0.404 hectare)

### 6.2.2 Mobility

Due to the large size of the United States, mobility and transportation probably play important roles in the United States infrastructure. Road, railroads, waterways and airfields are all present in the United States.

#### Roads

The United States has the largest number of registered cars in the world, 254,403,082 by 2007 [Bureau of Transportation Statistics, 2007], making roads an important part of the American infrastructure. Several road systems can be found between United States cities. The most important road system is the National Highway System, which compromises approximately 256,000 kilometers of road. The National Highway System consists of the Federal Interstate System, a 75,440 kilometer long highway and other highways that connect an arterial to major ports, airports, public transportation facilities or other intermodal transportation facilities. There is also the older numbered Highway system, of which some roads are part of the National Highway System but most have been replaced by the Federal Interstate. In the numbered road system major north-south routes have numbers ending with a 1 while major east-west routes have numbers ending with a 0.

Funding and maintaining of the National Highway System is done by both the federal government and the states in which the roads are located. Under the Federal-Aid Highway Act of 1956 the most important highways of the United States are funded by the Highway Trust Fund. This fund gets its money from fuel-taxes, creating a self regulating system where the users indirectly pay for the use of roads. Unlike most countries however, the taxes are not collected from the consumers but rather from the producers and importers of oil. As a result, only the few states where oil companies are present actually pay the taxes. American fuel-taxes are relatively low when compared to some other countries. For example, the taxes per each liter of gasoline in the United States are 4.86 dollar cents while the fuel-taxes in the Netherlands are approximately 93 dollar cents per liter[Federal Highway Administration, 2010a; Dutch Ministry of Finance, 2008]. This huge difference in taxes might explain the higher use of cars in the United States.

Figure 6.5 gives an overview of the National Highway System [Federal Highway Administration, 2010b].

#### Rail

The United States have a railroad system runned by the government owned company Amtrak. The railroad system has a length of 34,000 kilometer and there are 500 destinations spread over 46 states, as can be seen in Figure 6.6 [Amtrak, 2010b]. Despite this, the United States have the least used railway system of all the developed countries in the world, as the average American travels only 80 kilometers by train per year [International Union of Railways, 2008]. Most of the trains used by Amtrak use Diesel fuel, though the trains between Boston and Washington D.C. and the trains between Philadelphia and Harrisburg are powered by overhead wires. The frequency of service of the trains varies from each route. For example, the train between Los Angeles and New Orleans travels three times per week while the trains between New York City and Washington D.C. depart several times per

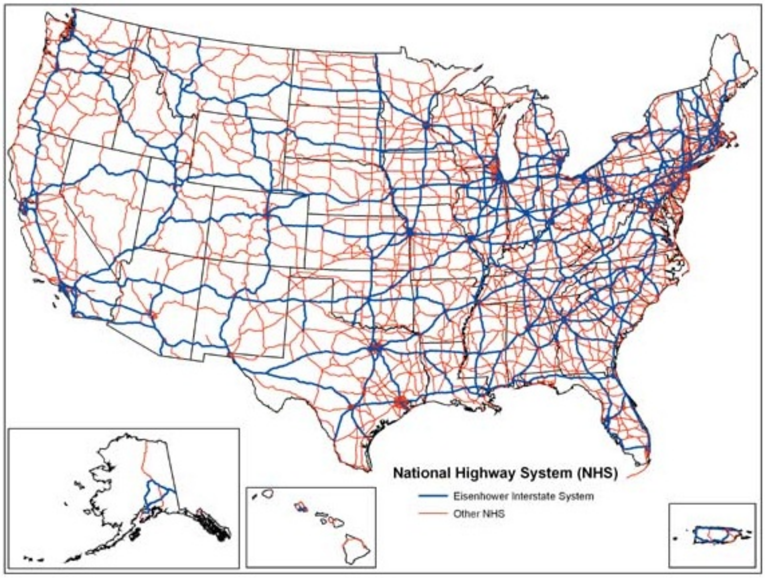


Figure 6.5: Map of the National Highway System

hour [Amtrak, 2010a]. The relative low use of trains when compared to other developed countries might have a correlation with the high use of automobiles. Since a large number of United States citizens have a car and the gas is cheap, railroads might not be as interesting as a form of transport as they are in other countries.

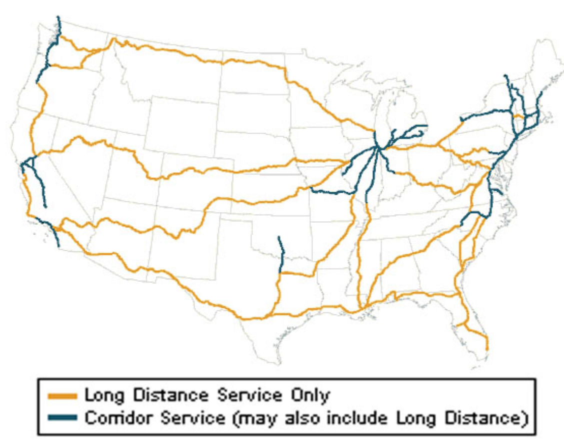


Figure 6.6: Map of the Amtrak rail system

### Waterways and Ports

The United States have waterways of over 41,000 kilometers, of which 19,312 kilometers is used for comercial purposes. [CIA, 2009] The Mississippi River, and the rivers that stream into it are responsible of the majority of the waterways, as can be seen in Figure 6.7. The United States also have several ports spread across the country. The most important ports in the United States include the ports of Corpus Christi, Duluth, Hampton Roads, Houston, Long Beach, Los Angeles, New York, Philadelphia, Tampa and Texas City [CIA, 2009].

Figure 6.7: Map of the United States Waterways [Wikipedia, 2010a]

### Airports

There are over 15 thousand airports located in the United States (both military and civilian), though only 5,174 airports have paved runways. This makes the United States the country with the most airports in the world. Based on the amount of aircraft movement the United States has the six biggest airports [Airports Council International, 2010b] though it only holds position 1, 4, 7 and 10 when looking at the top ten of biggest airports based on the number of passengers [Airports Council International, 2010a]. In both cases though, the Hartsfield-Jackson Atlanta International Airport, located in Atlanta, is considered the world's biggest airport. By cargo, three United States airfields make the top ten, though the Atlanta airfield is not one of them [Airports Council International, 2010c].

## 6.2.3 Energy

In 2008 the United States produced 4.11 trillion kWh of energy and 3.873 trillion kWh of this energy was consumed. 24.08 billion kWh was exported and another 57.02 billion kWh was imported to the United States. This makes the United States the largest consumer of energy in the world [CIA, 2009]. Of the generated energy 45% comes from coal plants, 23% from natural gas and 20% from Nuclear power. Roughly ten percent of the generated energy comes from Hydroelectric powerplants and other sources of renewable energy. The remaining power is generated by petrol, non-natural gas and chemicals[United States Energy Information Administration, 2009].

United States power is spread though three of the several independant power grids that can be found in North America. These powergrids not only connect to the United States, but to Canada and Mexico as well. Various utility companies are responsible for the generators, powerlines, substations and power distribution in order to keep the power grids operational. The powergrids are governed by a variety of international, national, regional, and state bodies. Electrical entitlements and operational matters between the United States, Canada, and Mexico are governed by several international treaties. Utility tarifs and governing of regulatory policies are done by the Federal Energy Regulatory Commission, that coördinate the use of powergrids between states. The powergrids present in the United States are [United States Department of Energy, 2007].

**Western Interconnect** connects to the United States, Canada and Mexico. It covers the western half of North America, where power can flow from British Columbia to Kansas or California or from Mexico to Wyoming and everything in between.

**Eastern Interconnect** covers the eastern part of the United States and Canada, including densly populatated areas such as Chicago, New York and Washington D.C.

**Texas Interconnect** covers most of Texas, that has its own grid under Texan laws and customs.

**Alaska and Hawaii** both have their own power grids due to the distance from other states.

### 6.2.4 Communications

Like most Western countries, the United States have a large communications network. Not only telephony, but also internet, television and radio are available in the United States. There are over 150 million telephone lines available in the United States and another 270 million mobile cellphones are in use. This ranks the United States in the second and third place in phone use of the world for landlines and mobile phones respectively. The United States phone network is considered a large, technologicaly advanced communications system that is constructed from a large system of fiber-optics, microwave radio relay, coaxial cable, and domestic satellites that carry every form of telephone traffic. The United States have the country code 1 for international calls and are conntected to the rest of the world by multiple ocean cable systems and several satellites.

As the country responsible for the invention of the internet, the United States play a vital role on the internet[Leiner et al., 2009]. The United States possessed some top level domain host adressess, such as .com .us .edu .gov .mil .net and .org. There are 383 million internet hosts located in the United States, making the country the biggest host in the world, and 231 million users have acces to the internet [CIA, 2009].

## 6.3 Climate

Due to the many landform changes throughout the country, the climate in the United States can differ from location to location. This causes a major variety in climate and weather.


Figure 6.8: Annual climate of the United States. [GeoNova, 2009]

### 6.3.1 North east

The north east states (Maine, New York, Pennsylvania, Minnesota, Ohio, Michigan) are subject to a humid continental climate. This climate is marked by variable weather patterns and a large seasonal temperature variance. [Encyclopedia Britannica, 2010] Summers are often warm and humid, winters can be very cold with frequent snowfall. The average temperature over the whole year lies around 1-15 degrees Celsius. Temperatures increase as one moves further inland and away from the moderating influence of the ocean. Rainfall is moderate, between 32 and 64 inches.

### 6.3.2 South east

The south east states (North Carolina, Georgia, Tennessee, Kentucky) tend to have a humid subtropical climate. This climate zone is characterized by hot, humid summers and cool winters. The climate in many of these states can be extreme. The average temperature lies around 15-22 degrees Celsius.

### 6.3.3 Far south east

The far south east states like Florida, Louisiana and Texas have a tropical wet climate. Mean temperatures in all twelve months are above 18 degrees, with an average of 22-28 degrees Celsius. This climate can cause extreme shifts in pressure systems, leading to a chance of hurricanes, tornados, floods and heavy rainfall. The average annual rainfall here is very high: 64 to 96 inches.


Figure 6.9: Annual average rainfall of the United States [GeoNova, 2009]

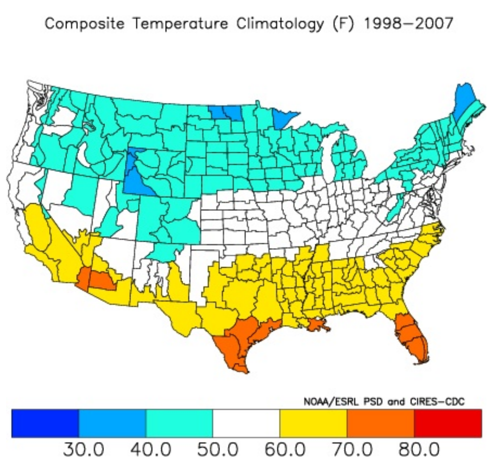


Figure 6.10: Annual average temperatures of the United States. Fahrenheit to Celsius formula: C = (F - 32) / 1.8 [Earth System Research Laboratory, 2009]

### 6.3.4 West

The west of the United States is slightly warmer. The outer west state California experiences a mediterranean climate. This climate is characterized by hot, dry summers and mild, wet winters. By the coast California is cooled by sea breezes, however inland locations can experience very high temperatures. The average temperature here is 22-30 degrees Celsius. Because of the drought in the summer, the average rainfall is low: only 16 to 32 inches annually.

A large part of the west of the United States is desert, and therefore is subject to a hot desert or arid climate. Temperatures are high (average of 22-30 degrees Celsius) and rainfall is very low (annual average of less than 8 inches). During colder periods of the year, night-time temperatures can drop to freezing or below. Also, most of the highlands are in the west, bringing an alpine climate. This climate becomes colder at high elevations, with the possibility of snowfall. The average temperature here drops to 1-5 degrees Celsius.

Hawaii is also subject to tropical wet climate with annual rainfall between 64 and 96 inches. Alaska has an arctic climate.

The average rainfall and temperatures in the United States can be seen in Figure 6.9 and Figure 6.10 respectively.

### 6.3.5 Area of interest: Silicon Valley

Silicon Valley is located in the south west of the United States (California) and has a mediterranean climate [Miller, 2010]. Silicon Valley is located a little more inland than San Francisco and is protected on three sides by mountains. This shelters the area from rain and fog, that is why Silicon Valley's annual rainfall is only 14.4 inches, much lower than in other bay area's [Oceanic and Administration, 2010]. The mountainous area also guarantees sunshine over 300 days a year. From June through September, there is hardly any rainfall. Temperatures average from 5 to 15 degrees Celsius in the winter, to 14 to 29 degrees Celsius in the summer [AccuWeather, 2010]. High temperatures are almost always without high humidity.

### 6.3.6 Area of interest: Dallas Gaming Mafia

Another area of interest is Dallas, Texas. The Dallas Gaming Mafia area features a large number of video game developers located in and around Dallas. Dallas has a humid subtropical climate, and is located in a very hot region. With mild winters of temperatures ranging from 13 degrees Celsius to 21 degrees Celsius, and hot summers ranging from 38 degrees Celsius to 47 degrees Celsius, the Dallas Gaming Mafia area is one of the hottest areas in the United States during summer months. Over the past 25 years, Dallas has averaged 31 annual nights at or below freezing temperatures. Average rainfall lies around 4 inches, making Dallas a dry area [Office, 2010].

### 6.3.7 Natural hazards

The FEMA (Federal Emergency Management Agency) [Federal Emergency Management Agency, 2007] has mapped all the national natural hazards from January 2000 to March 2007. Table 6.3 states the natural disasters.

There have been a total of 377 natural hazards in this period. Most of these are severe storms, followed by hurricanes, floods and tornados. The majority of these hazards occur in the south, as can be explained by the climate there. Florida has been the most targeted state with 79 occurrences of natural hazards.

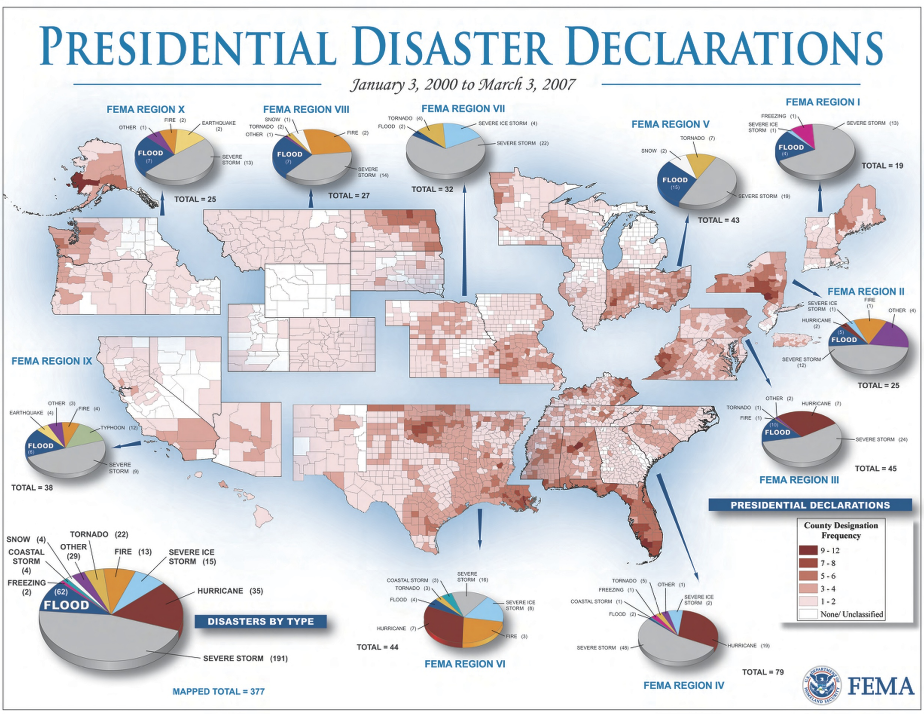


Figure 6.11: Presidential Disaster Declarations [Federal Emergency Management Agency, 2007]

| Region | States | Disasters | Total |
|---|---|---|---|
| FEMA Region I | Maine, New Hampshire, Vermont, Massachusetts, Rhode Island | Severe storm (13), flood (4), freezing(1) | 19 |
| FEMA Region II | New York, New Jersey | Severe storm (12), flood (5), fire (7) | 25 |
| FEMA Region III | Pennsylvania, Virginia, West Virginia, Maryland, Delaware | Severe storm (24), hurricane (7) | 45 |
| FEMA Region IV | North Carolina, South Carolina, Georgia, Florida, Mississippi, Alabama, Tennessee, Kentucky | Severe storm (48), hurricane (19), Severe ice storm (2) | 79 |
| FEMA Region V | Michigan, Ohio, Indiana, Illinois, Wisconsin, Minnesota | Severe storm (19), flood (15), tornado (7) | 43 |
| FEMA Region VI | Louisiana, Texas, Arkansas, Oklahoma | Severe storm (16), hurricane (7), severe ice storm (8) | 44 |
| FEMA Region VII | Nebraska, Kansas, Missouri, Iowa | Severe storm (22), severe ice storm (4), tornado (4) | 32 |
| FEMA Region VIII | North Dakota, South Dakota, Wyoming, Montana, Utah, Colorado | Severe storm (14), flood (7), fire (2) | 27 |
| FEMA Region IX | California, Nevada, Arizona | Severe storm (9), flood (6), typhoon(12) | 38 |
| FEMA Region X | Oregon, Washington, Idaho | Severe storm (13), flood (7), earthquake (2) | 25 |

Table 6.3: Presidential Disaster Declarations 2000 - 2007 [Federal Emergency Management Agency, 2007]

## 6.4 Flora and Fauna

The many landform changes in the United States also affect the flora and fauna of the country. The center of the USA consists mainly of grassland, where the moisture is not sufficient to support the growth of large forests. [Nations Encyclopedia, 2010] Different sorts of grass (short, mesquite, tall) can be found here. The eastern coastal areas consist of mixed forest and deciduous forest. In the south of Florida, subtropical forests can be found.The west of the USA consists of scrubland combined with coniferous forest, and desert. Alaska consists mostly of mountains with softwood forests, heath and tundra. Hawaii has extensive forests of bamboo and ferns. An overview of the vegetation can be seen in Figure 6.12.

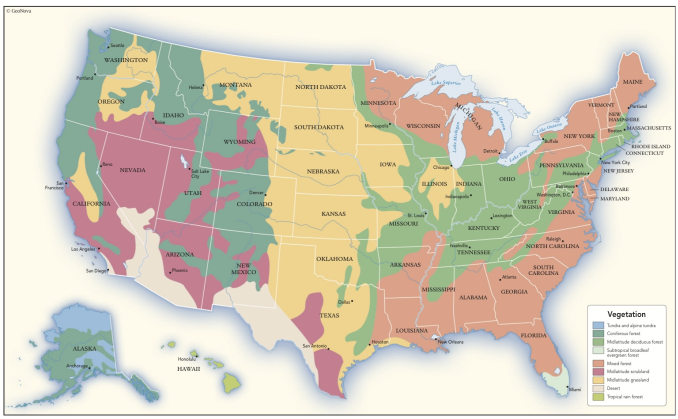


Figure 6.12: Vegetation of the United States [GeoNova, 2009]

The United States are rich in mammals, birds, fish, insects and reptiles. Many species are already identified and mapped, some are yet to be discovered. An estimated 432 species of mammals characterize the animal life of the United States. Some animals can only be found locally such as the Alaskan brown bear, or in reserves like the American buffalo. Laws and lists to protect endangered flora and fauna have been adopted throughout the United States in order to preserve the wildlife.

## 6.5 Demography

### 6.5.1 Population

The United States' population is the third biggest in the world with an estimated amount of 307,212,123 people [CIA, 2009]. In absolute numbers they fall right behind China and India however it has a rather low population density of about 30.7 people per square kilometer [World Atlas, 2010]. This differs nearly with a factor of 13 with the Netherlands (395 people/km2).

The top of the U.S. states population density list is dominated by east coast states whereas California - a west coast state - has the largest population of 36,756,666; more than a tenth of the total U.S. population.

| State | Population | Density |
|---|---|---|
| New Jersey | 8,682,661 | 451.99 |
| New York | 19,490,297 | 159.49 |
| California | 36,756,666 | 91.00 |
| Total | 307,212,123 | 36.92 |

Table 6.4: Population distribution of the US [World Atlas, 2010]

Table 6.4 shows a comparison between population count and population density. It shows that although a large number of people live in the states of California, Arizona and the Las Vegas area the most densely populated part of the U.S. is the eastern part. A more complete overview of the U.S. population density is shown in Figure 6.13.

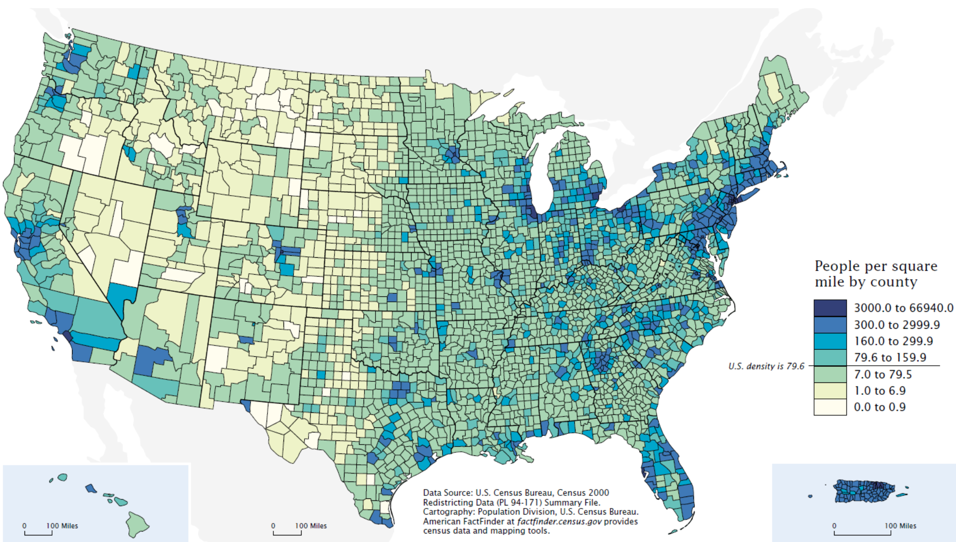


Figure 6.13: Population density of the United States (2000) [Census, 2010]

### 6.5.2 Languages

A number of languages are being used in the United States with it's main language being English taking up 82.1% of the total amount. Second is Spanish with 10.7% followed by other Indo-European (3.8%), Asian and Pacific island (2.6%), other(0.7%).[CIA, 2009] Although a considerable part of the nation is Hispanic and speaks Spanish most second and higher generation Hispanics report to be fluently in English.[Hakimzadeh, 2007] In fact, over 96% of the total population claims to speak Engelish well or very well.

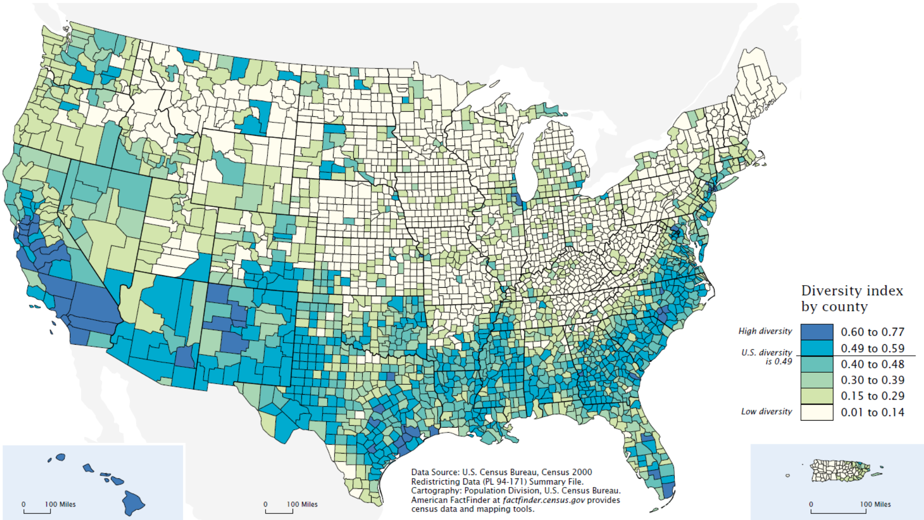


Figure 6.14: Ethnic diversity of the United States [Census, 2010]

### 6.5.3 Diversity of ethnicity

The ethnic groups of America can be subdivided as follows: white 79.96%, black 12.85%, Asian 4.43%, Amerindian and Alaska native 0.97%, native Hawaiian and other Pacific islander 0.18%. [CIA, 2009]

The largest racial minority are therefore the Black Americans. Another large minority in the United States are the Hispanics. They are not subdivided in an ethnic group since people who identify themselves as Hispanic can be associated with any of the ethnicities mentioned before. Hispanics are mostly people from Mid/South American countries as Mexico, Puerto Rico and Cuba. About 15% of the nations population identifies himself with being Hispanic or Latino. Increased birthrates of Hispanic groups compared to non-Hispanic groups will result in an increase of 188% of Hispanic people between 2000 and 2050. Their share of the nation's population would be nearly 25% at that time.

The most ethnic diverse regions are in the south of the United States. especially in the south-west (California). It's not uncommon to find public signs translated in Spanish around this area for this very reason. This ethnic diversity can be described using a Diversity Index that "reports the percentage of times two randomly selected people would differ by race/ethnicity" [Census, 2010]. The diversity index by county is shown in Figure 6.14.

### 6.5.4 Diversity of religions

In contrary to the ethnic diversity, there is a little less diversity in religion in the United States. The largest religion is by far Christianity with over 75% of the people being Christian. More than 51.3% of the people are Protestant, 23.9% are Roman Catholic, 1.7% Mormon, and 1.6% other Christian. Apart from the Christians there are 1.7% Jewish people, 0.7% Buddhists and only about 0.6% Muslims in the United States. [CIA, 2009]

By U.S. constitution is guaranteed that Americans are free to exercise any religion. Religion is important to the U.S. citizens and it is striking to see that atheists are rated "below Muslims, recent immigrants, gays and lesbians and other minority groups in sharing their vision of American society."[Jacobs, 2006]

### 6.5.5 Urbanization

The United States of America is a highly urbanized country with 82% of its people residing in urban areas. By a 2005-2010 estimate the annual rate of change for the urbanization in the US is 1.3%. The world's average is 48.6% urbanization with a 1.98% rate of change. An example of the United States' urbanization is New York-Newark with - as mentioned before - about 19 Million inhabitants. It is one of the largest urban agglomerations (second place after Tokyo) situated in the U.S. [CIA, 2009] An urban agglomeration is a city including its surroundings like suburbs and other thickly settled territory lying outside of the city.

## 6.6 Conclusion

Looking at the geographical aspects of the United States of America, we can conclude that the development of the country is hugely dependent on its infrastructure, topology, climate and demography.

Mobility plays an important role in the geography; the large number of registered cars, the large amount of kilometers of road and the big railroad system suggest that the infrastructure is very important.

The diversity of ethnicity and religion shows the huge variety of inhabitants of the United States.

Looking at the matter of simulation and gaming technology, the demography seems to be a big factor. Games are little dependent on infrastructure, topology and climate. They are however influenced by religious beliefs and ethnicity. This is mainly due to the fact that games need a specific audience in order to be sold.

Specific areas like Silicon Valley and the Dallas Gaming Mafia area are located at locations that are very urban, have a warm climate and are easy to reach. The reason that a lot of companies are located here, is mainly due to economic factors, geography only plays a very small part.

Furthermore, the other subjects we discussed are only small factors. For landscape simulation, the United States is interesting due to its variety in terrain. Also, the infrastructure of the USA influences the spreading of games to stores.

When we compare the geography of the United States with the Netherlands, we can conclude that the Netherlands overall is very small. There is little variety in terrain and climate in the Netherlands, however there are similarities in infrastructure and demography. See Tables **??**, 6.6, 6.7, 6.8, 6.9 and 6.10 for a quick overview of the comparison.

| | **United States** | **The Netherlands** |
|---|---|---|
| Size | 9,826,675 km2 | 41,528 km2 |
| Percentage water | 5% | 18.41% |
| Coastline | 19,920 km | 451 km |
| Border | 12,034 km | 1027 km |

Table 6.5: **General** aspect comparison table between the United States and The Netherlands

| | **United States** | **The Netherlands** |
|---|---|---|
| Terrain type | rock, barriers, drowned valleys,<br>marshes, wetlands, sand, mountains, hills | coastal lowlands,<br><br>some hills in the south-east |
| Major cities | New York (8,363,710),<br>Los Angeles (3,833,995),<br>Chicago (2,853,114),<br>Houston, Phoenix | Amsterdam (1,301,268),<br>Rotterdam (1,114,675),<br>Den Haag (1,017,937),<br>Utrecht, Eindhoven |
| Major rivers | Missouri, Mississippi, Yukon, Rio Grande, St. Lawrence | Rijn, Maas |
| Major lakes | Lake Superior, Lake Huron,<br>Lake Michigan, Lake Erie,<br>Lake Ontario | IJsselmeer |

Table 6.6: **Geology** aspect comparison table between the United States and The Netherlands

| | **United States** | **The Netherlands** |
|---|---|---|
| Average Climate | humid continental climate,<br>humid subtropical climate,<br>tropical wet climate,<br>mediterranean climate,<br>desert climate | temperate |
| Annual average rainfall | 810 mm | 792.9 mm |
| Natural Hazards | storms, hurricanes, floods, tornados, mud streams, forest fires | None |
| Natural resources | coal, copper, lead, timber, petroleum, zinc, iron, gold, silver,<br>nickel, bauxite, potash, natural gas | coal, oil,<br>natural gas |

Table 6.7: **Climate** aspect comparison table between the United States and The Netherlands

| | **United States** | **The Netherlands** |
|---|---|---|
| Arable | 19.13 % | 26.71% |
| Permanent crops | 0.22% | 0.97% |
| Other | 80.65% | 72.32% |

Table 6.8: **Land Use** aspect comparison table between the United States and The Netherlands

| | **United States** | **The Netherlands** |
|---|---|---|
| Number of airports | 19,738 | 35 |
| Railway | 34,000 km | 2,809 km |
| Roads | 256,000 km | 135,470 km |
| Waterways | 40,000 km | 5,046 km |

Table 6.9: **Infrastructure** aspect comparison table between the United States and The Netherlands

| | **United States** | **The Netherlands** |
|---|---|---|
| Total population | 307,212,123 | 16,515,057 |
| Population density | 30.7 per km2 | 395 per km2 |

Table 6.10: **Demography** aspect comparison table between the United States and The Netherlands

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# Chapter 7

# History

*Section by Ernst Fluttert, Albert de Graaf, Marije de Heus and Ruud Welling*

## Introduction

In this chapter we describe the history of the United States of America, focussing on the period 60.000BC till around 1990AD. Since this a big timespan, the main focus lies on the last 300 years where the United States actually exists. This chapter will list the most important events in their history. Our goal is to answer the question: *Which macro factors and/or actors can be distinguished from the history of North America that could support or inhibit the development and application of simulations and games in the US?*.

We will first start with a timeline and a listing of the most important Presidents. Then the history starts with the migration of the first people to the North American continent and the colonizational period, after this the independence and the civil war. The latter part is focused on the 19th and 20th century where many conflicts occurred like both World Wars and the Cold war, but also many major events like the Great Depression and the Afro-American Civil Rights Movement. Special attention is going to major technological events that may contribute to answer the main question, this will be done in a separate section. Point of attention will be any influence or relation with the Netherlands. The chapter will finish with an overview, conclusion and the answer of the main question.

## Timeline

The timeline as seen in Figure 7.1 will give a quick overview of the major events and milestones in the history of the United States of America. The timeline is split into three categories with their own focus:

**Conflicts** This category contains all important (inter)national wars and conflicts.

**Major Events** These are important events in the economical, political and cultural climate of the United States

**Tech Events** These are events regarding important milestones in the technical advancement.

All events listed in the timeline will be discussed later on in this chapter in more detail. Conflicts are important in the history but should not be the only focus of milestones, this is the reason that we also have the Major Events and Tech Events timelines.

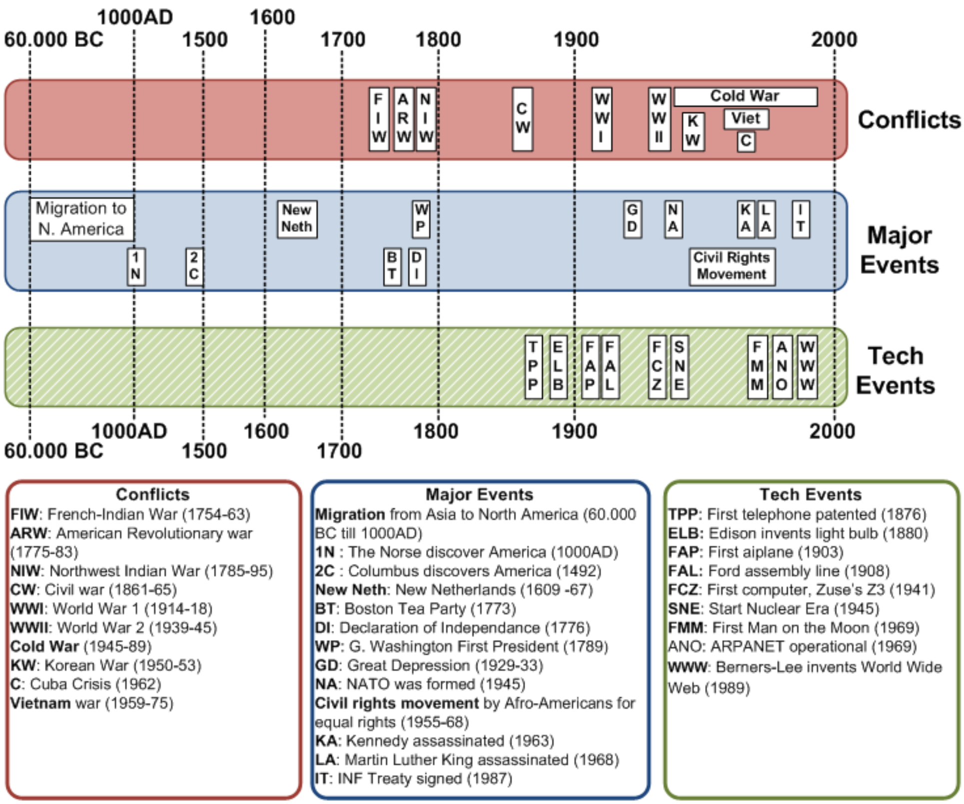


Figure 7.1: Timeline with most important events in the history of The United States of America

## Presidents

The president is the head of the government and head of state, futhermore he leads the executive branch of the federal government and is the Commander-in-chief of the United States Army. The president is elected by the citizens of the United States, who vote every four years. The first president was George Washington who took office in 1789 and the current (44th) president is Barack Obama who took office in 2009 House [2010].

We have listed the first and last four presidents, and great presidents in between in Table 7.1. In there the names, president number and years in office are listed. The ranking column is based on various studies Schlesinger Jr [1997], Murray and Blessing [1983] where many leading American historians composed a ranking system to indicate their greatest presidents. Please note that the last two presidents are not yet ranked.

| **Presidents of the United States of America** | | | | |
|---|---|---|---|---|
| **Name** | **Presidency** | **In office** | **Ranking** | **Party** |
| George Washington | 1 | 1789 - 1797 | 2 | Independent |
| John Adams | 2 | 1797 - 1801 | 11 | Federalist |
| Thomas Jefferson | 3 | 1801 - 1809 | 4 | Dem-Rep |
| James Madison | 4 | 1809 - 1817 | 17 | Dem-Rep |
| Andrew Jackson | 7 | 1829 - 1837 | 5 | Democratic |
| James Polk | 11 | 1845 - 1849 | 9 | Democratic |
| Abraham Lincoln | 16 | 1861 - 1865 | 1 | Republican |
| Theodore Roosevelt | 26 | 1901 - 1909 | 6 | Republican |
| Woodrow Wilson | 28 | 1913 - 1921 | 7 | Democratic |
| Franklin D. Roosevelt | 32 | 1933 - 1945 | 3 | Democratic |
| Harry Truman | 33 | 1945 - 1953 | 8 | Democratic |
| George Bush Sr | 41 | 1989 - 1993 | 24 | Republican |
| Bill Clinton | 42 | 1993 - 2001 | 20 | Democratic |
| George Bush Jr | 43 | 2001 - 2009 | - | Republican |
| Barack Obama | 44 | 2009 - | - | Democratic |

Table 7.1: List of the first and last four Presidents, supplemented by the greatest Presidents of the United States of America. (Dem-Rep stands for 'Democratic-Republican')

## 7.1 Pre-columbian era

The pre-Columbian era refers to the era before Columbus first arrived in America in 1492. During this era, North America was not yet conquered by Europeans and its only inhabitants were those whom we now call Native Americans. In this chapter we describe these first inhabitants of America, starting with their arrival.

It is generally accepted that the first human beings lived in Africa. About 60,000 years ago, the first humans left Africa and migrated to South Asia. 50,000 years ago some groups moved to North and South America. The earliest inhabitants of America are called Paleoamericans. 15,000 to 10,000 years ago the Haplogroup, from which nearly all native North Americans are descended, reached the Americas [hum, 2010]. The early Paleoamericans diversified into hundreds of distinct tribes [Jacobs, 2002]. They lived in small, mobile groups of 20 to 50 family members.

Around 15,000 years ago, the ice that separated North America from the rest of the world broke, enabling the continent to expand more quickly. This allowed both animals and human beings to migrate much more easily to North America, enabling rapid development of the continent.

The first complex civilizations, civilizations that create cities and think about how to fulfill their needs like getting easy access to water and food [Viegas, 2008] arose around 7000 years ago. Up and until the 17th century these civilizations were the main inhabitants of North America. Like most of the world's population at that time, the inhabitants from North America were hunters-gatherers, this means that 80% of their food came from gathering and 20% from hunting [com, 2008].

## 7.2 Colonization

Evidence (two Icelandic sagas: The Saga of Eric the Red and The Saga of the Greenlanders) is found that in 1000AD the first European explored North America: Leif Erikson, born around 970AD in Iceland, has visited a place he called Vinland around 1000AD [Goldingay, 2005]. Vinland was the Norse word for America and the *vin* part comes from the grapes Erikson saw growing there and the fertility of the land [BBC]. In 1960 the remains of a Norse city, three building complexes, were discovered. This Norse site, LAnse aux Meadows, is located at the northern tip of Newfoundland in Canada and is the only Norse city that has been discovered so far [Encyclopedia, 2005].

For many centuries Europeans did not try to explore the Americas as most believed the world was flat, thus going westward would go nowhere [Boller, 1995]. This changed halfway during the 15th century when Constantinople was captured by the Ottoman Turks in 1453 [Runciman], this meant that it had become more difficult for Europe to travel to Asia by land. In order to find an alternative way towards Asia, Christopher Columbus proposed a voyage west from Europe, but had problems getting the support needed for his plan. However, he eventually did get backing from King Ferdinand and Queen Isabella of Spain and he sailed off to the west. In that same year he reached land in the Bahamas [Clements R. Markham].

After Columbus there were more explorers from Europe that reached the east coast from America. In 1497 the Italian navigator John Cabot explored the east coast of Canada [16]. In 1524, Giovanni da Verrazzano explored the east coast from North America from Florida to Newfoundland until misfortune came his way during his third voyage and he was killed and eaten by native Carib inhabitants [Encyclopedia, 2009] and in 1534 Jacques Cartier penetrated the St. Lawrence River during his voyages on behalf of the French Crown [Encyclopedia, 2010]. These first explorers were sponsored by their country and they had to conquer land and convert inhabitants, collect taxes or start trade [Middleton, 2002].

### 7.2.1 New Netherland

During the 17th century Europe was growing socially, culturally and economically. This was especially true for the Netherlands, where it is called the Golden Age. During these years many intellectuals and businessmen immigrated to the

Netherlands. In 1609 the English sea captain Henry Hudson tried finding a passage to Asia for the Dutch East Indian Company when he encountered the east coast of North America. When he returned to the Netherlands he reported having found fertile grounds and other resources that would lead to trade possibilities. This lead to more Dutch expeditions to the east coast of North America [de Laet, 1625] .

In 1624, the first Dutch immigrants, a colony of about thirty families, set foot on New Netherland and in 1625 another forty-five Dutch families migrated to New Netherland. Also in 1625 Fort Amsterdam on Manhattam Island was founded, now known as New York City. Later on it was renamed to New Amsterdam and five years after that New Harlem was also founded. However, after the second Anglo-Dutch war (1665-1667), New Netherland was traded for Suriname and the new English rulers renamed New Amsterdam to New York. The Dutch recaptured New York later on but lost it to the English again.

Many places still have Dutch names, such as Lang Eylant (Long Island), Breuckelen (Brooklyn), Haarlem (Harlem), Konynen Island (Coney Island), Staten Eylant (Staten Island) and Helle Gat (Hell Gate). Also, many citizens of New York are of Dutch descent in direct relation to the citizens of New Netherland. The most famous among them are two Dutch families whose members have been presidents of the United States: the Roosevelt family (President Theodore Roosevelt and President Franklin Delano Roosevelt) and the Van Buren family (President Martin Van Buren).

## 7.3 Colonial period

Between the 15th and the 19th century, many Europeans migrated to North America. These people came from a variety of countries: Spain, Portugal, France, Great Britain and the Netherlands In the 19th century, more than 50 million people moved from Europe to the Americas [Eltis] and in the 16th century about 240,000 Europeans did [Axtell] [spa, 2010]. However, due to diseases and attacks from native Americans the population remained small for a long time, but with more and more Europeans moving to America for religious motives, conflicts and wars the population had risen to a quarter of a million by the end of the 17th century.

The European countries tried to control their colonies but had great difficulty with the huge distance between Europe and America. Another issue was that the European countries did not agree on how to control the colonies. Countries that had colonies in America were: Spain (Florida, New Mexico, California); the Netherlands (New Netherland; see also the previous chapter); Sweden (New Sweden); France (New France); Russia (Alaska); Britain (thirteen different colonies) [col, 2007].

In the next paragraphs we will take a closer look at Britain, having the most colonies in North America. Britain had three kinds of colonies: charter, provincial and proprietary. Provincial colonies had a government with commissions created by the monarch, but a governor and council were appointed with executive powers. The assembly could make local laws as long as they were consistent with Englands laws.

Proprietary colonies on the contrary were held by one or more family members of the monarch. Charter governments were political corporations with a fundamental constitution and a division of legislative, executive and judicial power [Donaldson, 1881].

Although there were some problems for European countries governing their colonies, most colonies did not become independent until much later. After the Glorious Revolution (1688-1689) in which William III of Orange-Nassau overthrew King James II of England and ascended the English throne, a plan was made to reinstall the colonies under the jurisdiction of the British Crown. In the 18th century, the British colonies were for the first time united under a colonial government [of Commons Information Office., 2002].

In the 18th century the British colonies started to take over French colonies in North America. This resulted in a war: the French and Indian war (1754-1763). From 1756 on, the war also took place in Europe between France and Great Britain and is known as the Seven Years' war. In 1763 the British won the war and took most of the French colonies.

To the original inhabitants of America the European invasion was disastrous: it resulted in displacement, diseases, enslavement and wars with the colonists. It is estimated that 80% of the native inhabitants died from common European diseases like measles and smallpox [Lange, 2003]. From 1670-1715 an estimated 24,000 to 51,000 Native Americans were sold as slaves by the British from the southern part of North America [of Commons Information Office., 2002]. About 60% of the population of North America consisted of slaves halfway the 18th century.

## 7.4 Independence

This Chapter is about the pressure of British government on the American colonies and the War for Independence.

In the ten years following the French and Indian war Britain issued several act's, like the Stamp Act, the Townshend Acts, the Sugar Act and the Tea Act Kindig [2010a] Kindig [2010c] Kindig [2010b] Greene and Pole [1991].Those acts were all meant to generate more money from tax income. The colonists opposed these acts, mainly because they had no representation in the British Parliament and that taxing them would thus be unconstitutional. The most wide known statement made by the colonists was the action, now known as, the Boston Tea Party. When three ships full of tea arrived at Boston, after the Tea Act was assented, the colonists tried to force the ships back to Britain, but the tea consignees did not back down Larabee [1979]. At a (non-official) meeting called by Samuel Adams, all people there decided that they would make sure that the tea would not be unloaded from the ships. The tea had to be unloaded within 20 days or it would be confiscated by the officials. At the last day before the deadline, a group of men disguised as Mohawk Indians climbed aboard the three vessels and, over the course of three hours, dumped all chests of tea into the water Alexander [2002]. The British government reacted with new laws, later known as the Coercive Acts. Twelve colonies came together at the First Continental Congress as a response to these acts. Although the Congress was unsuccessful in halting the enforcement of these acts, it had two important accomplishments: The first was a boycott of British goods by the colonies attending the Congress ed [1982]. The second accomplishment was to provide a second Congress in 1775.

### 7.4.1 The Revolutionary War

The American Revolutionary War started when a British commander sent regiments of soldiers to capture two Colonial leaders in Lexington and go to Concord to seize gunpowder. But spies and friends leaked this plan by hanging two lanterns from a Church in Boston to inform the colonial militia. As the word spread, a group of 70 militiamen awaited the Regulars in Lexington. At that first battle seven Americans were killed and the British troops moved on to Concord (after the arrival of some new regiments). But American militias arriving at Concord made the British army retreat to Boston. During the retreat they were plagued by small forces of militia shooting from behind fences and trees, inflicting over 125 casualties ushistory [Independent Hall Association].

This resulted in the Revolutionary War and the second Congress had to take charge of the war effort. The first decision was to create a Continental Army with George Washington as commanding general Cogliano [2000]. Washington accepted this job and chose to be a volunteer. The next problem to tackle was how to obtain money. The Congress solved this by authorizing the printing of money, and they assigned a committee to conduct relations with foreign governments when they would need help. Despite the battles at Lexington and Concord the majority of delegates were still not seeking independence from Britain. As a last effort to avoid war, they approved the Olive Branch Petition, a direct appeal to the King. The King refused to receive this petition and declared the colonies to be in a state of rebellion. The main cause for this was probably the Battle of Bunker Hill where the British troops conquer the hill after much losses (of the 2300, 1054 were either killed or wounded). As the war continued the need for independence grew. In July 1776 the Congress issued the Declaration of Independence, the birth of the United States. Because of the striking similarities between the Declaration of Independence and the Dutch Plakkaat van Verlatinghe, the latter was issued in 1581, Stephen Lucas thinks the Declaration might be based on the Plakkaat Wolf [1998].

But the war was not over, in 1778 the US got help from France Northrup [2003], in 1779 from Spain and in 1780 from the United Provinces (Dutch Republic). These combined forces ultimately defeated the British forces in 1781 after the British army got pinned down because their escape, a British fleet, was defeated by a French fleet. The last battle was fought on march 10, 1783, where the USS Alliance defeated three British warships. The formal negotiations to end the war were started in September 1782, and ended in September 1783. The negotiations resulted in the British accepting the independence of the United States, resolving the fishing rights, promised restitution of property lost by Americans loyal to the British cause and provided for evacuation of British forces from the States Inc [2010].

## 7.5 Westward Expansion

This chapter gives a brief overview of the expansion of the United States towards the west coast.

**Northwest Indian War** After the Revolutionary War, there were still some British agents in the United States and some sold weapons and ammunitions to the Indians and encouraged attacks on American settlers. These attacks were followed by a force of Federal soldiers who plundered several, almost unprotected, Shawnee towns. The chief of the Shawnees was killed in one of these attacks. The Shawnees retaliated by attacking American settlers, during the mid- and late-1780's approximately 1500 settlers and travellers were killed. The first offensive by General Josiah Harmar, in 1790, failed miserably after leading an inexperienced army into the territory of the Indians. A surprise attack killed most of the soldiers and civilians following the army. The next year, St. Clair, who ordered the first offensive, attacked the Indians with his own army. This army was also very inexperienced and was easily defeated. After these disasters General Anthony Wayne formed a well-trained force and defeated the Indians in the Battle of Fallen Timbers. The Treaty of Greenville, which ended the war, forced the Indians to move to the west, which made more land available for settlers. The boundary between the lands became known as the Greenville Treaty Line but white settlers disregarded this line frequently. Central [2010]

**The U.S. Constitution** In September 1786, commissioners from five states met to discuss adjustments to the Articles of Confederation to improve commerce. At the second Convention, where seven of the thirteen states were present, it became clear that the Convention could better rewrite the Constitution Archives and Administration [unknown]. The debates about the new Constitution were kept secret, so everyone could speak freely. The U.S. constitution was completed on September 17, 1787. The constitution was influenced by the Dutch constitution Alexander Hamilton [2004]. The congress decided that the new constitution was valid when 9 states ratified it. As soon as this happened (June 21, 1788), they decided to start operations under the new constitution on march 4, 1789. In 1791 The Bill of Rights added ten amendments, apart from these ten another 17 have been added, making a total of 27 amendments. Those, and the original Constitution form the current Constitution as is still used by the United States.

**The First President** George Washington became the first President of the United States under the new US Constitution, and is the only president to have received all electoral votes. Washington was authorized to choose the location of the permanent seat of the government, which is now known as Washington D.C. He also summoned the militia of several states to stop the Whiskey Rebellion America [1794].

## 7.6 The Frontier

The Frontier marked the western border of the U.S., outside this border lay the undiscovered part of America. This frontier shifted in several wars and purchases of land, as described below. As it was not tabulated in the 11th census (1890), this marked the end of the frontier.

**Louisiana purchase** In 1803, Thomas Jefferson doubled the size of the US by buying the territory of Louisiana from the French. This area still covers about 23% of the US. This purchase was one of the most important decisions Jefferson made while he was president. The Federalists strongly opposed to this purchase, and called for a vote to deny the request, but it failed by two votes. They also tried to prove that the land belonged to Spain instead of France, but there were papers proving otherwise. Their latest act was one of desperation; A group of Federalists planned a separate northern confederacy, but the Vice President, who has supposed to become President of the confederacy, did not accept the new function and the confederacy never became reality Pierce [2004] U.S. Department of the Interior [2003].

**War of 1812** There is not one cause for the war between the British Empire and the US, which lasted from 1812 to 1815. The British introduced trade restrictions in 1807 limiting trade between the US and France. They also impressed American citizens into the British Royal navy and supported American Indians who were attacking American settlers. These and more causes led to the war. In the US, the battles produced the sense of a "second war of independence" against Britain. During one of those battles a poem was created by Francis Scott Key, which would eventually supply the lyrics to the national anthem (The Star-Spangled Banner) Hubbell [1954]. In the end, the Treaty of Ghent was signed, which prompted the involved countries had to return the land to their previous owners (the prewar owners), the restitution of the prewar boundary. Parts of western Florida remained in American possession, although the Spanish objected. Also, some Native American tribes had to sign treaties with the US government because of their losses in the war Zuehlke [2006].

**Monroe Doctrine** This doctrine marks an important moment in the foreign policy of the US. It was introduced on December 2, 1823 and stated that no European power should colonize or interfere with the Americas. Would this still happen the U.S. would intervene. The doctrine was issued at the time when many Latin American countries were on the verge of becoming independent from Spain. The U.S. hoped to avoid having any European power take Spain's colonies. In 1823 the U.S. barely had an army of it's own, so the doctrine was largely disregarded at that time. It is, however, invoked by numerous presidents and is one of the longest-standing tenets David M. Kennedy [2006] Miller [2006].

**Indian Removal Act** The Indian Removal Act authorized the president to negotiate treaties that exchanged Native American tribal lands for lands west of the Mississippi river. It was used to force the migration of several tribes to the West. Several battles and small wars were fought between the US and the Native Americans who did not agree to this migration Service.

**Republic of Texas** Mexico invited Americans to settle in Texas, which at that time was part of Mexico and largely uninhabited, under the condition that they adopt Mexican citizenship and convert to Roman Catholicism. When in 1830 Antonio Lopez de Santa Anna became Mexico's president, he started stripping the Texas settlers of certain rights they had before. Although slavery was forbidden in Mexico, Texans still wanted to own slaves. In 1835, they revolted against Mexico and forced the president to declare them independent. Although this agreement was declared void by the Mexican Congress, Texas left Mexico alone for the next nine years. Most Texans wanted annexation to the United States, which happened on March 3, 1845 of the South [2008b].

**Mexican-American War** Mexico had warned the US that annexation would lead to a war. This, and some other causes lead to a war between Mexico and America. The results were not good for Mexico. This country lost about 55% of its national territory, and over two third if Texas is included of the South [2008a].

## 7.7 Civil War and Reconstruction

This chapter is about the Civil War and the Reconstruction after the civil war.

### 7.7.1 "pre-civil war"

After all disputes with foreign countries were settled, the differences within the United States started to become more visible. Tensions rose between the northern and southern states as the North want to prohibit slavery and the South did not.

**The Missouri Compromise** To uphold the balance of slave and non-slave states, the Missouri Compromise was accepted. This compromise prohibited slavery in the former Louisiana Territory north of the parallel 36 degrees and 30 arcminutes north except within the boundaries of the state Missouri Blaine [2000]. Thomas Jefferson believed that the division of the country created by this Compromise line would eventually lead to the destruction of the United States: ...but this momentous question, like a fire bell in the night, awakened and filled me with terror. I considered it at once as the knell of the Union. it is hushed indeed for the moment. but this is a reprieve only, not a final sentence. a geographical line, coinciding with a marked principle, moral and political, once conceived and held up to the angry passions of men, will never be obliterated; and every new irritation will mark it deeper and deeper.(Thomas Jefferson, http://www.loc.gov/exhibits/jefferson/159.html).

**Compromise of 1850** From the start of the Mexican-American War, enslavery was a hot and dangerous topic which threatened to tear the North and South apart. With the compromise of 1850 it was possible to avoid secession or civil war. This compromise was an package of five bills, being:

1. Admit California as a free state.
2. The slave trade was abolished in the District of Columbia.
3. The Territory of New Mexico and the Territory of Utah were organized under the rule of popular sovereignty

4. The Fugitive Slave Act was passed, requiring all U.S. citizens to assist in the return of runaway slaves.

5. Texas gave up much of the western land which it claimed and received compensation of $10,000,000 to pay off its debt.

Although the North was not happy with the Fugitive Slave Act, many historians argue that the Compromise played a great role in postponing the American Civil War, during which time Northwest and Northeast were growing closer Remini [2006]. But others argue that the Compromise only made more obvious sectional divisions and increased the chance of future conflict. Those views actually do not conflict because the new laws, both parties were satisfied for a moment, but after time the differences between North and South deepened The Columbia Encyclopedia [2010]. Postponing hostilities for ten years, the economy of the northern states continued to industrialize, unlike the south were the cotton industry based on slave labour lacked the ability to heavily industrialize Fox-Genovese [1983]. By 1860, the northern states were able to supply and maintain it's main army forces better, a very important advantage in the later stages of the civil war.

**Kansas-Nebraska Act** In 1854 another act was written to ease the relations between North and South. This act, the Kansas-Nebraska Act, allowed new states to decide for them self if they would allow slavery Johannsen [1973]. This (almost) nullified the previous two acts about slavery, especially the Missouri Compromise. The Missouri Line was now completely redundant. Unfortunately, this act had the opposite effect, instead of reassuring, the act made the gap even bigger [Nevins, 1947]. The act was signed by the President on May 30, 1884. A new party, the Republican Party, was created in opposition to the act and was aimed to stop the expansion of slavery. They soon emerged as the most dominant force throughout the North.

**Confederate states of America** After Abraham Lincoln, an outspoken opponent of the expansion of slavery in the US, became president, eleven southern states seceded from the Union, establishing a new government in 1961: The Confederate States of America Goodwin [2005].

### 7.7.2 Civil war

**Beginning of the war** The Confederate States attacked a Union controlled military installation at Fort Sumter on April 12, 1861 [6th ed]. This attack started the Civil War. In response, Lincoln dispatched detachments totaling 75,000 troops to protect the capital and preserve the Union. The Two armies had their first great battle fought at the First Battle of Bull Run, where the Confederate (surprisingly) won. The battle soon divided, taking place in both the East and the West. In the western states, the union was quite successful, winning the major battles. In the East however, most of the Union army commanders were not capable enough, there were several losses and several changes of commanders, who all failed to win from Robert E. Lee, until Meade McPherson [1988].

**Turnpoint of the war** Meade's first and most important battle was the Battle of Gettysburg, in which the Union won. it turned out to be one of the most bloody battles in the Civil War and is considered by many historians the turning point of war McPherson [1988].

**Rest of the war** After several more successes General Grant launched the war of attrition against Robert E. Lee's army. This war was separated into three main campaigns. The campaigns ended with the surrender of Lee on April 9, 1865McPherson [1988]. After the surrender many other Confederate armies also surrendered, effectively ending the war.

**Conclusion** The Civil war has been the deadliest war in the American history, 10% of all Caucasian males aged 20 to 45 died in the war Huddleston [2002]. After the Civil war, slavery was forbidden.

### 7.7.3 Reconstruction

Reconstruction took place for most the decade after the war. The "Reconstruction Amendments" were passed to expand civil rights for black Americans. In response, the Ku Klux Klan emerged as a white-supremacist organization. Increasing violence from this and similar groups influenced the Ku Klux Klan Act, classifying the KKK as a terrorist group. In 1876, after the election of Republican candidate Hayes, the Reconstruction ended and the Gilded Age began.

**Gilded Age** The Gilded Age is a term used by Mark Twain to describe the period from 1876 to 1890. During this period there had been a dramatic expanse of United States industry. At the end of the century America's per capita income exceeded that of every other country in the world and gained ranking as second nation of the world (behind Great Britain).

## 7.8 Progressive Era

This chapter provides a summary of what happened during the progressive era (1890s - 1920s.

**War** The United States began its rise to the a world superpower in this period, with a significant growth in both population as industrialization. They also had numerous military expeditions abroad, like the Spanish-American War (1898). This war, which was won by the US, contributed to the further weakening of the government in Spain, leading to it's fall. The United states gained several islands, Puerto Rico, Guam and the Philippines. Cuba became an independent nation Spa [1898].

**Corruption** One of the main goals was to remove corruption from politics, which was widely exercised during the Gilded Age. Some of this work was done by Muckrakers, journalists who exposed waste, corruption and scandals in the highly influential new medium of national magazines. The Progressive Era is also an era of modernization, they believed in science, technology, expertise, and especially education as the grand solution to society's weaknesses. Several acts were passed to prevent monopolies, trusts and regulation of rail road companies. these acts were not rigorously enforced until Theodore Roosevelt became President. Many of today's regulatory agencies were created in this time, like the Interstate Commerce Commission and the Federal Trade Commission. The Food and Drug Administration and the Federal Reserve were also founded in this era.

**Federal Reserve** The Federal Reserve is the federal, central bank of the U.S. Only this bank has permission to introduce US paper currency into circulation. According to the movie Zeit Geist, the U.S. was forced by the bank to become embroiled in wars, not to win, but to sustain the conflict, so the bank could profit from it. It also claims that it engineered the Great Depression and that it was responsible for the assassination of Louis McFadden, a congressman opposed to the Federal Reserve.

**World War I** In 1914, World War I started. America was not threatened by the war, it mostly played out on European soil. Until 1917 America pursued a policy of isolationism, avoiding conflict while trying to broker a peace. When a German submarine sank a British commercial ship, America pressed the Germans not to attack passenger ships, to which Germany complied. Willson tried to mediate a settlement repeatedly, but failed. Germany asked help from Mexico to attack the U.S. if the U.S. would attack Germany. They did this with a telegram, the so-called Zimmerman telegram. This telegram was intercepted and used by Wilson to ask the Congress to declare war on Germany. This happened on 6 April 1917. After America entered the war, the balance turned in favor of the Allies and by 11 November 1918 a cease-fire act was accepted. Isolationist sentiments following the war blocked the U.S. from participating in the League of Nations The Columbia Encyclopedia [2008].

## 7.9 Interbellum

This chapter is about the interbellum between the First and Second World War. These times can be divided into the roaring twenties, followed by the Great Depression US Department of State [unknowna].

### 7.9.1 Roaring Twenties

**Aftermath First World War** After the first World War the United States had the unilateralism policy tending towards isolationism, which meant that they wanted to stay out of the business of other countries. The United States was not part of the League of Nations, which was the predecessor of the United Nations. The main focus was towards the United States itself, and making rules and regulations for trading and cultural exchange. This was further influenced by the fear of communism that was considered a real threat for the American way of life. The result of this xenophobic behavior was the Immigration Act where immigrants from Asia and India were prohibited to immigrate, and the rest was limited to 2% of the total American population History [2010b].

**Prohibition** The Eighteenth Amendment to the US Constitution was better known as Prohibition and introduced in 1920. This prohibited the manufacture, sale, import and export of alcohol. The supporters of the Prohibition believed that no alcohol would improve society. But this amendment also let crime flourish alcohol on the black market, where Detroit was one of the prominent havens of imported alcohol. The prohibition ended when there was a repeal in 1933, with the Twenty-first Amendment Spaeth [1991].

**Women Suffrage** In 1920 the 36th state ratified the Nineteenth Amendment, which is known as Women Suffrage, making it an amendment to the Constitution. This was the result of a long process started in the 19th century and ended in 1920 and was fueled by the women's rights movement. Especially after the first World War, which was a war for democracy according to President Wilson, it became a hot topic that all democratic rights should be equal for both sexes. Although the bill and amendment were denied several times, it was accepted before the elections of 1920. This meant the law explicitly stated that women could vote McCammon et al. [2001].

**New Negro movement** The New Negromovement could be described as men and women of middle-class orientation who demanded their legal rights as citizens and wanted to tear down the old Negro stereotype. The first World War was a reality check for most African Americans that fought in France where they had a whole new kind of freedom they never had in the United States. The first World War also gave most African Americans the opportunity to make a decent salary, which further improved their wealth and society status. The peak of this movement was the Harlem Renaissance. Many artists, musicians, poets, novelist and others worked towards a new dignity and image of the African American. The movement was supported by the National Association for the Advancement of Colored People (NAACP) and other organization that wanted to improve the situation of African Americans. But the movement got a real blow when the great depression started and money became an issue Hutchinson [1995].

### 7.9.2 Great Depression

**Black Tuesday** During the twenties the US was very prosperous and wealth increased, this lead to the believe that the (stock)market could stay at the high price levels. This all changed on Black Tuesday, 29 October 1929, when stock-prices began to fall at an excessive rate and continued to do this for a full month. This incident was the start of the Great Depression which affected the worldwide economy and led to massive unemployment, deflation, low profits, poverty, and overall economic decline. The initial response of the government worsened the situation by imposing further protectionism rules on trade, which further decreased global trade with the United States. The low point was the winter of 1932-1933 where there was an unemployment rate of more then 20% White [1990].

**New Deal** The election program of Franklin Roosevelt was the "New Deal", his solution to the Great Depression. With this he won the election in 1932 and became 32nd president. The New Deal consisted of the reconstruction of the economy, by increasing government spending, making trade and production policies, supporting labour unions and creating employment. In his first 100 days he passed a record of bills and acts through the legislation bodies of the government to make the necessary reforms possible. The first new deal was primary focused on immediate relief, where the later deals were more structured on specific segments of the economy Skocpol and Finegold [1982].

## 7.10 World War 2

This chapter is about the second World War, and is divided into several subsections: Begin of the second World War, Europe Theater, Pacific Theater, home-front and technological advances US Department of State [unknownb], History [2010a].

### 7.10.1 Begin of second World War

The United States had isolated itself more and more from international affairs, and did not enter the second World War immediately. It entered the war much later then the other Allied countries did. The United States did supply the Allies (Soviet Union, Great Britain, China, France and others) resources via the Lend-lease program, this consisted mostly of war material. With this lend-lease program most allied countries could survive as it became a life line (especially for Great Britain). With Japan they cut of the supply of oil and other raw materials that they needed for their war effort. With a Japanese surprise attack on the military base in Pearl Harbor on 7 December 1941, the Americans finally entered the war. Declaring war against Japan was done the next day, by a special session of Congress. Four days later, December 11, Nazi Germany officially declared war against the United States.

### 7.10.2 Europe Theatre

The grand strategy of America was Europe First, which meant that most efforts would go into defeating Nazi Germany. The first year consisted of building up forces (mainly Air forces) in Great Britain. Their first efforts were bombing Germany with their bombers, however raids during the day were very costly and soon nightly raids began. Later on, this improved by better escort planes, like the P-51. The first joined land operations were in North Africa, this was in May 1943 together with the British, New Zealand and Australian armies. Although their very first operations were not always a success like the battle of Kasserine Pass, where the Axis forces won the battle. After this, advances were made with a landing in Sicily and the main land of Italy. In 1943 and 1944 the war began to change as the Axis forces were losing ground in the East by the Soviet Forces. For the Allied forces the war progresses on the main land of France, with the famous D-Day, that provided a foothold on Europe. Later that year an attempt (Operation Market Garden) was made towards the German inland, but this failed disastrously. In the winter of 1944/45 the last Axis offensive was fought (Battle of Bulge) which the Allies won. In may 1945 there was total unconditional surrender of the German Army signed, which ended the war in Europe.

### 7.10.3 Pacific Theatre

Where the Europe Theater got the main focus the Pacific was not forgotten, especially since the brutal surprise attack on Pearl Harbor dragged the United States into the second World War. In the first year of the war, 1941, the United States lost Guam and the Philippines but did not loose the entire fleet as the Japanese had intended. In 1942 the American Forces won the battle of Midway which could be seen as the crucial point in the Pacific Theater, as the Japanese lost four Aircraft carriers and thus most of their offensive power. The main strategy in the Pacific was Island Hopping, which meant that slowly strategic islands were captured while advancing towards Japan. In 1944 the Allied Forces captured the Philippines and also Iwo Jima and Okinawa. Although the Japanese forces had heavy losses, they would not surrender and even set out suicide missions, also known as the kamikaze. In August 1945 the United States dropped two atomic bombs on Nagasaki and Hiroshima and in result the Japanese agreed with the unconditional surrender, which ended the second World War.

### 7.10.4 Technology, homefront and conclusion

Technology played a crucial role in the second World War, for example the Manhattan project produced the first Atomic Bombs. With the war going on, there were much more resources available to develop and optimize technologies like electronic communication and detection. Also the first computers had their birth in the midst of the war.

In the start of the war, 1941, the government had to mobilize the entire country for the war effort. A drastic measure was to relocate 120.000 Japanese Americans in the war. This injustice and violation of civil rights where later on admitted by the United States. As the United States itself was not under attack, it could maximize production for the war effort and support the other Allied countries with desperate needed material and funds. In the end around 400.000 Americans lost their lives in the second World War. The United States had become a superpower after the war, and was the only nation with nuclear weapons. After the war there was a need for a global organization where international matters could be discusses, this was the United Nations in which the US took part. They abandoned the isolationism ways and had a greater international interest and involvement.

Another remarkable fact is that in this period Franklin Roosevelt served four terms of presidency (from 1933 till his death in 1945), which covered the Great Depression and the second World War.

## 7.11 African American civil rights movement

Before 1955 African-American people were discriminated against in the United States, especially in the southern states. The Separate but Equal doctrine allowed public facilities to be separated by race, on the condition that the quality of those facilities is equal. Practice learned that often coloured people got lower quality facilities. Violence against coloured people was not uncommon, also coloured people could often not register themselves to vote. In the period from 1955 till 1968, the African-American people stood up for themselves to attempt to be treated equally.

This section will cover some key events that lead to desegregation (equal treatment for all racial groups).

### 7.11.1 Montgomery Bus Boycott

Rosa Parks was a member of the National Association for the Advancement of Colored People (NAACP). In December 1955 Parks came back from a meeting where a strategy was discussed to disobey all laws that suppressed coloured people. In the bus, Parks refused to give up her seat to make room for a white passenger. This passenger called the police and Parks was arrested.

When this news reached the black community, the NAACP and the Montgomery Improvement Association organized the Montgomery Bus Boycott to demand equal treatment for all passengers in the public busses. Bus revenues were significantly reduced. In November 1956, the federal court ordered desegregation in Montgomerys busses. [Cozzens, 1999f]

### 7.11.2 Sit-Ins

In February 1960, four African American students walked in a store in Greensboro, North Carolina. They purchased school supplies and went to the lunch counter and asked to be served, knowing that they would probably not be. They were forced to leave when the store closed, but they had still not been served. The next day the students came with a larger group. The news about these sit-ins spread quickly and the civil rights organizations also helped spreading the word to college campuses. Two weeks after the first sit-in, students in eleven cities were holding sit-ins. [Cozzens, 1999d]

The strategy for these sit-ins was to go to the lunch counter, ask to be served. If they were served, they could go to the next lunch counter. If they were not served they would wait until they would be served. If they were arrested, a new group would take their place. The students often wore Sunday clothing, and they were always polite and nonviolent. These nonviolent confrontation tactics inspired activists to start the Freedom Rides. [Hartford, 2010c]

### 7.11.3 Freedom Rides

In 1961, civil rights activists wanted to test president Kennedys commitment to civil rights. The so called Freedom Riders took interstate busses to the south, and they sat in the front of the bus, to make the white people sit in the back of the bus. The first Freedom Ride departed on May 4, 1961 from Washington DC. [Cozzens, 1999e]

On May 14, two groups of Freedom Riders passed through Alabama. The first bus was attacked by a mob of about 200 people. They threw stones at the bus, but the bus managed to get away. About ten kilometres further the bus stopped to change tires and was firebombed, passengers had to flee for their lives. The other group was also attacked by a mob, and the Riders were beaten. Police arrived very late at the scene, it was later discovered that the FBI knew of the attack but arrived late on purpose. [Cozzens, 1999e]

Despite the attacks, the Freedom Riders did not give up. Most Freedom Riders got arrested for using white only facilities, a lot of Freedom Riders had to spend the summer in prison. The Freedom Riders forced the Kennedy administration to take a stand on civil rights. On November 1, 1961, a new desegregation order took effect: bus passengers were allowed to choose where they wanted to sit. Which was an important contribution to the civil rights movement. [Hartford, 2010b]

### 7.11.4 Birmingham Campaign

Martin Luther King Jr., who was president of the Southern Christian Leadership Conference (SCLC) finished a campaign in Albany, Georgia in the beginning of 1963. There was a change in the attitude of the people involved in the campaign, but King did not manage to make all public facilities open to both black and white people. He wanted to start another campaign and organized demonstrations in Birmingham, on April 6 1963, the police arrested 45 protesters who were marching to city hall. The day after, more people were arrested. Because of these protests, a judge ordered the civil rights leaders, including King to stop organizing demonstrations. While fighting for a change in Birmingham, King let himself get arrested on April 12. While in jail, he read an article in the Birmingham news, which called him a troublemaker. By writing on the margins of this newspaper he responded to this article. This response was later published as Kings Letter from Birmingham Jail. [Hartford, 2010d]

King was released on April 20. The SCLC organizers had already started planning new demonstrations, but unlike the other demonstrations, all demonstrators were going to be children. On May 1, children ageing from six to eighteen marched across the streets. They were arrested and put into police vans, however there were not enough vans and children had to be put in school busses. This day, nearly a thousand children were arrested and prisons were full. [Cozzens, 1999a]

The next day another thousand children skipped school to protest. Because there was not enough space in prison. The local government decided to use the fire fighters to use the water hoses to scare the children away, some children were injured. The news spread across the nation quickly and the Kennedy administration responded by desegregating public accommodations including lunch counters. [Cozzens, 1999a][Hartford, 2010d]

### 7.11.5 Civil Rights Act and Voting Rights Act

Kennedy had proposed new civil rights legislation, but some southern senators opposed and delayed this new legislation. On July 2 1964, president Johnson signed the Civil Rights Act of 1964, which banned discrimination based on race, colour, religion, or national origin. Lawsuits could be filed to enforce this law. This act also nullified local laws which required discrimination [Hartford, 2010a].

Before 1964 many coloured people were denied if they tried to become a registered voter. The Mississippi Freedom Democratic Party (MFDP) was one of the parties that wanted helped showing that coloured people truly wanted to vote. This political party soon got 80,000 members. However for a lot of coloured people it was still difficult to register themselves to vote. People had to pass a subjective test to register themselves to vote. It was up to the registrars to decide if someone passed the test or not. Coloured people were usually denied, even if they were more educated then the registrars. [Cozzens, 1999c]

On August 6, 1965 Johnson signed the Voting Rights Act, which meant that voters no longer had to pay to vote, and that voters no longer had to had to undergo a subjective voter test. This meant that even coloured people should no longer have problems with registering themselves to vote. The Voting Rigts Act and the political parties that promoted coloured people to vote were very effective: In 1964, 6.7% of Mississippis African American adults were registered to vote. By 1969, 66.5% of the African American adults in Mississippi had managed to register themselves to vote. [Cozzens, 1999b]

### 7.11.6 Assassination of Martin Luther King jr.

In the beginning of April 1968, King was in Memphis, Tennessee to support a strike for equal wages for African American workers. King resided in a Motel in Memphis. On April 4, King was shot while standing on the balcony, and he died in the hospital.

James Earl Ray, an escaped convict was the person who purchased the rifle that was used to shoot King. In March 1969 Ray confessed and was sentenced 99 years of prison. Even though Ray was found guilty, some people believed that the assassination of King was a conspiracy, but no solid evidence was found. [Foundation, 2010]

## 7.12 Cold war

### 7.12.1 Increasing tensions

When World War II had come to an end in May 1945, the Allied troops occupied the western half of Germany; the Soviet troops occupied the eastern half. In the Yalta conference, it was decided that the troops could stay there, and that they would not use force to push the other out. Soviet patrols guarded and closed the borderline, it would later be known as the Iron curtain. [Encyclopedia, 2007]

Truman and Stalin both had very different views on how Europe should be rebuilt after the wars, this sparked tensions between these two leaders. At the Potsdam conference, the two leaders were both very suspicious about the others intentions. Truman confirmed that the United States was in possession of a nuclear weapon. Stalins reaction was calm, he expressed hope that the United States would use it against Japan, which happened one week after the conference.[Gaddis, 2005] The

United States offered the soviets very little influence in Japan, which made Stalin protest.[LaFeber, 2002]

The Truman Doctrine, signed in May 1947, granted a total of 400 million dollars in military and economic aid to Greece and Turkey. This was done in order to contain the communist regime, the United States feared the spread of communism to western Europe and wanted to do everything in its power to contain communism. Containment of the communist regime became an important part of foreign policy. [Freeland, 1970]

The Marshall Plan was not only started to restore the economy in Western Europe, but also to prevent communism from spreading. In June 1948 Stalin responded to the Marshall Plan by blocking off all access to Berlin. Truman countered this move by flying supplies into Berlin. This meant flying cargo planes over Soviet territory. Since the planes were unarmed, they were no military threat to the soviets. The Soviets could only enforce the Berlin Blockade by shooting down the airplanes, which meant breaking previously made agreements. The Soviets chose to back off. After a little less than a year the blockade was lifted, leaving the Soviets humiliated. [Miller, 2000]

In 1949 the United States and eleven other countries formed the North Atlantic Treaty Organization (NATO). Stalin responded to this by starting his own version of the Marshall Plan to recover the Eastern European countries. He tested his first atomic bomb in 1949. Soon after, in 1950, he signed an alliance with China, and formed the Warsaw Pact in 1955, this was the East European counterpart of the NATO. Meanwhile the United States started developing the first Hydrogen Bomb, made plans to form an army in West Germany, and propose a peace treaty to Japan which would guarantee the United States some military bases in Japan. [Pappas, 2010]

### 7.12.2 Korean War

Since the Potsdam conference, Korea had been divided in two; the northern part was under Soviet control, and the southern part was controlled by the United States. In June 1950 the North Korean Peoples Army invaded South Korea with Stalin's approval. Truman managed to get help from the United Nations. Support soon arrived and after a year of war, a stalemate followed. Negotiations were started but because Stalin did not want to give up fighting, the stalemate lasted until Stalin's death, in March 1953. [Stokesbury, 1990] [Hickey, 2009]

### 7.12.3 Cuban missile crisis

The Cuban Revolution was an armed revolt lead by Fidel Castro. Fidel and his men have overthrew the dictator of Cuba in January 1959. The Soviets soon formed an alliance with Cuba. This was very important for the Soviet Union, because this new ally was very close to the American Coast.

The United States also wanted influence in Cuba, they trained and armed a group of Cuban exiles to attempt to spark an uprising against the new regime. They failed, and Castro declared Cuba as the first Communist state in the American Continents. After this failed invasion the Soviet government placed troops in Cuba. They also positioned some nuclear missiles which could attack at many different points in the United States at once. [Mintz, 2007a]

President Kennedy responded quickly, he quarantined the island. Several days later Kennedy and Soviet premier Khrushchev agreed to retreat if the United States would not invade Cuba and would remove all of their missiles from turkey. After this, the two leaders also decided to ban nuclear tests in the air and underwater after 1962. [Mintz, 2007a] [Museum, 2010]

### 7.12.4 Vietnam War

Since 1887, Vietnam was a French colony. During World War II, Japan occupied big parts of Asia, including Vietnam. The United States had sent troops to Vietnam in order to counter the Japanese presence. At the end of the second World War, China took the Northern part of Vietnam, and the British took the Southern area. The French got South Vietnam back, but the Vietminh (a Vietnamese independence movement) were trying to take control over Vietnam. For the containment of communism it was vital that this would not happen. As a part of the Truman doctrine, the United States shipped money and supplies to assist the French in Vietnam. This was not enough, the Vietnamese forces turned out to be stronger than expected and the French had to retreat in 1954. [Mintz, 2007b]

In order to keep South Vietnam independent, the United States sent its first forces to Vietnam in 1955. About two years later, in 1957, the North Vietnamese rebels (the Viet Cong) began attacks on the South Vietnamese government. President Kennedy was committed to increase defense spending and upgrading and modernizing America's army. He wanted to use air power and special forces to fight the guerrillas. The United States efforts were not working. In 1963 Buddhist priests set themselves on fire to protest against corruption in the South Vietnamese government. The United States responded by helping to overthrow the South Vietnamese president. [Mintz, 2007b]

The Viet Cong gave the United States a hard time. President Johnson (who became president after Kennedy was assassinated) wanted to prevent escalation of the war. However as the Viet Cong kept on resisting, more and more troops were sent to Vietnam. By 1967 the United States goal was more about avoiding a humiliating defeat then saving South Vietnam. More and more people were against this war, and the war was also very expensive. When President Nixon was elected in 1968, he planned withdrawal from Vietnam. In January 1973 South Vietnam, North Vietnam and the Viet Cong signed a cease-fire agreement. In April 1975 North Vietnamese tanks attacked the South Vietnamese presidential palace in Saigon, this was the end of the Vietnam War. [Mintz, 2007b]

### 7.12.5 Assassination of John F. Kennedy

On November 22, 1963. President Kennedy was assassinated during a political trip to Texas. Kennedy, aged 46, was shot in his back and killed with a shot in his head. Lee Harvey Oswald, who denied shooting anyone, was arrested on charges of the murder of the president. Two days after the death of president Kennedy, Oswald was killed by Jack Ruby. Ruby was convicted for the murder of Oswald. Before Ruby's trials were over, he became ill and died of cancer. Kennedy was buried three days after his assassination in Arlington National Cemetery. Some people believe that the Kennedy Assassination was a conspiracy. [McAdams, 2008]

### 7.12.6 The end of the Cold War

In December 1979 the soviet troops invaded Afghanistan to support their government. United States president Carter responded by withdrawing the treaty to reduce nuclear weapon production. He also imposed trade embargoes for grain and technology shipments to the USSR, he increased military spending and he announced that the United States would boycott the Moscow Olympic games in 1980. Carter described this as the most serious threat to peace since World War II [Gaddis, 2005].

When Mikhail Gorbachev became General Secretary in 1985 relationships improved [Gaddis, 2005]. Mikhail had an agenda of economic reform. The west was skeptic at first, but Gorbachev proved to improving the economic state instead of continuing the arms race with the western nations. [LaFeber, 2002]. In response to these concessions president Reagan to negotiate about scaling down the arms race. Negotiations started at the end of 1985 and soon they agreed to reduce their nuclear weapon arsenal by half. In 1987, at the third Reykjavk Summit, the Intermediate-Range Nuclear Forces Treaty (INF treaty) was signed. This treaty eliminated most nuclear missiles and their infrastructure. In 1989 president H. W. Bush and Gorbachev signed the START I treaty which reduced and limited strategic offensive arms. In the same year, the soviet troops withdrew from Afghanistan, and the soviets officially declared that they would no longer intervene in the affairs of allied states in Eastern Europe. When the Berlin Wall fell, it seemed that the "Common European Home", which was Gorbachev's vision on the future Europe where different communist and capitalist countries could live together, began to take shape. In December 1989 Bush declared the cold war was over. One year later, the Soviets and the United States fought as partners in the gulf war against Iraq. [Gaddis, 2005]

## 7.13 History of Technology

In this chapter we elaborate on the historical development of some of the most important technologies of the 20th century that we consider somewhat relevant to simulations and games. In order to decide which factors and actors influence the development simulations and games in the United States it is important to take a look at some other technologies to see what its role was.

### 7.13.1 Electrification

From 1831 on, several scientists tried to use electricity for lighting. Until 1880, none of these inventions were stable and save. Thomas Edison was the first one to develop a long-lasting lamp based upon the work of many inventors. Edison was not just a scientist, but a businessman as well. He immediately began to commercialize his invention and make different companies to manufacture the whole technological system upon which the light bulb would depend. Parts were generators, cables, generating plants, sockets and the bulbs themselves. These were produced by independent factories. These factories merged with others and formed the General Electric company. Edison decided that he would use DC (direct current), despite protests and good inventions from his rival Tesla, who favoured the use of AC. Tesla's invention were bought by George Westinghouse, and together they started building AC systems. Edison reacted with large promotion campaigns and a campaign led by Harold Brown, to show that AC was very dangerous. To demonstrate this, they used AC to electrocute animals. These demonstrations, and the electrocution of a prisoner finally led to the introduction of the electric chair as an alternative to hanging death row prisoners. A few years after the start of this 'war of currents' the first full electric convention was held. Because AC systems cost less and require less cables, Tesla got a contract to provide the electricity. At the convention itself, both Tesla and Edison gave a demonstration of their system. Tesla's system worked flawlessly, but Edison's system caused a power outage. Because of this, and other events, AC is now widely used throughout America. In fact, Tesla set the standard of using 60Hz. Although the convenient advantage of AC (which had lower costs and was more compatible with different types of machines), some cities provided DC, even up to 2007. The inventions of electricity, electrical engines, lights etc. revolutionized American industry. Electricity based systems were on all fronts better than the previously used steam powered systems Royster [2010]Muller.

### 7.13.2 Automobile

Most of the research and development of the automobile was done by Germans. The most influential person, from the United States, was Henry Ford. This was not because of his development of an automobile itself, but the development of the assembly line. In 1910, Ford implemented world's first assembly line to produce the T-Ford. With this assembly line it was possible to produce hundreds automobiles every day, instead of two to three. This, and some price reductions made the automobile affordable for most people, making it a mainstream product. The side effect of the production of the T-Ford was a very effective way of building products. Up until today assembly lines are still used all over the world, allowing mass production to History [2005].

### 7.13.3 Aircraft

The most known pioneers of aviation technology are the Wright Brothers. Together they developed the first good flying aircraft in 1903. Although no-one believed that they really invented a good aircraft, they became world famous for their aircraft after demonstrations in Europe and the U.S. They also invented the three-axis control system, this system is still used today in fixed wing aircraft. In the years following their success, several aviators copied some of their work for their own aircraft. One of them was Glenn Curtis, Curtis, who owned a bicycle shop, just like the Wright Brothers, joined the Aerial Experiment Association (AEA). He developed several aircraft for the AEA, where the third, the Dune Bug, was the most important. With this aircraft he won the Scientific American Trophy and received the first United States Pilot License. As a result, he, and aviation in general, were propelled firmly into public awareness. After this success, he started for himself, where he worked together with a naval officer to produce better aircraft. Both the Wright Brothers and Curtiss started a flight school. In the end, the Curtis and Wright companies were combined into the Curtis-Wright company metro library [unknown].

### 7.13.4 Radio and Television

**Radio** Tesla, who was an important inventor as stated in Electrification, also did work on the area of Radio. He got a number of patents on wireless transmission. Despite this, Marconi was wrongly named the inventor of the radio. It took until 1943 to set this right and mark Tesla as the inventor of the radio. Marconi however, was the one really working on radio transmission and was the first to transmit a transatlantic message, he did this in 1902. These early radios were not exactly stable, but other inventors soon invented ways to make it an effective communication system Bellis [2010a].

**Television** There were two distinct paths of technology, a mechanical system and an electronic television system. The latter was the better technology, providing better quality images. Much inventors did some work on the television, in the end resulting in the 'thick' television as was popular until a few years ago. Television, being a revolutionairy new technology for communication became one of the most important devices in one's home. It is also one of the fasted devices for one-way communication, which makes it an important device for the spreading of news Bellis [2010b].

### 7.13.5 Spacecraft

Spaceflight has developed greatly in the twentieth century. Konstantin Tsiolkovsky wrote the first proposal of spaceflight. The first rocket that actually reached space was a German rocket in June 1944 on a test flight. The first human spaceflight was Vostok 1 in 1961 with a Soviet cosmonaut. The US was the second nation to achieve manned spaceflight, also in 1961. Eight years later the American Neil Armstrong was the first person to set foot on the moon.

### 7.13.6 Computers

Although most families own a computer since the early or mid 90's, the first computer was designed way earlier by Charles Babbage. In 1822, he wrote a letter to Sir Humphrey Davy, a British chemist and inventor, explaining his design of a calculating engine which can be considered to be the first computer.

It was not until 1941 that the first computer was actually built; the German Zuse's Z3 was the first operating calculating device. In the next decade, the United States also built some computers: the Atanasoff-Berry Computer, Harvard's Mark I, ENIAC and a modified ENIAC. Many Europeans (like Babbage ans Zuse, but also Turing and Stibitz) contributed to the development of computers, but the US was not very far behind.

### 7.13.7 Internet

The first communication netwerks were built in the 1950s and 1960s. The ARPANET, the world's first packet switching network, was created by the Defense Advanced Research Projects Agency of the United States Department of Defense. These first networks are not like the internet as we know it, since they connected a very limited number of computers, for example a few computers at universities all over the US. The first e-mails were sent in 1965 by American systems: SDC's Q32 and MIT's CTSS. The World Wide Web as we know it was developed in 1989 by an employer of CERN, Tim Berners-Lee, a British computer scientist.

## Conclusion

The United States is a relative young country, but already has a turbulent history. From the revolutionary war towards being a superpower. In Table 7.2 the most defining moment for the United States of America are summarized.

| **Major events** | |
|---|---|
| **Period** | **Event** |
| 60.000BC - 1000AD | Migration of people towards the North American continent |
| Around 1000 | First European (Norse) discovers America |
| 1492 | Columbus discovers America |
| 15th - 19th century | Colonization by European countries |
| 1775 - 83 | American Revolutionary War and Independence |
| 1789 | First President of the United States of America ( George Washington) |
| 1861 - 65 | Civil war, between the Northern and Southern states |
| 1917 - 18 | Participation in the first World War |
| 1929 - 33 | Great Depression, international economic decline |
| 1941 - 45 | Participation in the second World War |
| 1945 | First Nuclear bomb, start of Nuclear Era |
| 1945 - 89 | Cold War between the United States and the Soviet Union |
| 1955 - 68 | Civil rights movement by African American, for equal rights |
| 1959 - 75 | Vietnam war |
| 1962 | Cuba Crisis: Soviet Missiles on Cuba |
| 1969 | First man on the moon (Neil Armstrong) |

Table 7.2: Short overview with major events and milestones in the history of the United States

The relation between the United States and the Netherlands is not always obvious, although they share some history. The Netherlands (United Provinces) had a colony at the Hudson river: New Amsterdam (currently known as New York). The immigrants also brought in Dutch names like for example: Roosevelt and van Buren. Later the Netherlands assisted in the Revolutionary War and the Constitution of the United States was inspired on the one of the United Provinces. Since the independence of the United States it had strong trade relations with the Netherlands. It was the second World War where the United States were part of the Allied Forces that drove out the Axis forces from the Netherlands, and later assisted with the rebuild with the Marshall Plan. In the Cold War the Netherlands and the United States were part of the same coalition (NATO).

The main goal was to to explore the macro factors that support or inhibit the development and application of simulations and games in history the United States. At first it may seem that the history of the United States has little in common with games and simulation, as computers have only been common since the last 20 years. However on a higher and abstracter view, we could determine some factors that contributed towards the advancement of computers, simulations and games.

- War contributes in different ways:
  - Focus on technology: In times of war there seems to be more focus on technological improvements, although mostly military. After a war or period of time it can be used and/or transformed for public usage. For example: First computers, GPS and ARPANET.
  - Scenarios: War provides good scenarios for simulation for training and recreation purposes. It can also provide inspiration for games and/or simulation for studies and alternatives analysis.
- Democracy, independence and (civil) rights: From the very declaration of independence in 1776, the United States always protected and promoted their independence. The belief in the democratic system and rights of its citizens has high priority within the country. This is a fundamental pillar in which innovation and capitalism can thrive.
- Capitalism: The belief in a free market, without to much interference of the government. This results in fast and dynamic economy which is profit driven, but also competitive, innovation and knowledge driven. For example the DC versus AC choice when electricity was introduced.

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# Chapter 8

# Politics

*Section by Nils van Kleef, Johan Noltes, Steven van der Vegt and Thomas Visser*

## 8.1 Introduction

This chapter gives a brief summary of the political macro factors and actors at work in the United States. Their support or inhibition of the development and application of simulations and game technology in the United States will be discussed. The discussion of the political macro factors is split in an international and a national section. This chapter focusses on the last hundred years. Older political aspects can be found in the History section.

## 8.2 International politics

### 8.2.1 Introduction

In the 20th century, the international system has changed from the traditional nation-state oriented system to a structure containing many nonstate actors, failing states and ungoverned areas. Although the nation-state remains the dominant political body, the international system has expanded with international organisations, multinational corporations and non-governmental organisations, terrorist groups. The United States has to deal with opportunities for both conflict and cooperation with these other actors [Stolberg, 2006].

This chapter discusses the international politics and legislation with respect to the United States of America. It will be discussed how the foreign affairs are incorporated in the government, what international challenges the United States have faced and what the role of the United States is in international society.

### 8.2.2 Foreign affairs

The foreign policy of the United States of America is led by the United States Secretary of State as the head of the United States Department of State, equivalent to the ministry of foreign affairs in many other countries. In the Obama administration, Hilary Clinton is assigned to this position. The mission statement of the department is as follows:

> "Advance freedom for the benefit of the American people and the international community by helping to build and sustain a more democratic, secure, and prosperous world composed of well-governed states that respond to the needs of their people, reduce widespread poverty, and act responsibly within the international system." [Department of State, 2009]

The U.S. Secretary of State is the primary conductor of diplomacy with other countries. By constitution, the President is given ultimate authority over foreign affairs and is, as the Commander in Chief of the United States Armed Forces, in charge of the armed forces. The constitution does however allow the President to appoint public officials with the advice and consent of the Senate to certain positions and corresponding responsibilities. This is an important property allowing the creation of the government and is discussed more thoroughly in the following chapter. The foreign policy powers of the Senate include the authority to declare war (as the only political body in the United States Government) and the regulation of commerce with foreign nations. [of the U.S. Constitution]

**International accords** The U.S. law distinguishes between three types of international agreements: treaties, congressional-executive agreements and sole-executive agreements. Treaties are long term commitments between actors in the international system. These can be made by the President with the advice and consent of two-thirds of the Senate only. Congressional-executive agreements can be made by the President with only a majority of the Senate and House of Representatives. Sole-executive agreements can be made by the President alone, without intervention from the Congress. The last two types of agreement are not defined in the Constitution but the Supreme Court considers them valid [Helms, 2001].

**Foreign affairs in the constitution** The creation and coming into force of a treaty is described by Article 2, Section 2, Clause 2 of the Constitution:

> "(..) He shall have Power, by and with the Advice and Consent of the Senate, to make Treaties, provided two thirds of the Senators present concur; (..)" [of the U.S. Constitution]

The clause grants the President with the power to compose a Treaty, which then has to be approved by the Senate. A treaty is approved by and with the advice and consent of the Senate, for which normally a majority is enough. In this case, it is specifically stated that a two-thirds vote is needed, to ensure bipartisan support. [senate.gov, 2010].

After a treaty is approved, it becomes effective as a part of the U.S. federal law. This means that the Congress has the same power over the treaty as it has over regular laws. The Congress can choose to modify or repeal the treaty, even if consequently international law is violated.[Helms, 2001].

The Congress is the only body of the U.S. Government with the power to declare war. All the powers of the Congress powers are listed in Article 1, Section 8, containing eighteen clauses. Clause 11 of that section describes the Congress' powers related to war:

> "(..) To declare War, grant Letters of Marque and Reprisal, and make Rules concerning Captures on Land and Water; (..)" [of the U.S. Constitution]

A Letter of Marque and Reprisal is a letter that was traditionally used to give a civilian the right to capture an enemy ship, often pirates, and take its goods. In 2001, after the terroristic attacks, it was proposed to renew the use of letters of marque and reprisal, lining the attacks under air piracy, as a tool against terrorism. [Paul, 2001]

By the third Clause of the same section 8 the Congress is also granted with the power to regulate commerce:

> "(..) To regulate Commerce with foreign Nations, and among the several States, and with the Indian Tribes; (..)" [of the U.S. Constitution]

This clause has been interpreted very broadly and served as a constitutional basis for many laws passed by the Congress over the last fifty years. [Kenneth R. Thomas, 2005]

### 8.2.3 Recent history

Since the conclusion of the Cold War around 1991, new international problems have presented themselves. The new issues include tensions in the Middle East, terrorism, the threat of new nuclear powers and climate change. Also, the relation between the United States and Russia are subject of renewed tensions.

#### Middle East

Since the war between Iran and Iraq (1980-1988), the United States of America have been involved in several conflicts in the Persian Gulf. The United States supported Iraq against Iran in the Iran-Iraq war. In the Gulf War (1990 - 1991), the invasion of Kuwait by Saddam Hussein's Iraq, the United States fought against Iraq as President George Bush deployed American forces as an ally to Kuwait [Mearsheimer and Walt, 2003].

After the British Mandate of Palestine fell apart into two states (1947), Israel and Palestine, the United States immediately recognised Israel as a country. The relation between the United States and Israel is based on common democratic values, religious affinities and security interests. More than any other state, Israel receives foreign aid from the United States. The United States Congress has been supporting Israel's military campaigns as acts of self-defense but condemns other acts of violence towards Palestine [Migdalovitz, 2007].

**War on Terror**

After the attacks upon the United States on September 11, 2001, by Al-Qaeda, President George Bush launched a campaign to eliminate international terrorism [Bush, 2010]. Two main operations of this campaign, besides smaller operations in the Philippines, the Horn of Africa and the Sahara, are the War in Afghanistan and the Iraq War. President Obama renamed the campaign to "Overseas Contingency Operation" [Kamen, 2009].

**War in Afghanistan** On October 7, 2001, the United States and the United Kingdom started Operation Enduring Freedom with the goal to overthrow the Taliban regime in order to remove Al-Qaeda from Afghanistan. Preceding to the invasion, President Bush issued an ultimatum demanding that the Taliban, among other things, would deliver Al-Qaeda leader Osama Bin Laden. The Taliban responded by stating that there was no evidence that linked bin Laden to the attacks and the invasion commenced.

After the initial operation by the United States and United Kingdom, the United Nations established the International Security Assistance Force (ISAF) in 2001. In present day, the ISAF is still in Afghanistan and consists of troops from 42 countries, including The Netherlands. In many of the participating countries the majority of the public does however want their troops to return home [Pew Research Center, 2010].

**Iraq War** The Occupation of Iraq started at March 20, 2003, when American and British forces entered the country. The main argument for the invasion that the Bush administration gave was the threat of Saddam having weapons of mass destruction (WMD). In 2002, the United Nations Monitoring, Verification and Inspection Commission was sent to Iraq to investigate whether or not Iraq did possess WMD. The commission found no evidence that Iraq had WMD but, although the Iraqi government did cooperate relatively[1] well, suspiciously few official documents on the weapons program were found. [Blix, 2003] The U.S. also suspected Saddam of supporting al-Qaeda, but the grounds for this claim have been subject of discussion [Mearsheimer and Walt, 2003].

After the invasion, the Iraq Survey Group led by the CIA and the DIA concluded that Iraq had not possessed weapons of mass destruction recently. Traces of weapons were found, but they dated from before 1991. The Iraq Survey Group also stated that Iraq had the ambition to renew its weapons program after the UN sanctions, which began in 1990 after the invasion of Kuwait by Iraq, would be lifted. [Iraq Survey Group, 2010]

Nine months after the start of the invasion, on December 13 Saddam Hussein was captured. On December 30, 2006, he was executed after the trail in which he was found guilty of crimes against humanity. [loc.gov, 2007]

After Saddam Hussein was captured, the situation in Iraq deteriorated and eventually resulted in a situation were several sections of the Iraqi population fought each other as well as the coalition forces. The situation was described by the U.N. as "civil-war like".[un:, 2006] In the mean time, the new constitution had been ratified

[1] The United Nations Special Commission that was present in Iraq from 1991 to 1998 was thwarted by the Iraqi government.

and the first elections since the invasion, which resulted in the current government, took place.

To fight the increasing violence, Bush announced on January 23, 2007, that more than 20,000 additional soldiers and Marines would be sent to Iraq. [Bush, 2007] The level of violence dropped 80% as a result of the operation as stated by the U.S. Defense Department in December 2008.

The Obama administration has planned a withdrawal period of 18 months, starting February 2009. Iraqi Prime Minister Nouri al-Maliki supports the U.S. in this schedule.

**Role of The Netherlands in the War on Terror** The Netherlands is involved in the War on Terror as an ally to the U.S. and a member of the NATO. The Netherlands contributes to the International Security Assistance Force (ISAF), active in Afghanistan, with 1,880 soldiers, 2.1% of the ISAF military force. [Pew Research Center, 2010] The Dutch soldiers are involved in the improvement of security, social development and the construction of public administration. [rijksoverheid.nl, 2010a] Task Force Uruzgan, the name of the operation led by the Dutch, will end August 2010, when all soldiers will return home. This discussion was not without controversies, as the Dutch government fell on February 20, 2010, over the question wether or not to extend their stay in Afghanistan. [Politieke redactie NRC Handelsblad, 210]

The Iraq War was originally only supported in a political way, stated the Dutch Prime Minister Jan Peter Balkenende. Whether or not the Dutch military did contribute to the invasion secretly remains highly debated. Some research journalists found evidence of Dutch participation, while an official investigation by the "commissie-Davids" concluded a lack of evidence [Vrij Nederland, 2010]. In Iraq, the Netherlands takes part in the NATO Training Mission - Iraq (NTM-I), assisting the training of Iraqi Police and the military force of Iraq. The support started in August 2004, when Dutch military arrived in Bagdad. The goal of the mission is the development of the Iraqi security personel. The operation is progressing according to plan, despite the difficult circumstances. Since August 2009 the Netherlands contributes five of the total 190 soldiers to the NTM-I. [rijksoverheid.nl, 2010b]

The Netherlands also contributes to the Stabilisation Force Iraq, from July 2003 to March 2005. In that time, 1,100 soldiers were active in the province of Al-Muthanna in southern Iraq. On March 7, 2005, the Dutch forces transferred the command to the British, ending the twenty-month operation in which two Dutch soldiers gave their lives. [rijksoverheid.nl, 2010b]

### Nuclear threat

President Obama called the possibility of a terrorist organization obtaining a nuclear weapon "the single biggest threat to U.S. security, both short-term, medium-term and long-term." The main concern is Pakistan, were Taliban and al-Quaida coexists with the world's fastest-growing nuclear arsenal. Pakistan is willing to work with the international community in finding a solution to the international concerns, but at the same time wants to keep the possibility for nuclear weapons open in case of an armed conflict with India. The two countries are in conflict since they came into existence in 1947. [Broad, 2010]

In 1970, the Nuclear Non-Proliferation Treaty came into force. The treaty recognizes six nuclear weapon states (NWS): China, France, Soviet Union, the United Kingdom and the United States. For these countries, the NPT prohibits the transfer of nuclear weapons and the assistance to an non-nuclear weapon state (NNWS) to acquire nuclear weapons. The other countries (i.e. the NNWS) that ratified the treaty agree not to possess nuclear weapons. All parties agree to accept investigations by the International Atomic Energy Agency (IAEA) to verify if they comply to the treaty. India and Pakistan, together with Israel, are the only three countries that did not sign the treaty. North-Korea withdrew from the NTP in 2003 after being accused of the possession of nuclear weapons. The country claims it possesses nuclear weapons and conducted nuclear tests in 2006 and 2009. [cia, 2010] In 2009, North Korea withdrew from the six-party talks, a number of meetings aimed at resolving international concerns about the North Korean nuclear weapons program with South Korea, China, the U.S., Russia and Japan, and has been rebuilding its nuclear program since then. [Landler, 2009]

Although Iran did sign the NPT and claims its nuclear program is exclusively for peaceful purposes, which is allowed under the NPT, there are concerns that Iran is pursuing a nuclear weapons program. The U.N. Security Council adopted resolutions which imposed sanctions on Iran as long as the country refuses to suspend its uranium enrichment. Although Iran has cooperated with the IAEA, the agency still has some concerns. [Kerr, 2009]

### Climate Change

In 1997, the Kyoto Protocol was presented as an extension to the United Nations Framework Convention on Climate Change (UNFCCC), with the goal of “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.” [unfccc, 2010] Former U.S. President George W. Bush however did not sign the protocol, causing the protocol not to reach the Congress. President Obama presented the New Energy for America plan during his electoral campaign, aimed at, among others, investing in renewable energy and addressing the global climate crisis. Obama established a new office in his government, the White House Office of Energy and Climate Change Policy, signaling that the climate change is indeed an important issue of today’s politics.

### Tensions between the United States and Russia

With the end of the Cold War, denoted by the collapse of the Soviet Union in 1991, a period of high tensions between the U.S. and Russia, which was called the Union of Soviet Socialist Republics (USSR) before then, came to an end. In the years that followed, the relation between the two superpowers improved. George H. W. Bush and Bill Clinton had good relationships with Boris Yeltsin, the first President of the Russian Federation, the Russia as we know it now [Encyclopædia Britannica, 2010a]. The relation between Vladimir Putin, Yeltsin’s successor, and George W. Bush was much colder. The intention of the U.S. and the NATO as a whole to expand to Eastern Europe was perceived by the Kremlin as conceivably hostile. In 2002, Bush withdrew from the Anti-Ballistic Missile Treaty, enabling him to build a missile defence system, partially located in Poland. [Encyclopædia

Britannica, 2010b] Putin, in return, worked to strengthen ties with Iran, China and India [Encyclopædia Britannica, 2010a].

In 2008, Russia was involved in a growing military conflict between neighbour Georgia and South Ossetia, a separatist region of Georgia. Dimitry Medvedev, who had just succeeded Putin a few months earlier, decided to send troops to South Ossetia and support the rebels. NATO condemned Russia's actions towards Georgia, who was hoping to join the NATO. In response to NATO's reaction, Russia put the cooperation with NATO to a halt. One month later, the Russian troops left Georgia. [Encyclopædia Britannica, 2010a]

In early 2009, a new chapter in the ongoing dispute between Russia and neighbour Ukraine escalated into a conflict with Europe [NRC Handelsblad Redactie, 2009]. It was "the most serious security event in relation to gas that has ever happened in Europe" , stated the Oxford institute for Energy Studies [Ferrero-Waldner, 2009]. Gazprom, supplier of natural gas and former Russian state enterprise, accused the U.S. of pulling the Ukrainian strings, who was at that moment in the process of becoming a NATO member[2]. [zha, 2009]

During the Obama administration, Russia and the U.S. decided to 'reset' their relations and did so by symbolically pressing a reset-button [Shuster, 2010]. On April 8, 2010, both states signed the New START (Strategic Arms Reduction Treaty) treaty, the newest in a series of treaties that aimed at reducing the number of nuclear weapons, inter-continental ballistics and weapons in general.

#### U.S. and the control of world oil

One of the most important driving forces behind the U.S. foreign policy is oil. Many say that there was a hidden agenda behind the Iraq war, that it was a measure to secure the production of oil. The U.S. dependence on oil imports is steadily increasing and can be seen as the 'Achilles heel' of American power. Therefore, it is in the nation's interest to increase oil production and the diversity of sources of supply.

A number of U.S. politicians have had close links with the U.S. oil industry, most notably President George W. Bush and Vice President Richard Cheney. Currently, the U.S. foreign policy and U.S. companies are the central power behind the structure of the worldwide oil industry. In good times, it enhances global economy and politics, but in bad times it could serve as leverage.[Bromley, 2005]

### 8.2.4 International relations

In this section we look at the neighboring countries Mexico and Canada. What is their shared history, how did their borders came in to being, and what major treaties do they have? We put some extra focus on NAFTA, a treaty which they all share together.

#### Neighbouring countries

**Canada** Canada and the US share a history of more than two centuries together. They were in war only once during the war of 1812 when the US invaded British

[2]Current President of Ukraine Viktor Janoekovitsj, elected in February 2010, cancelled the admission.

North America. They share the largest border in the world (8,891 km). According to a nation wide poll the USA citizens have a positive perception of Canada. Canada placed first in the annual Gallup country rating. [Saad, 2010]

**Border** The present border originated with the Treaty of Paris in 1783 which ended the war between Great Britain and the separating colonies. After surveying all the land of the colonies they both agreed that the land boundary would be placed mainly along the 49th parallel. The water boundary was not settled for some time. This resulted in the Pig war which was a small incident on one of the island in the dubious area. An American farmer shot a pig of a Canadian farmer because it was eating his crops. They couldn't agree on the compensation and the case escalated. They both called for there army which than resulted in a discussion about which country owned the island. Due to this conflict the borders got finally fixed, with the pig as the only casualty of the incident.

The border is the largest undefended border in the world. Citizens can cross the border freely but have to register themselves at an immigration officer.

**Diplomatic relations** The US and Canada have a very successful international relation. They are each others chief economic partners and their economies have merged even more since the NAFTA (see below). The elaborate in international conflicts such as the world wars and the cold war. Due to the open border and NAFTA there is a high volume of migration and trade.

**Mexico** Mexico lays at the south border of the USA. The share a border of 3,169 km (1,969 miles) with each other and according to figures of the International Boundary and Water commission it is the most frequently crossed border in the world with about 250 million people crossing every year [Staff, 2006]. The total area of Mexico is 1,972,550 km$^2$ with a average population density of 55/km$^2$. This is much higher than the US 31/km$^2$.

**History** In this paragraph we will put our focus mainly on the shared history of Mexico and the US. The time before the US independence is therefore out of this scope.

Mexico and the US have a complex relation with each other. Two interesting periods to notice are the Texas Revolution (1835-1836) and the Mexican-American War (1846-1848).

The Texas Revolution was a military conflict between Mexico and settlers in Texas. Back then Texas was an part of the Mexican state Coahuila y Yejas. An American banker was granted a large piece of land in that area. His son brought 300 families into Texas for settlement and fruition. In 1829, because US immigrants outnumbered the local population, so the Mexican government decided to introduce property tax, increase tariffs on US shipped goods and forbid slavery. Many settlers refused to obey this new laws which led to Mexico closing the border to the US. In 1835 General Antonio Lopez de Santa Anna became the dictator of Mexico. He was determined to enforce the new laws. In the following year Texas settlers fought there way to independence. Texas stayed an independent state until 1845 when on 1 March they signed a bill and became the 28th state of the USA.

While Texas considered themselves as independent, Mexico never acknowledged this independence and saw them as a rebellious region that would be retaken. They warned the US several times that annexation would mean war. So after the bill was signed in 1845 Mexico broke all diplomatic relations with the US. Due to some circumstances a similar situation as in Taxes now started to happen in California, also a part of Mexico that time. They were playing the Texas game and declared California independent from Mexico. On November 10, 1845 the US did an offer to buy Texas and California for 25 million USD (around 625 million USD today). The government of Mexico was very unstable and unable to make a decision. After this peaceful attempt things escalated. On April 25 1846 a 2000-strong Mexican cavalry attacked a 70-man patrol in the Texas Area. After this event the US declared war with Mexico.

After 2 years of battle the two countries signed a peace treaty. Mexico was outnumbered and not able to defend itself anymore. Mexico lost more than 1,300,000 km$^2$ of land (55% of its national territory). US gained California, Nevada, Utah and parts of Colorado, Arizona, new Mexico and Wyoming.

**Treaties** USA and Mexico have several treaties such as the Gadsdem Purchase and the North American Free Trade Agreement. They are both members of various international organizations such as the Organization of American States and the UN.

**Gadsden Purchase**

This treaty is signed by President Franklin Pierce on June 24, 1853. It is a purchase of a 76,800 km$^2$ region at the south of Arizona. The ground was bought because of the upcoming railroad era. Linking the South with the Pacific coast would expand trade opportunities, but the area between the to destinations was supposed to be to mountainous. The land was acquired for $10million$(241,000,000 today).

**Organization of American states**

International organization headquartered in Washington D.C. Its members are the 35 states of Americas.

**NAFTA** The North American Free Trade Agreement is an agreement signed by the governments of Canada, US and Mexico creating a trilateral trade block in North America. This agreement was signed on January 1, 1994 and consists of two supplements: the North American Agreement on Environmental Cooperation(NAAEC) and the North American Agreement on Labor Cooperation (NAALC).

The goal of NAFTA was to eliminate trade and investment barriers between Canada, USA and Mexico. Trade between US-Canada trade was mostly already duty free, but it included a serious reduce in tariffs between US-Mexico trade.

An agreement like the NAFTA could have a huge impact on the environment. For that reason the Clinton administration included a side agreement on the environment with Canada and Mexico. This led to the creation of the Commission for Environmental Cooperation (CEC). The CEC created a framework to study the influence of NAFTA on the environment. Their conclusion was that NAFTA was not a systematic tread to North American environment. The most serious increases in pollution due to NAFTA were found in the base metals sector, the Mexican petroleum sector and the transpiration equipment sector in the US en Mexico, but not in Canada. [Reinert and Roland-Holst, 2000]

**Effects of NAFTA** Last year the treaty was in place for 15 years and the NAFTA studied the effects of the decrease of tariffs and taxes between the three countries. According to the NAFTA-rapport the last 15 years North America has enjoyed a steady economic growth, there are more high-paying jobs and consumers, families farmers and businesses have more purchasing power.

Since the Mexico's membership of NAFTA they attracted a lot of big companies. These companies see Latin America as an investment to America. Once based in Mexico they can export goods to the US easily. Companies as Wal-mart are opening stores in Canada and Mexico. Corona is with 29Due to the tariff free in- and export of goods between the participating nations and the low wages in Mexico, companies place large assembly-plants across the border of Mexico. After assembly goods return to the USA.

Canada and the US are each others chief economic partners. Since NAFTA their economies have increasingly merged. According to a 2007 study commissioned by the Canadian Embassy in the United States, CanadianAmerican trade supported 7.1 million American jobs. [naftanow.org, 2010]

#### Major multilateral relations

**North Atlantic Treaty Organisation** As a member of the NATO, the United States is involved with the other 27 members. The main implication is that when another member state is attacked, the United States is obliged to support their NATO ally.

**United Nations programs participations** The United States played an important role in the establishment of the United Nations (UN). However recently the UN is losing its popularity in the USA. A movement against the USA's participation in the UN advocates the restoration of the sovereignty of the USA. This will be discussed here.

**World Trade Organisation** The United States is a member of the WTO. Relevant agreements of the WTO will be discussed, e.g. the General Agreement on Trade in Services, the Trade-Related Aspects of Intellectual Property Rights Agreement and the Agreement on Technical Barriers to Trade.

#### Major bilateral relations

Describes the relation with China, France, Germany, Israel, The Netherlands, Iraq, Iran, North and South Korea, Japan and Russia. Also, the influence of the participation in the multilateral relations on the bilateral relations is discussed.

### 8.2.5 International treaties

Several international treaties in which the United States were involved and/or signed are: the Oslo Accords (1993), the World Intellectual Property Organisation Copyright Treaty (1996), the Rome Statute of the International Criminal Court, the

Patent Law Treaty (2000), the Convention on Cybercrime (2001), the Strategic Offensive Reductions Treaty (2002) and the Kyoto Protocol (2005).

### 8.2.6 Relation to games and simulations

Games are very popular outside the United States, in Europe and Asia [Feng et al., 2005]. In this section we'll discuss the implications that the international politics has on the development of software outside the US. We will look at the export of software and IT services of the neighboring countries Canada and Mexico.

Why or why not would it be interesting to outsource your software-project to one of these countries? NAFTA creates the opportunity of free import and export of all products between all the three participating countries and it protects the intellectual ownership. What specific properties do these countries have in software and computer services?

Canada exported for 4,000 billion USD of software and computer services in 2003. This seems a lot, but US firms exporting goods back into the US account for a vast amount of this. There are several advantages of outsourcing to Canada. Canada is considered politically stable, they have the same timezones as US, US cities are nearby and Canada has English as its main language. Although Canada's wages are a bit lower than in the US outsourcing to Canada is less interesting because of currency risk, especially in case of a weak dollar. Some figures: There are 240,000 IT specialist in Canada. Each year the educational system produces 6000 software engineers. The rest is result of migration into Canada. Because of the high cost for a programmer (28,000 USD p/y) the focus in products is mainly on high level design and development [Computerworld, 2003a].

Mexico exported for 30 million USD of software and computer services in 2003. The industry is relatively small compared to other countries like India and Russia. There are a few advantages for outsourcing your software project to Mexico: the wages are low, Mexico has the same timezones as the US and Mexico offers an ideal starting point to access the Latin American market. The amount of exported goods is considered low. This allocated to the low supply of English speaking personnel and the low levels of experience and expertise. For example there are only 30,000 qualified programmers in Mexico. Each year the educational system produces a few thousand software engineers. Most the motivated and higher educated programmers want to work for international companies and migrate to the US [Computerworld, 2003b].

### 8.2.7 Comparison with the Netherlands

In this section we will look at the similarities and differences in international politics between the USA and the Netherlands. We will look at the neighboring countries Germany and Belgium, political relations between the Netherlands and these two countries and major treaties in which the Netherlands is involved.

**Neighboring countries** Belgium is a former Netherlands province. They declared themselves independent in 1830. The capital is Brussels. They have a high population density of 341/km$^2$. There country is bilingual were in the north the Dutch language and in the south the French language is spoken. Belgium gives home to the European parliament and the European Commission. The border is officially marked in the treaty of Maastricht in 1843.

Germany is the eastern neighbor of the Netherlands and has Berlin as its capital. Germany used to be a collection of many regions which were bounded together after the French capitulation in the French-Prussian war in 1871. 25 princedoms where bounded together in what they called little Germany. The border is older than Germany itself. It was established around 1815 with Prussians. After WWII The Netherlands tried to claim extra German ground as a compensation for the damage of the war but in the end the borders returned almost to the same state as before the war.

**Major treaties** The Shengen agreement is an agreement signed in 1985 between 5 of the 10 member states of European community. Those states included Belgium, France, Luxembourg, The Netherlands and West Germany. The treaty made it possible to travel freely between the participating countries by removing the systematic border controls.

The Benelux (its name is formed of the first letters of the participating countries) is an union between Belgium, the Netherlands and Luxembourg. It was signed in 1944 in London by the governments of the three countries. At first it was a treaty to equal trade tariffs, later it expanded to include fields like culture, economics and geographic grouping. In 1951 the Benelux joined France, West Germany and Italy to form the East Coal and Steel Community, an early form of the European Union (EU). In 1997 the Amsterdam Treaty incorporated the Shengen treaty in a mainstream European Union treaty which removed all the border controls in the European Union.

The EU is a political and economic union of 27 countries and ensures free movement of people, goods, services and capital between the participating countries. The EU can be compared to the NAFTA. Both treaties are between adjacent countries and both incorporate free trade. But there is also a big difference. The EU is much more than only a free trade area. It incorporates policies about Energy, Infrastructure and Environment.

### 8.2.8 Effects of US politics on international economies

What are the effects of internal US politics on international economies? We will examine the general differences of the two largest parties and their results on international economies.

Historically the southern slave holding states had cheap production and saw it as their right to buy products from over the world. They called themselves free traders. The mechanized north tried to compete with the much more efficient British industries. They wanted tariffs to protect their industries. Since then tariffs were introduced, increased and decreased. While protectionism is said to be good for the local economy, it is not for the world marked. The Netherlands benefit from a free marked. The Democratic Party has a name for increasing tariffs as a method of earning income. Generally speaking, and only looking at free trade, the Netherlands has most benefits from a Republican president. However, there are more factors which are important to consider. Republicans have the habit of spending more money than they receive. They promise lowering taxes, and get the money from compacting the government. This results in higher US depths in other countries like China. These high debts results in a high interest and also come with the risk of inflation and a weak dollar. This will also influence foreign country economies. So you cannot really say which party is better for the global economy. Also it is important to keep in mind that the above example is very abstract. There are many examples to find which are exceptions like the Clintons who finished the NAFTA treaty.

### 8.2.9 Conclusion

Politically a lot has changed the last 100 years. The US developed some complex political international relations. We looked at the situation in the middle east and the war on terror. We can see from those events that todays US is a very powerful player in political games. Other countries, such as the Netherlands, are influenced by decisions made by the US like supporting the war in Iraq. This also goes for their role in climate change. All countries are effected by each others green house gasses. When a big player such as the US does not sign a protocol such as Kyoto this affects us all.

In this chapter we mainly focused on international politics. We looked at treaties, international relations and their neighboring countries. In the next chapter we will look at the internal politics.

## 8.3 National politics

### 8.3.1 Introduction

In this section, the national political macro factors that influence the development and application of simulations and game technology in the United States will discussed.

The first aspect that will be discussed is the last 25 years of the national political history.

The second aspect is the political system in the United States. The government structure, political parties, and other issues like corruption, bureaucracy and stability will be discussed.

As third aspect, the national legislation will be discussed. This will be based on the constitution, human rights, environmental protection, employment law and intellectual properties.

The fourth aspect will be the current political situation, addressing the present political issues.

The last aspect will discuss the relation to simulation and game technology with the United States.

This chapter will conclude with a comparison to The Netherlands based on the earlier mentioned aspects and shows what the influence of national politics is on simulation and game technology.

### 8.3.2 Recent political history

The United States is a presidential, federal republic, in which the President of the United States, Congress, and judiciary share powers reserved to the national government, and the federal government shares sovereignty with the state governments. Since 1985, five presidents have served the United States. In this section, the past five presidents and their terms will be discussed both in terms of national and international context. This includes the presidential terms of Ronald Reagan, George H. W. Bush, William J. Clinton, George W. Bush and Barack Obama.

#### Ronald Reagan

1981 - 1989, Republican, 40th President of the U.S.. Ronald Reagan aided by the Soviet invasion of Afghanistan, the Iran hostage crisis and a worsening economy at home, won the election in a landslide in 1980 [Britannica Online Encyclopedia, 2010]. He was a former actor starring in B movies.

Reagan was most famous for his economic policies dubbed "Reaganomics". The focus of these policies was to reduce marignal tax rates, reduce the growth of federal spending, decrease inflation by controlling the money supply growth and reducing governmental regulation [Niskanen, W.A., 1988].

One of the worst crisis in his presidential career was Black Monday, October 19, 1987. The Dow Jones dropped by 22.5% (508 points) [BBC News, 2010]. It was not followed by a depression, thus the stock markets could recover from this crash. A lot of speculation over the cause of the stock falls has taken place, but economists could never attribute the cause to a single issue.

Ronald Reagan left office with a 63% approval rating [Newport, F.; Jones, J.M.; Saad, L., 2004] and is still rated highly in polls.

#### George H.W. Bush

1989 - 1993, Republican, 41st president of the U.S.. George H.W. Bush is nowadays primarily known for his presidency at the time of the First Gulf War and since 2000 as well as being the father of George W. Bush.

He won the 1988 presidential elections largely on the basis of his motto: 'no new taxes'. He broke this promise in 1990 when he did raise taxes. This caused a decrease in his approval rating and likely caused him to lose the 1992 presidential elections.

On 20 December 1989, the United States invaded Panama. They arrested the leader, Manuel Noriega, who is currently serving 40 years in jail for drug trafficking [Gilboa:1995]. It was the first U.S. war since 1945 that was not related to the Cold War. The unofficial reasons for the invasion are still unclear, but some believe that it has to do with the U.S.' constant crises with Noriega [Gilboa:1995]. Bush might have wanted to confirm his image with the American people. Official reasons state drugs trafficking, defending human rights and democracy, safeguarding the lives of U.S. citizens in Panama. The U.S. Southern Command, part of the U.S. Department of Defense concerned with Southern America was located in Panama at the time of the invasion (it was relocated to Miami in 1997).

The First Gulf War started on August 2, 1990, when over 100,000 Iraqi troops and 700 Iraqi tanks entered Kuwait. Kuwait had been an ally of Iraq during the

Iraq-Iran war, but due to diplomatic and economic reasons Iraq invaded Kuwait. On August 9, the UN Security Council voted unanimously (15 votes in favor) against the annexation of Kuwait by Iraq. Armed forces (mainly consisting of U.S. troops) entered Kuwait by 17 January 1991 and by 28 February Iraq agreed to a ceasefire [bbc:2]. U.S. troops did not invade Iraq, eventually leading to the Second Gulf War under Bush's son.

On November 9 1989 the Berlin Wall fell. This was only one act in the course of the collapse of the Soviet Union. On December 2 and 3 1989 Bush met with Mikhail Gorbachev at the Malta summit. These meetings were regarded as important in furthering the relations between the U.S. and the Soviet Union. This led to the declaration of a US-Russian strategic partnership at the end of the Cold War.

The NAFTA (North American Free Trade Agreement) was negotiated between the U.S., Canada and Mexico. Its goal was to eliminate trade and investment barriers between the respective countries. It was signed by the next president Bill Clinton in 1993. The American economy has grown by 54% since the introduction of the NAFTA treaty in 1993, but the US trade deficit with Canada and Mexico also grew 12 times as large to $111 billion dollar in 2004.

Bush' approval rating when leaving the office was 56%, quite a bit higher from the low of the 34% he had at some point during election time.

#### William J. Clinton

1993 - 2001, Democrat, 42nd President of the U.S.. William J. Clinton, or rather Bill Clinton as he is widely known, was the first U.S. President born after World War II.

Nearly 20 years before Obama signed the Patient Protection and Affordable Care Act in March 2010, Clinton tried to introduce health care reform himself. After naming his wife Hillary to head the task force of experts to set up a plan that Clinton could then propose to Congress. The Republicans rallied against the proposed plan and a lot of Democrats offered plans of their own. Even after numerous tweaks, there were still not enough Democratic Senators behind one of the plans to pass a bill. The plan failed and the Democratic Senate Majority Leader declared the plan dead on September 26, 1994 [Bok, 1998].

November 8, 1994 was a day of elections for the House of Representatives. Hot on the wings of the failed health care reform, the Republicans gained control of the House of Representatives for the third time in 72 years (these elections are held every 2 years). Clinton was a politician that attracted both Democratic and Republican support in the Senate but thereby alienating some of his more left-wing Democrat allies. His policies were called centrist, mainly on economic and several social issues. His signing of the NAFTA (North American Free Trade Agreement) indicated this. This passed the House of Representatives by 3/4th of Republicans and 2/5ths of Democrats voting in favor. Clinton also signed the Brady Handgun Violence Prevention Act (restricting the buying of hand firearms by individuals).

Clinton introduced the first balanced budget in decades and had a federal budget surplus. He was the first Decmocratic President to serve two consecutive terms since Franklin D. Roosevelt's presidency which lasted until the end of World War II. During his two consecutive terms he focused mostly on the economy, better education and environmental rules and he was president at the time of one of the greatest eras of prosperity for the U.S. [House, 2010]. He initiated the infamous don't ask don't tell policy restricting openly gay, lesbian and bisexual people from serving in the U.S. army while also banning the army from finding out anything about the sexual orientation of people serving in 1994. This was a compromise between Democrats and Clinton's campaign promise of allowing all citizens to serve in the U.S. army regardless of sexual orientation and others who preferred the ban on non-straight people from serving in the army to continue existing.

Clinton was impeached (put on trial to be removed from office) in December 19, 1998 by the House of Representatives, where the Republicans had a majority. He was acquitted by the Senate on February 12, 1999. He had a sexual affair with Monica Lewinsky, then a White House intern. He was impeached by at first swearing he did not have exual relations with her, thus lying about it. To the rest of the world the impeachment seemed like a political affair, with all Republicans and all but 5 Democratic Representatives voting to impeach. In 2004 Clinton wrote his memoires titled My Life, describing his life and his presidency. He included a lot of his thoughts on his relations with other people as well as issues he faced.

Clinton left office with a 66% approval rating, highest of all presidents since World War II [Gallup, 2010]. Clinton's wife Hillary Clinton is the current U.S. Secretary of State. She ran for president in the 2008 Presidential Elections but failed to win in the Democratic Primaries where she ran against incumbent U.S. President Barack Obama 8.3.5. She was formerly a U.S. Senator for the State of New York (from 2001 until her as in 2009) [govtrack.us, 2010].

**George W. Bush**

2001 - 2009, Republican, 43rd President of the U.S... George W. Bush is mainly known for starting the war on terror, his huge budget deficits and his impopularity during his second term both in the U.S. as well as internationally. Bush was chosen as president in the 2000 presidential elections. In one of the closest races in history, in the final and decisive state Florida, there were a lot of irregularities. Following several weeks of tugging between then-Vice President Al Gore (the Democratic presidential candidate) and George Bush, on December 13 2000, Gore conceded. On January 20 2001, after serving for 6 years as Governor of Texas, Bush was sworn in as president [infoplease, 2007].

On September 11, 2001, terrorists flew planes into the World Trade Center. Bush responded with a War on Terror. This lead to the invasion of Afghanistan on October 7, 2001 and eventually the Invasion of Iraq on March 20, 2003.

Bush faced a lot of criticism during his term. Noteworthy was his handling of Hurricane Katrina, which devastated New Orleans on August 29, 2005. Another point against him was the longest post-World War II recession that started in December 2007. Large tax cuts which benefitted mostly richer people in the U.S. During his term the national debt increased greatly.

Bush left the office with an approval rating of 22%, the lowest rating since Gallup (the measuring bureau) started asking about presidential approval over 70 years ago [cbs, 2009]. He also holds the record for high approval rating with 90% following September 11, 2001.

#### Barack Obama

2009 - present, Democrat, 44th President of the U.S.. He will be discussed more in-depth in current situation 8.3.5.

### 8.3.3 Political system

The U.S. federal regime dates from 1790 and is considered to be the first modern national federation government in the world. The constitution defines three levels of government: central, state and local. Next to the political structure, some other aspects that influence politics will be discussed.

#### Central government

The federal government of the U.S. is the central government entity defined in the constitution and is setup with separation of powers conform the Trias Politica defined by Montesquieu. The first three articles of the constitution define the legislative branch, the executive branch and the judicial branch. [cia, 2010] [of the U.S. Constitution]

**Legislative branch** The legislative branch of governance is Congress, which is allowed to make laws. Congress is 'bicameral'; consisting of the House of Representatives (the lower house) and the Senate (the upper house). The house of Representatives has 435 members, which are elected and allocated on basis of the population of each state. The senate consists of 100 members in total: each of the 50 states provides two senators to serve for a six-year period in the Senate. [The White House, 2010e]

**Executive branch** The executive branch of the federal government is the President, supported by the Vice President and the Cabinet. The president is head of state and head of government, as well as Commander in Chief of the army. The day-to-day enforcement and administration of federal laws is in the hands of several departments. The Presidents Cabinet is formed by the heads of these departments. The President also has the power to sign treaties and appoint members of the Supreme Court. These decisions have to be confirmed or 'ratified' by the Senate. This is also referred to as the "by advice and consent" rule. [The White House, 2010c]

**Judicial branch** The judicial branch is composed of the Supreme Court and several Federal Courts. The Supreme Court consists of nine judges, who serve for live. They are nominated by the president and confirmed with advice and consent of the Senate. The federal court system is based on the English common law. Each state has its own unique legal system, which is based based on English common law. Supreme court has the right of *judicial review*, this is the right to review the constitutionality of a statute or treaty, or to review an administrative regulation for consistency with either a statute, a treaty, or the constitution itself. [The White House, 2010d]

**Political parties** Federal and state elections generally take place within a two-party system, although this is not enshrined in law. Since the 1860s, the two major political parties are the Democratic Party and the Republican Party. The Democratic Party was founded in 1820 and is considered as center-left. The Republican Party was founded in 1854 as is considered as center-right. Despite broad political influence of the Democratic and Republican parties, so-called “third” parties and independent candidates remain a feature of American politics. [Bibby, 2004] Figure 8.1 shows the results of the 2008 Presidential Elections, with 365 electoral votes (52.9% popularity vote) for democrat Barack Obama and 173 electoral votes (45.7% popularity vote) for republican Johan McCain.

In comparison with the U.S., The Netherlands does have a lot political parties, which all have a different idealism. However, in the U.S. it is not common to use block voting, while this is so in The Netherlands. This may explain the stability of the two-party system, and the difficulty to grow as a third party.

**Voting system** The President and the Vice-President are elected together indirectly by the citizens of the United States, through an Electoral College. Voters in each state select an elector designated by different parties or candidates running for president. Electors typically promise in advance to vote for the candidates of their party. The winner of the election is the candidate with at least 270 Electoral College votes. This means that it is possible for a candidate to win the electoral vote, but not have the absolute majority of votes nationwide. Both the President and Vice-President can serve a maximum of two terms since the ratification of the 22nd Amendment in 1951. Franklin D. Roosevelt is the only president who served four terms. [The White House, 2010b]

All members of Congress are elected directly. The Senate has two senators for each state, all serving a six year period. One-third of the senators is renewed each two years. The House of Representatives has 435 members, elected for a two year term. The next Congress elections will be held on November 2nd, 2010.

### State government

The United States is divided into 50 states and one federal district, which all have their own government structure. The federal government has the right to accept new states, who have to conform to the constitution. The first state to sign the constitution was Delaware in 1787, the two newest states, Alaska and Hawaii were accepted in 1959. State governments have the power to make laws on all subjects that are not granted to the federal government or denied to the states in the Constitution. These include education, family law, contract law, and most crimes. Unlike the federal government, which only has those powers granted to it in the Constitution, a state government has inherent powers allowing it to act unless limited by a provision of the state or national constitution. [The White House, 2010f]

States have a similar political setup as the federation. The executive branch is headed by the Governor, who is selected in a separate election for a four-year period. The legislative branch consists of a Senate and a House of Representatives. Each state does also have it’s own state constitution. They differ in some details between states, but generally follow a pattern similar to that of the federal Constitution, including a statement of the rights of the people and a plan for organizing the government.

| Country | CPI |
|---|---|
| New Zeeland | 9.4 |
| Netherlands | 8.9 |
| United States | 7.5 |
| Somalia | 1.1 |

Table 8.1: Corruption Perception Index in 2009 (0=corrupt, 10=fair) [Transparency International, 2009]

**District of Columbia** Next to the 50 states, there are areas which are not under state jurisdiction, for example the Federal District of Columbia, where the capital Washington is located. The centers of all three branches of the federal government of the U.S. are located in the District. Because the district is not a part of a state, citizens are not represented in Congress and cannot vote for the Senate and House. However, they can vote for the Presidency.

### Local government

There are 89,500 local governments, including 3,033 counties, 19,492 municipalities, 16,500 townships, 13,000 school districts, and 37,000 other special districts. [U.S. Census Bureau, 2010] Generally, there are three types of city government: the mayor-council (similar to state government structure), the commission (combining legislative and executive branch), and the council-manager (council as legislative branch and a 'manager' as CEO). These are the pure forms; many cities have developed a combination of two or three of them. [The White House, 2010f]

### Corruption

The extent of corruption can be measured by using the 'Corruption Perception Index' (CPI) calculated by Transparency International. The CPI measures the perceived level of public-sector corruption in 180 countries and territories around the world. The CPI is a "survey of surveys", based on 13 different expert and business surveys. The CPI has a value between 0 (corrupt) and 10 (fair). Table 8.1 shows that the U.S. have a lower CPI value than The Netherlands, this means that the perception of corruption is higher in the U.S.. Table 8.2 shows that the CPI is relatively stable with values between 7.2 and 7.6 for the U.S., and 8.6 and 9.0 for The Netherlands. [Transparency International, 2009]

### Government stability

The stability of a government is measured by the World Bank. It assigns a value between -2.5 and +2.5 to counties, based on multiple risk indicators. The Netherlands scores +0.95 (80 percentile), whereas the U.S. scores +.59 (68 percentile). [Daniel Kaufmann, 1996-2008]

In the existence of the United States, there have been two presidents who have resigned: Richard Nixon in 1974 and Andrew Jackson in 1837. There are four presidents who died a natural death and four presidents that were assassinated.

| Year | United States | The Netherlands |
|---|---|---|
| 2001 | 7.6 | 8.8 |
| 2002 | 7.7 | 9.0 |
| 2003 | 7.5 | 8.9 |
| 2004 | 7.5 | 8.7 |
| 2005 | 7.6 | 8.6 |
| 2006 | 7.3 | 8.7 |
| 2007 | 7.2 | 9.0 |
| 2008 | 7.3 | 8.9 |
| 2009 | 7.5 | 8.9 |

Table 8.2: Corruption Perception Index for the United States and The Netherlands (0=corrupt, 10=fair) [Transparency International, 2009]

| | ‘85 ‘86 | ‘87 ‘88 | ‘89 ‘90 | ‘91 ‘92 | ‘93 ‘94 | ‘95 ‘96 | ‘97 ‘98 | ‘99 ‘00 | ‘01 ‘02 | ‘03 ‘04 | ‘05 ‘06 | ‘07 ‘08 | ‘09 ‘10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| President | R | R | R | R | D | D | D | D | R | R | R | R | D |
| Senate | D | D | D | D | D | R | R | R | R | R | R | D | D |
| House | R | D | D | D | D | R | R | R | D | R | R | D | D |

Table 8.3: Political majorities

In the last 25 years, there have been two democratic presidents and three republican presidents. Table 8.3 shows the political party of the president, the majority in the House of Representatives and the majority in the Senate. Most of the times, the house and/or senate did not have the same political color as the president. This may disturb making and executing legislation and lead to political instability.

**Bureaucracy**

In the list of ’Easiness of starting a business‘ with 183 countries, the United States rank fourth, whereas The Netherlands is ranked as 70th. This means that it is easier to start a business in the U.S. than in The Netherlands, regarding compliance to regulations, registering with authorities etc. [The World Bank, 2010]

Research has shown that the bureaucracy in the health care sector costs more than it would cost to provide health care to all uninsured citizens. [Medical news today, 2004] The bureaucracy can also be seen while visiting the U.S., since 2008 visitors need to fill in their visa request online before their departure.

**Political pressure groups**

Although regulations and legislation are made by Congress, political pressure groups play an important role in the decision making process. They act for the cause of their specific constituency. Business organizations will favor low corporate taxes and restrictions of the right to strike, whereas labor unions will support minimum wage legislation and protection for collective bargaining. In this section, the influence of think tanks and political action committees (PACs) will be discussed.

**Think tanks** A think tank is an organization or individual that conducts research and engages in advocacy in areas such as social policy, political strategy, economy, science or technology issues, industrial or business policies, or military advice. Think tanks in the U.S. form both foreign and domestic policy and generally receive funding from private donors and members of private organizations. Members may feel more free to propose and debate controversial ideas than people within government. Government think tanks play an particular important role in the security and defense field. An example of a think tank in the games and simulations industry is TechCast, which makes forecasts of new technologies. [TechCast, 2007]

**Political action committees** In the U.S., a Political Action Committee (PAC) is the name commonly given to a private group, organized to elect political candidates or to advance the outcome of a political issue or legislation. Federal law allows for two types of PACs, connected and non-connected. Most of the 4,600 active, registered PACs are "Connected PACs", which are established by businesses, labor unions, trade groups and health organizations. Groups with an ideological mission, single-issue groups and members of Congress and other political leaders may form "non-connected PACs". [Federal Election Commission, 2010]

### 8.3.4 Legislation

#### Constitution

The foundation of the U.S. political and legal system is the Constitution. It is the source of all government power and also provides important limitations on the government to protect the fundamental rights of United States citizens. There is still discussion whether the U.S. Constitution is based on the Constitution of The Netherlands or not. At least some elements of the constitutions have similarities. [Fisher, 2009] [of the U.S. Constitution]

- The first three articles describe the legislative, executive and judicial branches and the accompanying rights and obligations.
- The fourth article describes the relationship between the states and the federal government and amongst the states.
- The fifth article describes how amendments can be made to the constitution.
- The sixth article states that the Constitution and laws and treaties following from it, are the supreme law of the federation.
- The seventh article describes the ratification of the Constitution

**Bill of Rights** The Bill of Rights comprises the first ten ratified amendments to the Constitution. Those amendments were adopted between 1789 and 1791, and all relate to limiting the power of the federal government. They were added in response to criticisms on the Constitution during the state ratification conventions and by prominent individuals such as Thomas Jefferson. The amendments were proposed by Congress as part of a block of twelve in September 1789. By December 1791 a sufficient number of states had ratified ten of the twelve proposals, and the Bill of Rights became part of the Constitution. The first proposal is technically still waiting for ratification, the second proposal was ratified in 1992. [The National Archives and Records Administration, 2010]

The White House summarizes the Bill of Rights as follows: [The White House, 2010a]

- The First Amendment provides that Congress make no law respecting an establishment of religion or prohibiting its free exercise. It protects freedom of speech, the press, assembly, and the right to petition the Government for a redress of grievances.
- The Second Amendment gives citizens the right to bear arms.
- The Third Amendment prohibits the government from quartering troops in private homes, a major grievance during the American Revolution.
- The Fourth Amendment protects citizens from unreasonable search and seizure. The government may not conduct any searches without a warrant, and such warrants must be issued by a judge and based on probable cause.
- The Fifth Amendment provides that citizens not be subject to criminal prosecution and punishment without due process. Citizens may not be tried on the same set of facts twice, and are protected from self-incrimination (the right to remain silent). The amendment also establishes the power of eminent domain, ensuring that private property is not seized for public use without just compensation.
- The Sixth Amendment assures the right to a speedy trial by a jury of one's peers, to be informed of the crimes with which they are charged, and to confront the witnesses brought by the government. The amendment also provides the accused the right to compel testimony from witnesses, and to legal representation.
- The Seventh Amendment provides that civil cases also be tried by jury.
- The Eighth Amendment prohibits excessive bail, excessive fines, and cruel and unusual punishments.
- The Ninth Amendment states that the list of rights enumerated in the Constitution is not exhaustive, and that the people retain all rights not enumerated.
- The Tenth Amendment assigns all powers not delegated to the United States, or prohibited to the states, to either the states or to the people.

### Human Rights

The constitution of the U.S. protects the human rights of it's citizens and recognizes a number of human rights, including freedom of speech, freedom of assembly, freedom of religion, the right to keep and bear arms, freedom from cruel and unusual punishment, and the right to a fair trial by jury. [of the U.S. Constitution] The United States Commission on Civil Rights (USCCR) is an independent agency of

| | International convention on the elimination of all forms of racial discrimination | International covenant on civil and political rights | International covenant on economic, social and cultural rights | Convention on the elimination of all forms of discrimination against woman | Convention against torture and other cruel, inhuman or degrading treatment or punishment | Convention on the rights of the child |
|---|---|---|---|---|---|---|
| NL | R | R | R | R | R | R |
| U.S. | R | R | S | S | R | S |

Table 8.4: Cooperation in international treaties on human rights (S=signed, R=ratified)

the executive branch established under the Civil Rights Act of 1957. The Commission has the mandate to investigate complaints of citizens that has been discriminated. On the World press freedom ranking, the U.S. is ranked 20th, whereas The Netherlands is ranked seventh. [Reporters without borders, 2009]

**Geneva Conventions** The Geneva Conventions are drawn up of four treaties and three additional protocols that set the standards in international law for humanitarian treatment of the victims of war. The singular term Geneva Convention refers to the agreements of 1949, negotiated in the aftermath of World War II, updating the terms of the first three treaties and adding a fourth treaty. The conventions define the basic rights of those captured during a military conflict, establishing protections for the wounded, and addressing protections for civilians in and around a war zone. The treaties of 1949 have been ratified, in whole or with reservations, by 194 countries, including the United States. There are three amendments (Protocols) to the conventions, which are all three signed by the U.S., but only the last is ratified.

**International conventions** In the 20th century, the United States took a leading role in the creation of the United Nations and in the drafting of the Universal Declaration of Human Rights. Much of the Universal Declaration of Human Rights was modeled in part on the U.S. Bill of Rights. In the latter part of the 20th century, however, the US has participated in few of the international human rights treaties, covenants and declarations adopted by the UN member states. In the 21st century, the US actively attempted to undermine the Rome Statute of the International Criminal Court. Table 8.4 shows a number of important international conventions on human rights, and the signing and ratification of it by the U.S. and The Netherlands.

### Environmental protection

In the U.S., the Environmental Protection Agency leads the nation's environmental science, research, education and assessment efforts. The mission of the Environmental Protection Agency is to protect human health and the environment. It is responsible for developing and enforcing environmental related laws. [U.S. Environmental Protection Agency, 2010]

| Country | Framework convention on climate change | Kyoto protocol | Vienna convention | Convention on biological diversity |
|---|---|---|---|---|
| The Netherlands | R | S | R | R |
| United States | R | S | R | S |

Table 8.5: Cooperation in international treaties on environmental protection (S=signed, R=ratified) [United Nations Framework Convention on Climate Change Interim Secretariat, 2004] [United Nations Framework Convention on Climate Change Interim Secretariat, 2005] [United Nations Environment Programme Ozone Secretariat, 2004] [Secretariat of the Convention on Biological Diversity, 2000]

The four international treaties mentioned in Table 8.5 indicate the extent to which a country is involved in environmental protection issues. A 'S' means that the treaty is signed by that country, a 'R' means that it has been ratified and accepted by that country. Table 8.5 shows that two of these treaties are not ratified by the U.S., while for example The Netherlands has ratified three of them.

**Employment law**

U.S. employment law is a collection of laws on state and federal level. Federal laws are made by the Department of Labor, and sets the standards that organize workers' rights to organize in the private sector and provides more limited rights for employees of the federal government. These federal laws do not apply to employees of state and local governments, agricultural workers or domestic employees; any protections those workers have is derived from state law. The Fair Labor Standards Act (FLSA) of 1938 establishes minimum wage and other labor rights for most private sector workers. The minimum wage is set to $7.25 per hour in 2009. [United States Department of Labor, 2009]

The International Labour Organization (ILO) is a specialized agency of the United Nations that deals with labor issues. One of the principal functions of the ILO is setting international labor standards through the adoption of conventions. It is noteworthy that most of these conventions are not ratified by the United States. The Netherlands did ratify most of these conventions.

**Social security** The original Social Security Act of 1935 and the current version of the Act comprehend several social welfare and social insurance programs. The best known programs are Federal Old-Age and Disability Insurance, Unemployment benefits, Temporary Assistance for Needy Families, Health Insurance (Medicare, Medicaid, SCHIP) and Supplemental Security Income (SSI). These programs are executed by the Social Security Agency. [Social Security Agency, 2010] In 2010, the new Health Care bill has been accepted, providing a health care insurance to 'every American'. Before acceptance the government only provided health care insurance to a limited number of groups. However, in general the social security system in The Netherlands covers more than the US system.

**Hiring and firing laws** Employment law in the U.S. has traditionally been governed by the common law rule of "at-will employment", meaning that an employment relationship could be terminated by either party at any time without a reason. Although law prohibits certain discriminatory firings, in most states an employer can still fire an employee for no or any reason, as long as it is not an illegal reason. [Mark A. Rothstein, 1987] In The Netherlands, it is only allowed to fire an employee with a very good reason, employees have a legal right of protection of exemption.

The National Labor Relations Act gives private sector employees the right to choose whether they wish to be represented by a union and establishes the National Labor Relations Board to hold elections for that purpose. [National Labor Relations Board, 2010]

**Child labor** The Department of Labor is the federal agency that monitors child labor and enforces child labor laws. The most sweeping federal law that restricts the employment and abuse of child workers is the FLSA. Child labor provisions under FLSA are designed to protect the educational opportunities of youth and prohibit their employment in jobs that are detrimental to their health and safety. FLSA restricts the hours that youth under 16 years of age can work. [United States Department of Labor, 2010] Despite these regulations, some organizations notice that child labor law violation still exists on a small scale in the U.S.. [Human Rights Watch, 2009]

**Intellectual property rights**

The United States intellectual property law was established in Article 1, section 8 of the Constitution "to promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries;". [of the U.S. Constitution]. Examples of intellectual properties are patents, copyright, trademarks and industrial design rights.

**Patents** A patent is an intellectual property right granted by the Government of the United States of America to an inventor "to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States" for a limited time in exchange for public disclosure of the invention when the patent is granted. The United States Patent and Trademark Office (USPTO) is the Federal agency for granting U.S. patents and registering trademarks. [The United States Patent and Trademark Office, 2010]

Most other national patent laws use the 'first-to-file' principle, meaning that the first person who files an intellectual property, can get a patent. However, United States patent law uses the 'first-to-invent' principle, where a patent is given to the first person who invented something. In the U.S. it is also possible to get a patent on software (i.e. games), whereas this is not possible in The Netherlands.

**Copyright** The first legislation about copyright is the Copyright Act of 1790, securing the exclusive right of an author to publish and vend "maps, charts and books" for a term of 14 years, with the right of renewal for one additional 14 year term if the author was still alive. Copyright law has been renewed in 1909, 1976, 1998 and 2005 to adapt to new technologies, to extend the duration of protection, and to make other changes. In the U.S., the administrative aspects of copyright, including registering and copyright claims, are the responsibility of the United States Copyright Office, a part of the Library of Congress. At the moment, works created in or after 1978 are granted copyright protection for a term ending 70 years after the death of the author. [United States Copyright Office, 2008] In The Netherlands it is not possible to register copyright claims.

The Berne Convention (1886) is an international agreement governing copyright, requiring its signatories to recognize the copyright of works of authors from other signatory countries the same way it recognizes the copyright of its own nationals. The U.S. initially refused to become party to the Convention since it would have required major changes in its copyright law, but in 1989, the U.S. "Berne Convention Implementation Act of 1988" came into force and the U.S. became a party of the Berne Convention.

### 8.3.5 Current political situation

#### 2008 Democratic Primaries

Hillary Clinton was initially favourite to win the nomination as the Democratic candidate. She thought the race was going to be relatively easy and therefore made a couple of crucial mistakes in her campaign. It is important to be aware of these, as these give a good view of the political climate in the USA during the elections. Her strategy was focused on [Tumulty, K., 2008]:

- Showing her as an experienced, established politician. However, after 8 years of George W. Bush as Republican president, a lot of Americans wanted a change from the established politics. They wanted a fresh breeze in politics, and did not want another Washington insider as president. Obama gave the exact message of change these people were hoping for.

- Picking people for her campaign team for their loyalty to her, instead of because of their competency and knowledge of how to win the primaries for her. To illustrate, Clintons chief strategist said early on in an insiders meeting that a quick win in California would give Clinton all of the Democratic delegates (votes) of this state, forgetting that Democrats appropriate the delegates to the candidates due to vote percentages instead of the winner-takes-it-all principle. The inexperience of her team led to the next mistake.

- Winning in the large states. But as she did win the bigger states, those were too often small margins. Obama tried to get as many votes as possible in the bigger states but also focused on caucus states. Many smaller states use caucuses (conferences) to determine their votes and Obama focused on winning here, while Clinton virtually neglected these states. The caucus states were worth 12% of the delegates, and in the close race that the Democratic primaries turned out to be, even small numbers of delegates counted.

- Relying on money she already had, as well as bigger donations from a smaller number of people. Money donors in the USA are only allowed to donate $2,400 to candidates in the primaries by law [Federal Election Commission, 2009]. Once her own money began to dry up, she got into financial troubles. Obama instead focused on small donations from a large number of people using new media such as the internet. He often asked the people who signed up on his website to donate a small amount of money, as they often did. This not only raised him over $100 million online from 800,000+ people [Tumulty, K., 2008], but also gave him an almost steady income over the course of his campaign. This showed Obama knew how to use the power of newer media such as the internet and how to approach common people.

- Winning the race early. Her campaign team took a long time to regroup after finishing a disappointing third in Iowa. After every win she was slow to get ready for the next fight [Tumulty, K., 2008]. Obamas team was always ready for the next primaries. A separate operation was already underway for the next states every time.

All these factors contributed to Obama winning the Democratic primaries on Saturday, June 7 [Seelye, K.Q., 2008] by Clinton and being nominated as official Democratic presidential candidate on Wednesday, August 27 [Nagourney, A., 2008].

### 2008 Republican Primaries

John McCain, as the Republican presidential candidate, was Obama's main opponent in the 2008 presidential elections. After trading early wins with other Republican candidates, John McCain gained when he won all of Florida's 57 delegates with 36% of the total vote there [BBC News, 2008]. This was the biggest Republican thus far and was the last primary before Super Tuesday. On Super Tuesday (the single day where the most states are at stake), John McCain gained enough momentum to eventually secure the Republican nomination. On March 4, 2008 McCain had obtained 1,195 delegates, enough to clinch the Republican partys presidential nomination. Mike Huckabee withdrew from the race, making McCain the presumptive Republican nominee [Pethokoukis, J., 2008].

### 2008 Presidential elections

In the 2008 Presidential elections, it was decided who would succeed George W. Bush and become the 44th President of the United States. Obama's running mate, Joe Biden, was a candidate for Democratic nomination but resigned after disappointment in Iowa. McCain ran for President with Sarah Palin, who was governor of Alaska at that time[3]. Subjects that played a substantive role in the campaign of both nominees was the war with Iraq (and the foreign policy as a whole) and the economic crisis. Also the personal views and background of the candidates was, as always, subject of discussion. The election was however in this respect quite unique. It was the first time in 56 years that none of the candidates were the former President of Vice President. Also, both candidates were not born in one of the continental states. However, an important difference between the two candidates was their global approach to the elections. McCain posed himself as an experienced politician and commander. Obama was presented as a young passionate politician, not bound by old ideas but driven to bring the necessary change to his country. In the end, America chose for Obama's promise of change. United States Department of State / Bureau of International Information Programs [2008]

[3] Sarah Palin resigned as governor of Alaska on July 26, 2009

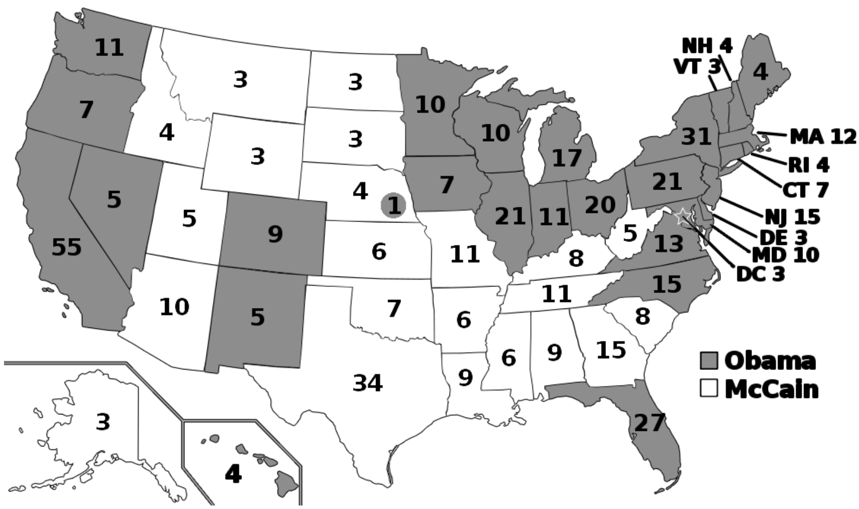


Figure 8.1: Electoral College map showing the results of the 2008 US presidential election.

**Present political issues**

**President Barack Obama**

With the election of Barack Obama as 44th president of the United States, after 8 years of Republican presidency, a Democrat once again holds the office of President of the U.S.. Obama was U.S. Senator of the State of Illinois from 2005 to 2008.

Obama was named winner of the 2009 Nobel Peace Prize on October 8, 2009. Some are critical because he has not had a major achievement yet, but some past winners had gotten it as an encouragement prize as well. He donated the full prize money (about 1.4 million USD) to charity.

On two different dates, Obama sent U.S. troops to Afghanistan. These were mid-February 2009 and December 1, 2009. He proposed to withdraw the troops 18 months after the second date.

Some of the controversies surrounding Obama is the fact that there are Americans who believe he is born outside the U.S. and therefore would be president of the U.S. illegally. Research has shown that Obama was born on Hawai.

In March 2010 Obama signed the Patient Protection and Affordable Care Act. In the Senate, all 60 Democrats and Independents voted in favor and all 39 Republicans voted against. In the House of Representatives, all 178 Republicans and 34 Democrats voted against. It is a softer version of the Bill that was originally intended by Obama to pass. Americans are concerned that the bill is giving the government too much involvement in health care. More Americans currently oppose it than approve of it.

### 8.3.6 Relation to simulation and game technology

**Militainment**

Militainment is a term made up from the words military and entertainment. It is used for entertainment material featuring and celebrating the military. Examples are movies, television shows and video games. Since this study tour is (partly) about gaming we will focus on video games.

The American government has made several video games in which the army is promoted. One of the most recent games is America's Army. In this first person shooter you are a soldier and must fight against terrorists. The game is free of charge and can be played online. The game's edge is beeing a real soldier. You must attend several training missions before you can start playing real missions. The game also has a button which brings you directly to the US Army website. Some people labeled this militainment as direct propaganda. America's Army is, according to a November 2009 new article in the Washington Examiner, the most effective recruitment tool. According to a MIT study 30 percent of all Americans in the age 16 to 24 has a more positive impression of the Army because of the game. [Game Politics, 2009]

**Entertainment Software Rating Board**

The ESRB is a self regulating non-profit organization established in 1994 by the Entertainment Software Association (ESA). The ESRB rates software for the USA and Canada. Although the rating is voluntary most of the games sold in the US and Canada are rated. Most of the reseller chains have in their policy that they only sell rated games and most console manufactures only permit games that have been rated by the ESRB on their platforms. [Entertainment Software Rating Board, 2010]

### 8.3.7 Comparison with The Netherlands

In this section, a comparison is made of the national political situation of the United States and The Netherlands, based on most of previously mentioned aspects.

Table 8.6 shows a general comparison of the political systems in the United States and The Netherlands. Differences between the U.S. and The Netherlands can be found in the Executive branch and the Judicial branch. In the U.S., the president is both head of state and head of government, while in The Netherlands the queen is head of state and the prime minister is head of government. This can also be seen in the elections, in The Netherlands only the legislative branch can be elected, while in the U.S. also the executive branch are elected. In the U.S. the federal court system is based on English common law, while the Dutch system is based on a civil law system incorporating French penal theory. Another difference is in the judicial review of acts of the legislative branch; in the U.S. this is possible, while in The Netherlands it is not. However, the governments structure of The Netherlands and the U.S. have a lot of similarities, probably because the Dutch setup local government in the 15th century.

In Table 8.7, a comparison of the legislative systems in the United States and The Netherlands is made. It shows that on the earlier mentioned subjects, the

| | United States | The Netherlands |
|---|---|---|
| Government type | Federal republic | Constitutional monarchy |
| Executive branch | President, Vice President, Cabinet | Queen, Prime minister, Cabinet |
| Legislative branch | Congress | Cabinet, First and second chamber |
| Judicial branch | Federal and state courts | Supreme court |
| Country division | 50 states, one district | 12 provinces |
| Elections | Indirect for executive, direct for legislative | Direct for executive |
| Political parties | Two major parties (democratic and republican) | Multiple parties |
| Corruption Index | 7.5 | 8.9 |
| World press freedom ranking | 20 | 7 |
| Easiness of starting a business | 4 | 70 |

Table 8.6: Comparison political system

| | United States | The Netherlands |
|---|---|---|
| Geneva Conventions | Partly | Fully |
| Mentioned human rights conventions | Some signed, some ratified | All ratified |
| Mentioned environmental conventions | Some signed, some ratified | Some signed, some ratified |
| Patents | First to invent | First to file |
| Copyright duration | 70 years | 70 years |

Table 8.7: Comparison of legislation

United States has signed the same conventions and treaties as The Netherlands, but did not ratify all of them.

### 8.3.8 Conclusion

In this section, the national political macro factors and actors of the U.S. have been discussed. The government structure shows some similarities with The Netherlands, probably because The Netherlands were the first to set-up a political structure in the early United States. The main differences can be found in the assigning of powers to the different branches. Another noticeable element is the relation between the central and state government in the U.S.; the Constitution defines which subjects can be discussed at which level.

The legislation part showed that the U.S. government has less influence on an individual than the Dutch government. A good example is the social security system, or the common "at-will employment" law in the U.S.. The comparison also showed that the United States signs international conventions, protocols and treaties, but does regularly not sign them. The Netherlands do more often sign and ratify these international agreements.

It is shown that national politics does influence the gaming and simulation industry. Government uses games to influence public opinions and can regulate the policy of use.

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# Chapter 9

# Technology

*Section by Joeri van der Lei, Steven Sybenga and Mattijs Ugen*

This chapter describes important technology developments and the effects on games and simulations. After drawing up a historical overview, the current technological trends are described and related to games and simulations. Section 9.4 explicates the Technology Achievement Index and compares the United States to the Netherlands. The diffusion of important technologies, and research and development in the U.S. are described in section 9.5 and 9.6. Finally, a conclusion is made.

## 9.1 Historical overview

In order to draw conclusions on the technological standards of today, knowledge of how the current level was reached is useful. To provide an overview of the most important technological sectors and some examples of the developments made by these sectors, a list grouping important sectors per decade is displayed here.

This list has been compiled by cross-referencing multiple technology timelines, dividing notable events, inventions and improvements into their corresponding technological sectors. Boyle [2009]; Ratnikas [2010]

### 9.1.1 1960s

**Aviation and space travel** During the so called "Space Race" between the United States and the Soviet Union, developments toward the launch of space missions get a lot of attention. Meanwhile, the aviation industry creates the world's largest airplane with the Boeing 747;

**Communications and information technology** Although the 1960s focused mainly on the telephony network, the communications and information technology sector develops the first steps toward the Internet and the early desktop computer;

**Military** The development of the nuclear submarine and the launch of new types of missiles mark only a few of the many events in the war technology oriented efforts of the United States;

**Nuclear research** After the 'success' of the nuclear technology that helped end the second world war in the 1940's, research toward nuclear solutions in the form of nuclear power for submarines continues.

### 9.1.2 1970s

**Communications and information technology** The Ethernet—one of the most important parts of the early and current day Internet—was developed in the 1970s. Also, multiple telephone companies start experimenting with the first cellular phones;

**Computer technology** The introduction of the microprocessor and the rapid improvements on the design by Intel Corp. marks the beginning of the ever accelerating development of computer hardware;

**Medicine and biology** With the development of the CAT-scan and the creation of the first synthesized recomninant DNA, the biological technology sector earned great interest among scientists and the health care sector.

### 9.1.3 1980s

**Communications and information technology** The development of the first real mobile phone by Motorola and the opening of several wireless spectra by the FCC marked the start of the big business that mobile communications is today;

**Computer technology** With the introduction of the Personal Computer by IBM, the Macintosch by Apple and the BlackBerry by Research In Motion, the computer becomes an accessable piece of equipment;

**Consumer electronics** As electronic components get cheaper over time, production companies start to release more affordable consumer electronics like handheld calculators and CD-players.

### 9.1.4 1990s

**Aviation and space travel** The launch of the United States military Global Positioning System and several space missions mark the 1990s as an important decade for aviation and space technology;

**Communications and information technology** The introduction of the GPS network also marked a great interested for the communications sector. The first standards concerning WiFi were also introduced by the IEEE;

**Computer technology** The computing sector continues to grow and create ever smaller and more powerful electronics;

**Consumer electronics** Previous inventions get cheaper over time and new appliances are invented at an increased rate.

### 9.1.5 2000s

**Consumer electronics** The consumer electronics sectors keeps on developing smarter and more powerful products for the consumer, with Apple's iPod as a prime example of modern engineering. Personal computers become part of every day life and are considered to be consumer electronics;

**Medicine and biology** With the completion of the Human Genome Project—mapping the entire human genome makeup—and the development of the first effective cancer medicine, the medical and biological sector makes great leaps in the 2000s;

**Aviation and space travel** NASA detects what appears to be water on both the moon and mars.

### 9.1.6 General trends

Judging on how the list of prime sectors has been compiled, these sectors are important according to multiple sources. Although a single source like this might not prove very reliable, combining the results of all sources quoted above leads to a more reliable and complete picture. Biases toward a certain sector or type of events are evened out by sources that do not have that same bias.

A number of technological sectors recur throughout the decades, such as *communications and information technology*, *computer technology* and *consumer electronics*. Many of the recurring sectors are still of importance today.

A number of the world's largest software companies are based in the United States. Among these companies is Microsoft, the company that supplies the operating system that runs a vast part of the computers worldwide. Another example is Google, the company that serves many widely used online products. Combining the fact that information- and communication technologies play a part in the technological history of the United States and the market share for software such as Microsoft Windows, it becomes clear that this sector has been a recurring trend in the United States.

Starting in the 1970s, the United States plays a large part in the world's computer technology sector. After the introduction of the microprocessor, computers—at that time not a common household appliance—became more and more powerful. In combination with the drive to create ever smaller components for these machines, the famous law of exponential groth introduced by Gordon Moore still holds to this day Moore [1965]. The role the computer technology currently plays is discussed in more detail in section 9.3

As can be read in the chapter on culture, the United States is a consumer culture. Looking at the many inventions for the consumer market, it becomes apparent that the sector for consumer electronics is strong. Whether this is driven by the culture or another factor, the United States play an important role in the sector.

## 9.2 Current technological trends

Having looked at the history in technological trends for the past 50 years, the current trending topics for technological advancement in the United States are needed to be able to draw conclusions on the technological standings of the country in comparison to The Netherlands. A number of such issues will be mentioned in this section, combined with an elaboration on these issues themselves.

### 9.2.1 Energy

With the need for electrical energy ever growing, the energy sector needs to innovate to be able to cope with the demand. The production and distribution of energy is mainly concentrated around energy plants producing electrical energy and distributing this through power lines over long distances.

Ideas to change this age old model have been around for a while, but are starting to gain more interest in the past few years. One such idea is the use of what is known as "smart grids". The smart grid differs from the classical power grid in that it is concentrated on a more distributed model of energy production: homes with solar panels that provide the grid with excess energy during sunny days and local wind mill parks providing power to nearby industrial areas. It is argued that a smart grid will be more resilient to failures of power plants and the like due to its decentralized setup. Energy [2009]; Overholt [2009]; Geisler [2009]

### 9.2.2 Security

Security has been the interest of the government, corporations and the public for quite a while. With the increase of power in computer technology in mind, new issues concerning security come to light. To elborate on the subject, the trend towards security has been split into several components below.

#### Privacy management

Because the general public is often the end user of a product or service, it is the common man or woman that has to spread his or her personal information everywhere. In the case of a service like online banking the security of user's personal information is extra important. As authentication credentials form an interesting commodity for criminals, banks and other corporations are fighting against phishing attacks to prevent the theft of personal information. Dhamija et al. [2006]

#### Encryption

The obfuscation of data by encrypting it with a cipher is older than information technology itself, though still of importance today. In order to make it harder for anyone to 'listen in' on the use of services such as described in the previous section, connections to these kind of services are often encrypted. With the recent success in brute-forcing Secure Socket Layer encryption, interest for successful and secure ways of encryption have increased. Molnar et al. [2008]

#### Digital rights management

The protection of intellectual property has long been an issue of great importance in the United States. As digital data is nothing more than a sequence of bits, copying a piece of data from one place to another is trivial. Software distributers, music labels and other distributers of digital data have therefore applied something that is commonly known as DRM, or Digital Rights Management.

DRM envelops multiple technologies, all aimed at preventing duplication of the data it manages. Implementations of DRM vary; some rely on hardware support to disallow usage of the medium that carries the data, others perform a software check on the integrity of the data. [Vaseva, 2009]

With the amount of effort put in hacking software protection, software distributers are starting to invent DRM measures that become harder and harder to bypass. UbiSoft, for example, implemented a measure in a recent computer game that required a constant Internet connection for it to work. [Leyden, 2010]

### 9.2.3 New technologies for the Internet

Most people view the Internet as the web pages that are served to them via a web browser. Although the Internet is more than just web pages, the information served as such has changed a lot in the recent past. With revolutionary web services as YouTube and Facebook, requirements for the web have changed. Although most of these services don't lead to new technologies, the sheer volume of data that these services produce and send over the wire force their creators to innovate in the way these volumes are handled.

Peer-to-peer applications are another widely adopted relatively new way of using the Internet. As the name implies, peer-to-peer applications makes different peers exchange information, rather than centralizing this information on a single server. This eliminates the need for large scale solutions to transfer data. The success of this technology has lead to it being used in a variety of ways, the illegal distribution of copyrighted material being the most well known.

To be able to cope with the increased usage of high bandwidth services on the Internet, the speed of home connections grows faster over time. The diffusion of internet availability and connection speed is covered in section 9.5.

## 9.3 Technologies specific to gaming and simulation

This section will identify technologies that have a specific relation to gaming and simulation.

### 9.3.1 Computer hardware

As gaming is generally done on some form of computer, the hardware a computer runs on has a certain effect on the way these games are played and the possibilities for the developers of games. Almost all components of a computer influence its capability of processing game content, though a few core components that are the most significant will be discussed here.

The first noteworthy component is the Central Processing Unit, or CPU. The CPU is responsible for most of a computers calculations. The world market for microprocessors for use in personal computers is dominated by two United States based companies: Intel and Advanced Micro Devices, or AMD. The two companies have a rich history of inventions and disputes over technologies.

A trend in computer hardware that is getting stronger for a few years now, is to put multiple processing cores on a single substrate, or die. These so-called multi core processors focus on increasing processing power through parallelization in stead of increasing the speed of a single processing core. A technique previously primarily used for high end server hardware, multi core processors are currently becoming a mainstream technology and produced for the consumer market. Whereas the market is currently mainly focused on processors with two cores—dual core processors—the number of cores per product is increasing, with the market moving towards processors with four cores—quad core processors—and the introduction of processors with even more cores.

A second component that is of significance to gaming is the Graphics Processing Unit, or GPU. As the name implies, this component renders the graphical content of a game to the screen. Two major manufacturers of GPU products are nVidia and ATI. As with the CPU, these two manufacturers are both based in the United States[1], making the country the primary producer of GPU products.

The products by nVidia and ATI behave much like those of Intel and AMD, controlling the majority of the market. The rivalry between the two companies has led to fast increasing processing power in GPU products.

### 9.3.2 Software advancements

The previously mentioned trend towards processors with multiple processing cores calls for a change in the way software that is intended to run on these processors is written. As most gaming applications have traditionally been created to make optimal use of the increase in processing power of a single core, the gaming industry has been relatively slow to catch up to the rise of popularity in multi core hardware.

Cloud computing is another technology that has gained a lot of interest in the past few years. The principle of this is the use of a number of powerful computers to do many little things for other, generally less powerful, computers. The group of systems that perform these tasks is called the cloud. The task this cloud might perform varies greatly. A well known example of such a setup is the Google Mail service, where the cloud performs the actual sending and receiving of mail and the user of the service only needs a computer capable of showing a web page.

Where gaming is concerned, experiments with serveral implementations of cloud computing are currently being carried out. Software that renders the content of a game and sends it to a client over the Internet is one such experiment.

## 9.4 Technological achievement

The technological achievement of a country is a complex thing to measure. To be able to draw a conclusion on how the United States is doing in this field, a number of statistics from different reports will be compared.

### 9.4.1 Technology Achievement Index

The Technology Achievement Index is

[1] Although ATI used to be a Canadian based company, it is considered to be a United States company since AMD aquired it in 2006.

> "A composite index of technological achievement, reflecting the level of technological progress and thus the capacity of a country to participate in the network age."

The index is intended to provide a general overview of a country's technological level and measures the technological achievements of a country in four areas M. Desai et al. [2002]:

1. Creating new technology;
2. Diffusing recent innovations;
3. Diffusing existing technologies that are still basic inputs to the industrial and the network age;
4. Building a human skill base for technological creation and adoption.

The creation of technology component of the TAI measures the capacity to innovate and adapt technologies for local use. It is measured through two components: The number of patents granted per capita and the receipt of royalty and license fees from abroad per capita, measuring the market value of the inventions M. Desai et al. [2002].

The diffusion of recent innovations component is measured by the coverage of internet, the main product responsible for the network age and the exports of technology products as a part of all exports. The export of technology products measures the competitive edge of the countries innovations and the internet coverage is a prime indicator for distribution of information.

The diffusion of old innovations component of the TAI measures the base level of a counrty's ability to adopt newer innovations, as many technologies have prerequisites for their usage. The two indicators of this are diffusion of telephones and electricity. Widespread diffusion of telephones is an important prerequisite for the adoption of the internet while electricity determines the possible amount of technological human activity.

The development of a human skill base is important not only for developing new technologies but also for their use. The main indicators for this component are the mean number years of education and the enrolment in tertiary education in science, mathematics and engineering. The quality of education of course varies from country to country but still provides an overall view of the level of human skills.

These four main categories and eigth subcategories are all assigned a number from zero to one using the global maximum and minumum as goalposts. The TAI is the simle average of all indicators.

| # | Country | TAI Value (2002) | Patents/residents (1998) | Royalties/residents (1999) |
|---|---|---|---|---|
| 1 | Finland | 0.744 | 187 | 125.6 |
| 2 | United States | 0.733 | 289 | 130.0 |
| 6 | The Netherlands | 0.630 | 189 | 156.6 |

Table 9.1: Technology Achievement Index

In this table, the first column is the international rank of the country by its technology achievement value, indicated by the TAI value in the second column. The third column indicates the amounts of patents granted to the residents of the country per million people. The fourth column indicates the amount of royalties and licence fees paid out to the country's residents per 1000 people. M. Desai et al. [2002]

The years from which these numbers date back have been indicated within parethesis per column. Although the numbers date back roughly ten years, they are assumed to be correct enough to be able to draw conclusions based on them today as no more recent data could be found.

It becomes clear from Table 9.1 that the United States has a high technological achievement rate, ranked second on an international scale.

The amount of granted patents per resident of the United States is the only number that is significantly different from the rest. This could indicate a greater number of inventions per resident of the country, though the approach towards the patent system differs per nation. M. Desai et al. [2002]

Although the TAI of different countries varies greatly, from the 0.744 of the leader Finland to 0.066 of the poorly developed Mozambique there are roughly four groups of countries according to the report that presents the figures:

**Leaders, a TAI greater than 0.5** This group not only has diffused old technology widely but also innovates a lot and is self-sustaining with a wide base of human skills;

**Potential leaders, a TAI of 0.35–0.49** Altough these countries have a high level of human skills, their main seperation from the leaders is the diffusion of either new technology or older innovations;

**Dynamic adopters, a TAI of 0.20–0.34** These countries are mostly developing countries with a high level of human skills, such as India and China. Many of them have large hubs of technology although there is no wide diffusion;

**Marginalized, a TAI less than 0.2** With small amounts of technology diffusion and human skills, these countries are at the bottom of the ladder.

### 9.4.2 Georgia Tech's High Tech Indicators

Georgia Tech's High Tech Indicators, or HTI, is a ranking system composed of four factors, together measuring the technological competitiveness of a country. A recent report by D. Johnson et al. presents data that provides a look into the technological standing of many western European countries. Johnson et al. [2010]

The HTI is composed of the following four factors:

**National orientation** A nation's focus on developments toward competitiveness;

**Socioeconomic infrastructure** Resources that support a nation's functioning a modern, technology-based industrial nation;

**Technological infrastructure** A nation's capacity to develop, produce and market new technologies;

**Productive capacity** Resources and efficiency of those resources devoted to manufacturing.

The combination of the four components of the HTI is called the INPUT and is used as an indication of the technological standing of a nation. Or, as the report quotes, "an indicator of a country's recent overall success in exporting high technology products".

### 9.4.3 Comparison of the United States and the Netherlands

First of all, it has to be noted that both countries are doing excellent on a global scale. The United States of America ranks a close second behind Finland whilst the Netherlands is sixth on the overall rankings in the Technology Achievement Index. There are a few interesting points when making the comparison between the Netherlands and the United States:

- Although the number of patents granted per million people is higher in the US than in the Netherlands, the Netherlands receives more royalty and license fees, which may indicate that the Netherlands has more marketable solutions;
- The higher number of patens in the USA may indicate a higher level of innovations that are less marketable or a more informal patent culture in the Netherlands.

The USA is on a higher level in terms of diffusion of recent innovations, which is measured by the number of Internet hosts per thousand people and the high- and medium technology exports as a percentage of total exports. In both categories the United States is ahead of the Netherlands. Interestingly, the opposite is true for the number of telephone connections per 1000 people. This is striking since wide diffusion of telephone lines is a prerequisite for widespread use of the internet. One possible explanation could be a difference in the number of mobile phones, as they are included in said figure.

In terms of education, the United States is ahead of the Netherlands. Not only are the mean years of education higher, there is also one and a half times the interest in a tertiary education in science at 15.3% versus 9.5% for the Netherlands. This confirms the higher level of innovations in the USA as mentioned earlier.

As can be seen in the graphics in the report on the High Tech Indicators, the United States scores very high on all four of the components of the index. The Netherlands lacks most in the areas of techonological infrastructure and productive capacity, by comparison. This difference seems to be true for most of the Europian countries, marking the United States as a nation that is better at exporting technology than the nations in the Europian Union.

## 9.5 Diffusion of important technologies

To give a clear indication of how technological developed in the U.S. we have to scrutinize a couple of important technological means of communication and the position of the U.S. compared to the rest of the world. Internet and telephony are as a modern and still inproving technology the most interesting technologies to analyse.

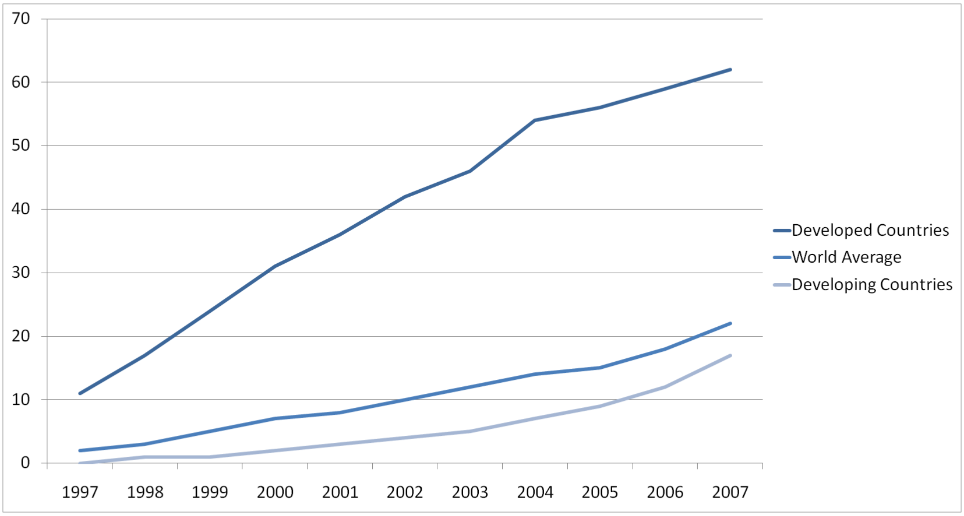


Figure 9.1: Internet usage in developed and developing countries Union [2008]

### 9.5.1 Internet

In the last 40 years the internet has grown from scratch to one of the most important tecnologies. This makes the penetration of the internet a good point of reference to see how well this county has develloped itself in terms of technology. The ITU research (figure 9.1) confirms this and shows us that more developed countries have significant more internet penetration than developing or underdeveloped countries Kiiski and Pohjola [2002].

The U.S. is, together with Australia and some European countries, one of the most internet penetrated countries worldwide (internetWorldStats). In 2009 over 74% of the US population was able to use the internet and this number is still rising as can be seen in figure 9.2.

Not only at this side but also on the other end of the internet is the U.S. an important player. If we look at the number of internet host the U.S. is by far number 1 CIA [2010]. This might however be a wrong indication because the host count includes .com, .net and .org.

While the internet was growing and gaining popularity and more people started to use it, the 'simple' services like email and websurfing were rising rapitly. The slow dial-in connection however, held back the developing of new internet services which required a faster connection. Facing this problem, well developed countries started to invest in a faster internet connection and with this faster connection they had a head start on other countries and even extended their lead. This makes the broadband penetration as well as connection speed good indicators of how technological developed a country is.

#### Broadband penetration and connection speed

Figure 9.3 shows us a lineair increase of broadband subscribers in the U.S.. However, if you compare this to other countries (figure 9.4) the U.S. scores above average but

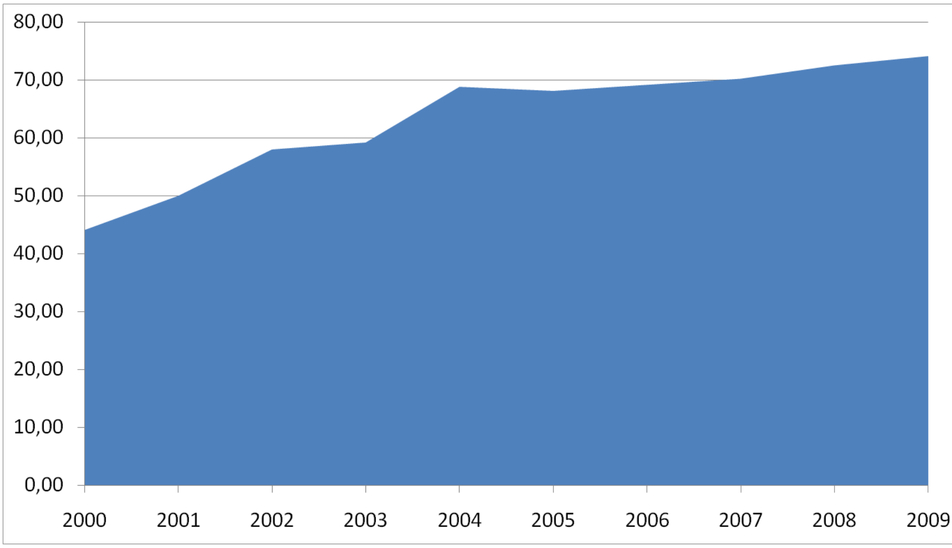


Figure 9.2: Internet Penetration U.S. Group [2009]

is failing behind compared to Korea, China and the Netherlands. According to the SWA survey, there's a big difference between rural and urban areas: "while 67 % of urban households and suburban households subscribe to broadband, only 46 % of rural households do."(SWA report). Another imortant factor is income, 35% of the households whose income is $20,000 or less had a broadband connection. This broadband penetration was 53% for households with an income between $20,000 and $ 30,000. 85% of the upper income Americans, households with more than $75,000, had a broadband connection in 2009.

One of the reasons the U.S. lacks here might be the difference in the telephone system between the U.S. and The Netherlands for example. In The Netherlands you usually pay per called minute, this can be by subscription, pre-paid or just afterwards but it is the same price for each domestic call (some phone companies give discount if you call a pre-registered number but we don't take them into account in this case). However the U.S. has a system of local, long distance and international calls. Local calls are often free of charge and users only have to pay for long distance and international calls. This makes it possible to get a free dial-in internet connection. This makes it, especially for the low-income families, a big step to switch to a paid broadband connection.

Looking at the number of broadband connection it might not be obvious that the U.S. is also falling behind in average connection speed. The numbers of broadband subscribers are an average of all inhabitants, even those in rural areas and the average connection speed is calculated by only taking the internet users into account. Keeping this in mind it is distressing to see that the U.S. is falling behind even more. South korea, Japan, Sweden, Netherlands, Germany and 22 other countries had a better average download speed in 2009CWA [2009].

As expected the urban areas (New York, Washington, Los Angelos etc) have a faster average internet connectionStrover [2001] CWA [2009].

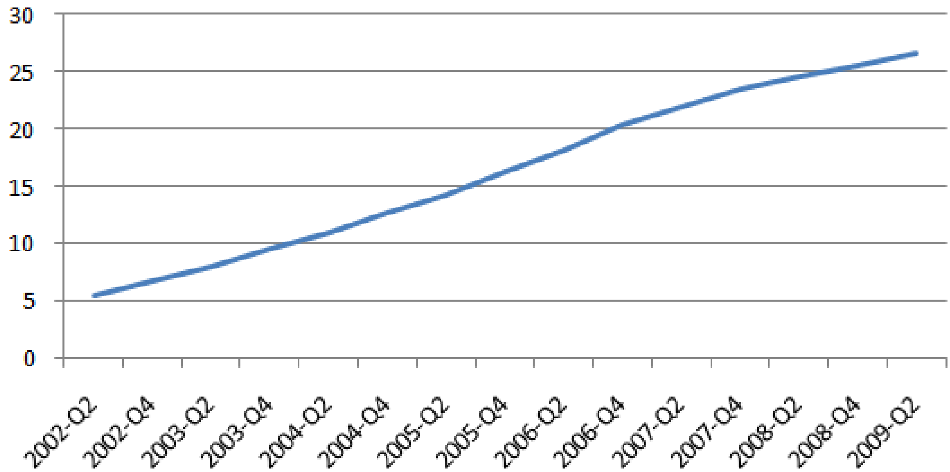


Figure 9.3: Broadband subscriber in the U.S.

As a result of these alarming data the FCC (Federal Communications Commission) launched a national broadband plan that will seek to ensure that every American has access to a broadband connection. Wigfield [2009]

National broadband goals are:

**1** At least 100 million U.S. homes should have affordable access to actual download speeds of at least 100 megabits per second and actual upload speeds of at least 50 megabits per second.

**2** The United States should lead the world in mobile innovation, with the fastest and most extensive wireless networks of any nation.

**3** Every American should have affordable access to robust broadband service, and the means and skills to subscribe if they so choose.

**4** Every community should have affordable access to at least 1 Gbps broadband service to anchor institutions such as schools, hospitals and government buildings.

**5** To ensure the safety of Americans, every first responder should have access to a nationwide public safety wireless network.

**6** To ensure that America leads in the clean energy economy, every American should be able to use broadband to track and manage their real-time energy consumption. Commission) [2010]

### Internet Protocol version 6

With the number of required addresses for the Internet ever increasing, the number of available addresses has been an issue of concern for a while. The development of

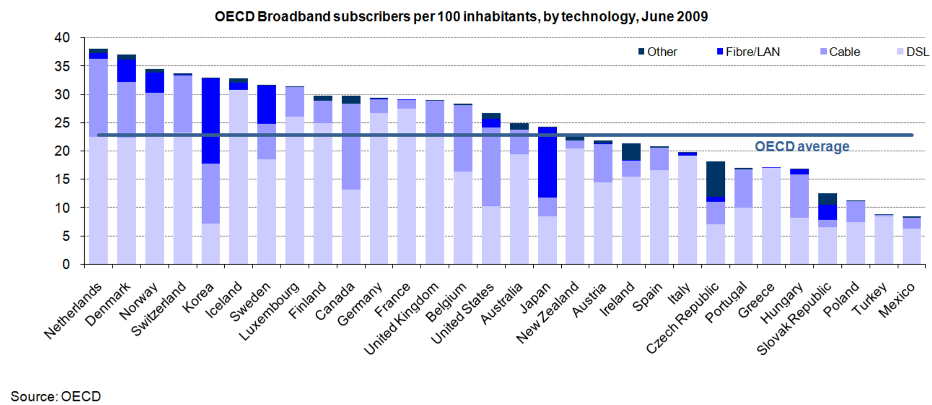


Figure 9.4: Broadband subscriber per 100 inhabitants

a new way of addressing individual machines over the Internet has been realised in version six of the Internet Protocol.

The level of implementation of the new protocol shows a degree of international participation and technological innovation in the solution for the diminishing number of available Internet addresses. As can be seen in statistics presented by Google in 2008, the United States are participating above average in the implementation of the new protocol. It must be noted, however, that the overall usage of IPv6 is still very low. Even the world leader in implementing IPv6, Russia, is still below 1% connectivity. According to Google, this is mainly because many webservers and internet service providers do not yet support the new protcol Gunderson [2010].

### 9.5.2 Telephone

As for internet, the telephone penetration is also a good indication of how technological developed a country isUnion [2008]. The United States had 150 million land lines in use in 2008 leaving only China behind. This number of landlines was growing until the introduction of the mobile phone (see figure 9.5). Since that moment, the number of mobile cellular subscribers increases rapidly and with 270 milion subcribers in 2008, the U.S. ranked third CIA [2010].

In december 2009, the U.S. had four mobile operators with a combined market share over 80%. The number one, Verizon led with a share of 31.2% followed bij AT&T with 25% and both Sprint and T-mobile with a market share of 12.1% Radwanick [2010].

From a technological point of view it is even more interesting to see how the relatively new smartphone market developes. This kind of telephones not only hold the basic functionality of calling but also contain a GPS receiver, digital camera, touch-screens and internet and are considered the future of mobile technology.

In the U.S. 17% of all phones are smartphones (december 2009Radwanick [2010]) and it's share growing rapitly. At this moment every smartphone producer tries to gain as much market share as possible by making deals with the earlier mentioned mobile operators and by offering the newest technologies on their phone. In decem-

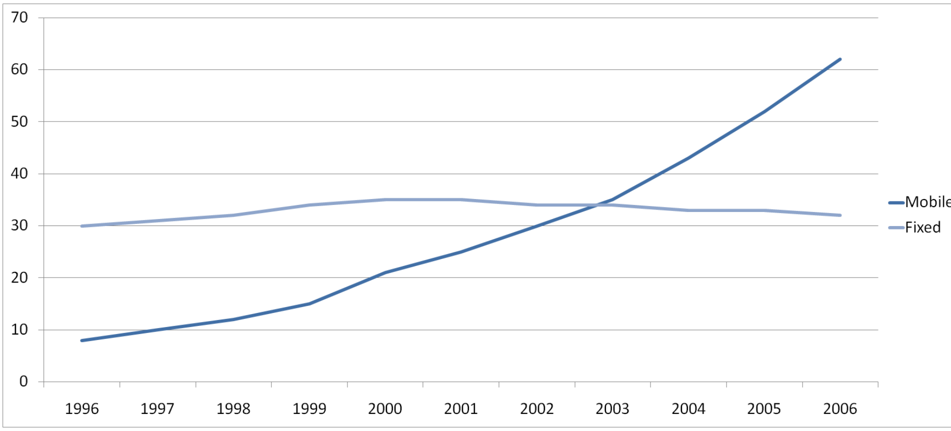


Figure 9.5: Increasing mobile phone usage Union [2008]

ber 2009 RIM led this marked with a share of 41.6%. followed by Apple (25.3%) and Microsoft (17.9%) Radwanick [2010].

With the upcomming smartphone usage is it very important for the producers to deliver their phone with a well known operating system. The most new software for smartphones will only be compatible with these operating systems. For the last two years the operating system of Symbian, a joined venture of Nokia, Ericsson, Panasonic and Samsung, is leading this race. 47.2% of all smartphones shippen worldwide had a Symbian operating system. RIM is second, followed by Apple and Microsoft. The number five, Google's operating system android however is catching up very fast and might be the number two within a couple of years. This creates opportunities for Motorola, HTC Samsung, LG and ofcourse Google itself as they are already using this operating system.

## 9.6 Research and Development

Earlier in the technology achievement index section we took a closer look at the level of diffusion of technologies in the USA and the Netherlands. The main findings were:

1. The USA is on a higher level of innovation and technological diffusion than the Netherlands;
2. The Netherlands has more marketable innovations through royalty and license feed even though exports of high- and medium technology are lower.

We will now ask ourselves whether a difference in research and development expenditure is a possible explanation for these findings.

First we will look at the overall R&D spending as presented by Frank Gannon-Gannon [2003]. In 2002 the gross domestic expenditure on R&D of the Netherlands was 8.3 billion US$. While this pales in comparison to the gross expenditure of the USA at 272.2 billion US$, the actual expenditure as part of the GDP is more relevant. The Netherlands has a GERD as a % of the GDP of 2.02% trailing not only the USA at 2.7% but also countries like Sweden, Finland, Germany and France.

A closer look at both the TAI numbers and the R&D spending as part of the GDP shows a correlation between the two. In fact, the top five countries worldwide in TAI also occupied the top five domestic expenditure in R&D as a percentage of the GDP. The Netherlands, sixth in the TAI actually spends way less of its GDP on R&D compared to most other TAI Leader countries.

### 9.6.1 The R&D expenditure of the Netherlands

As said earlier, the R&D expenditure of the Netherlands is lower than what one would think just looking at the TAI. In fact, private R&D expenditure has been trailing as of the past decade and it has become a point of interest for the government. According to Edo Haveman [2008],

> "The Netherlands lead over other countries in terms of R&D expenditure in the public sector has narrowed considerably over the years, and is now - based on the latest figures for 2006 - 0.05-0.06% of GDP above the EU15 and OECD average"

The main reason for the low private expenditure appears to be the unatractive economy for foreign investments due to the openness of the Dutch EconomyEdo Haveman [2008]. Furthermore, the level of human skills is unnatractive for foreign companies, though location and other inherent effects are also a factor.

## 9.7 Conclusions

Taking a look at the past 50 years of technological history for the United States in section 9.1, there do not seem to be any specific factors that still influence the development of technology today. Looking at the matter of simulation and gaming technology, the history is of even less importance; they are a creation of recent times.

Although no large scale factors of the technological history of the United States play a part in the development of simulation technologies and games, the steady increase in computing power of computer hardware obviously does. As this steady increase has been part of the country's technological history, it can be concluded that the development of computer hardware *is* is an important subfactor that enables and accelerates the development of simulation technologies and games.

The importance of the computer hardware industry also shows itself in the presence of the four main companies that produce the hardware that drives the gaming industry to develop ever more advanced technologies and gaming content. These companies—AMD, ATI, Intel and nVidia—together rule the market for processing power that enables the use of gaming and simulation technologies worldwire, making the United States an important technological center of the world.

In comparison with the United States, the Netherlands is only a small player on the technological market. This should come as no surprise, as the difference in scale is enormous. However, The Netherlands are not far behind when looking at technological achievement, as shown by the Technology Achievement Index. The High Tech Indicators also show that nations in Europe are not as technologically active as the United States.

The lead of the United Sates over the Netherlands also holds when looking at gaming and simulation in particular; as stated above, companies based in the United States control the world market for computer hardware, technological components required for the use of both gaming and simulation. On the software side, the difference is not as evident. Taking into account that most of the gaming and simulation products released worldwide originate in the United States, however, leads to the conclusion that the software side, too, is more present in the United States than it is in the Netherlands.

Looking at the internet and (cellular) telephone penetration the United States are falling behind the last years, as can be seen in table 9.2. For this reason the United States government and the FCC started a plan named the “national broadband plan”. The goal is to help as many American households to get afforable high speed Internet.

The mobile phone penetration in the United States is also lower then in The Netherlands. The main reason is that the United States has large rural areas where the phones don’t have a signal. More important is the mobile phone market, and especially the fast growing smartphone sector. The big producers in this sector are American companies and they play a key role in the operating systems too. Google’s Android, currently number five mobile operating system is gaining popularity and will be very important in the near future.

| | United States | The Netherlands |
|---|---|---|
| Population (2009, Est.) | 307.2M | 16.7M |
| TAI value (2002) | 0.744 | 0.630 |
| TAI world ranking (2002) | 1 | 6 |
| Internet usage fraction of residents (2009) | 74.1% | 85.6 % |
| Internet Growth (2000–2009) | 138.% | 266.8% |
| Telephone land lines per resident (2008) | 0.48 | 0.43 |
| Cellular telephones per resident (2008) | 0.88 | 1.19 |

Table 9.2: Comparison table between the United States and The Netherlands

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# Part II

# Meso research

# Chapter 10

# Introduction

The second sub-study of this research is conducted on the Meso level. The goal of this section is to reseach Meso characteristics of the U.S. and the Netherlands in order to gain insight into the Games and Simulations developments in four selected sectors. Companies, Univesities, the Government and the Healthcare sector will be investigated to identify meso factors that may influence these.

The specific research question used in this section is:

*What actors and factors can be found in selected sectors that support or inhibit games and simulations developments?*

To answer this research question the management science methodology Porter's diamond is used. This model can be used to analyze an industry or sector from different points of view and determine its competitiveness in relation to other sectors.

Porter's diamond has four basic determinants and two additional variables. Figure 10.1 shows these determinants and additional variables from Porter's diamond.

The four basic determinants of Porter's diamond are:

**Demand conditions** The demand, both domestic and foreign, in a sector

**Factor conditions** Two different conditions can be distinguished: those that limit the sector and can hardly be influenced by the industries in the sector and flexible limiting conditions which can be influenced to get a competitive advantage within the sector.

**Firm strategy, structure and rivalry** How companies are created organized and structured

**Related and supporting industries** Industries that strongly support or positively influence the industries within the sector and thereby influence the attractiveness of the sectors.

Beside these four four determinants, Porter's distinguishes the following two additional variables:

**Government** The government has a strong influence on the competitive forces within a sector and is therefore part of the model

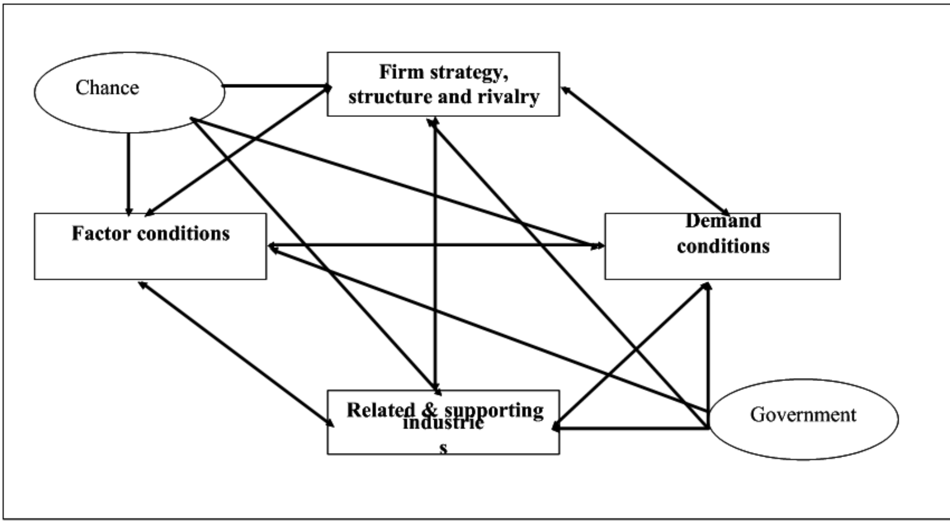


Figure 10.1: Determinants and additional variables of Porter's diamond

**Change** Accidents and accidental circumstances which influence the competitiveness of an industry, but cannot be influenced by the industries within the sector itself.

To define sectors to start the analysis, the ISIC Rev.6 (draft) is used. The analysis consist of the following identified sectors:

- Scientific research and higher education
- Manufacturing of consumer electronics
- Military
- Healthcare

Each sector is analysed according to the determinants and variables of Porter's diamond. To arrive at appropriate conclusions the results of these sectors will be compared with the same setors within the Neterlands. Furthermore issues and developments within the Games and Simulations are distinguished. The following four chapters contain the research results of the meso sectors.

# Chapter 11

# Higher Education

*Section by Cecill Etheredge, Albert de Graaf, Jordy Molenaar, Johan Noltes, Mattijs Ugen and Stefan Weijers*

In this chapter, a meso-level analysis of the influence of higher education sector on games and simulations developments is described. The following research question will be answered:

> *What actors and factors can be found in the higher education sector that support or inhibit games and simulations developments?*

In the International Standard Industrial Classification (ISIC) Revision 4, the higher education sector is defined as follows: [United Nations, 2008]

> This class includes the provision of post-secondary non-tertiary and tertiary education, including granting of degrees at baccalaureate, graduate or post-graduate level. The requirement for admission is at least a high school diploma or equivalent general academic training. Education can be provided in classrooms or through radio, television broadcast, Internet or correspondence.
>
> This class includes:
>
> - post-secondary non-tertiary education
> - first stage of tertiary education (not leading to an advanced research qualification)
> - second stage of tertiary education (leading to an advanced research qualification)
>
> This class also includes:
>
> - performing arts schools providing higher education
>
> This class excludes:
>
> - adult education as defined in group 854

This chapter first discusses the sector analysis using the Porters Diamand method, compares the sector in the U.S. with the higher education in the Netherlands and gives an overview of the technical developments in the gaming and simulations industry in the U.S.

## 11.1 Sector analysis

In this section, an analysis of the higher education sector will be made using Porter's Diamond. This model defines four main conditions, all influencing each other. An additional two factors—government influences and chance—complete the model. The six parts of this model will be discussed here together with a short elaboration on the noteworthy relations between the conditions.

### 11.1.1 Demand conditions

The demand for higher education will be measured in the number of students that enroll in higher education each year. A high number of students that enroll in higher education in a particular year, represents a high demand for education. The demand for education is further divided into new enrollments—freshman year students—and the total number of students enrolled in higher education. Also, a division in multiple factors like gender, age and ethnicity is provided.

It must be noted that the demand for higher education presented here is the apparent demand; the demand that is visible because people that have demand for higher education are enrolled in higher education. The actual demand for higher education would be the numbers presented here, summed with the amount of people that would want higher education but can not fulfil this demand, for whatever reason. As these statistics are not readily available, the actual demand for higher education is considered to be comparable to the apparent demand for the scope of this research.

**Demand by enrollment**

Table 11.1 shows the number of freshmen enrolled in higher education in the years 2000–2007. From this table, it can be seen that the demand for higher education has steadily risen in the past few years. However, this number has to be compared with the change in residents in the U.S.. The number of residents for the year 2000 and the year 2007—the start and end year for the following statistics—are included in the rightmost column of the table. [U.S. Census Bureau, 2006; U.S. Department of Education, 2009]

| Year | Number of freshmen | Male freshmen | Female freshmen | Total Population |
|---|---|---|---|---|
| 2000 | 2,427,551 | 1,123,948 | 1,303,603 | 281,421,906 |
| 2001 | 2,497,078 | 1,152,837 | 1,344,241 | |
| 2002 | 2,570,611 | 1,170,609 | 1,400,002 | |
| 2003 | 2,591,754 | 1,175,856 | 1,415,898 | |
| 2004 | 2,630,243 | 1,190,268 | 1,439,975 | |
| 2005 | 2,657,338 | 1,200,055 | 1,457,283 | |
| 2006 | 2,707,213 | 1,228,665 | 1,478,548 | |
| 2007 | 2,776,168 | 1,267,030 | 1,509,138 | 302,200,000 |

Table 11.1: Freshmen enrollments in the past years

As can be seen from table 11.1, the fraction of the population of the U.S. that enrolls in higher education has risen slightly from 8.62‰in 2000 to 9.19‰in 2007.

This would mean a slightly risen demand for higher education in this period, meaning residents have put more value to education in the past few years.

Apart from the amount of yearly freshmen, the total amount of enrolled students is a measure of demand for higher education. Table 11.2 shows several partitions of enrollment statistics. Noteworthy difference is the difference between male and female students. Only 42% of the enrolled students in 2007 were male, a clearly lower amount than the amount of female students. It would appear that the female population of the U.S. has a greater demand for higher education than the male population. Additionally, the fraction of male students enrolled overall is 3% lower than the fraction of male freshman, indicating a higher dropout rate than female students.

Another noteworthy figure from the table is the difference between public and private institutions. Public institutions are essentially run by the government and mostly rely on government funding, whereas private institutions are privately run and mostly rely on other forms of income. This difference is significant for measuring the demand for higher education, as the requirements of a student are different for the two types of institution. The admission standards for private institutions are often higher than those of public institutions and tuition fees are often higher. This results in the more wealthy residents of a country being more able to enroll into a private institution than the less wealthy. This result makes drawing conclusions on the difference between public and private institutions where demand conditions are concerned hard, per the reasons mentioned in the introduction of this section.

It is a well known fact, however, that the standard of education in private institutions is higher than that of public institutions, resulting in a higher education level of its graduates. The view of the job market that graduates of private institutions are worth more than those of public institutions makes it clear that this difference does create a higher demand for 'private graduates'.

| Partition in public / private institutions | |
|---|---|
| Public | Private |
| 13,490,780 | 4,757,348 |
| Partition in male / female enrolled students | |
| Male | Female |
| 7,815,914 | 10,432,214 |
| Partition in full-time / part-time enrolled students | |
| Full-time | Part-time |
| 11,269,892 | 6,978,236 |

Table 11.2: Comparative table, enrollment statistics in number of students, 2007 [U.S. Department of Education, 2009]

To be able to make a comparison between the demand for higher education in the United States and the rest of the world based on enrollment statistics, the *Gross Enrollment Rate*, or GER, is a useful tool. The UNESCO Institute for Statistics defines the GER as the number of students enrolled in a particular level of education, divided by the number of residents in the theoretical age group for the same level of education. For the United States, this number is estimated at 82% in the year 2007. The difference between male and female enrollments is once again visible here, with the GER for higher education in the United States being 96% for female residents versus 68% for male residents. [UNESCO Institute for Statistics, 2007b]

All of these statistics are significantly higher than the same numbers for the Netherlands, where only 60% of the theoretical age group is enrolled in higher education. This difference is firther discussed in section 11.2. [UNESCO Institute for Statistics, 2007a]

### Demand by expenditures

A second way of measuring the demand of higher eduction is the expenditures done in the corresponding research sections. Higher expenditures in a particular section would correspond to a higher demand for either the number of students in the sector or scientific results of that sector. The following table presents research and development expeditures of public and private universities and colleges, partitioned for different fields of science. [Science Resources Statistics, 2010]

| | Public institutions | Private institutions |
|---|---|---|
| Total R&D expenditures | 35,291,876 | 16,616,850 |
| Government funding | 63.4% | 73.8% |
| Other funding | 36.5% | 26.2% |
| Computer sciences | 2.7% | 3.0% |
| Environmental sciences | 6.4% | 3.3% |
| Life sciences | 57.2% | 66.5% |
| Mathematical sciences | 1.1% | 1.4% |
| Physical sciences | 7.7% | 7.3% |
| Psychology | 1.9% | 1.5% |
| Social sciences | 4.5% | 2.2% |
| Engineering | 16.1% | 13.8% |

Table 11.3: Comparative table, research and development expenditures in higher education, 2008 (numbers in thousands of USD)

A few numbers and differences in this table are noticable, first of which is the difference between public and private institutions. When these numbers are correlated with the difference in enrolled students, it becomes clear private institutions spend more funds on research and developments per student than public institutions, with $2,616 per student for public institutions versus $3,493 per student for private institutions. The demand for results from this research would seem to be higher in the case of private institutions. This demand for results comes mainly from governments—both national, state and local—indicated by the large portion of the research budget originating from governments.

The second number of interest is the amount of money spent on research in the field of life sciences. This field contains agricultural, biological and medical sciences, among other. Of these, medical sciences consume most of these expenditures with just over half of the 31 billion U.S. dollars spent on life sciences in 2008. The large fraction of funds spent of medical research and development has been in effect in the past few years; the interest in medical sciences is not new. As with the research budgets in general, the demand for this research comes mainly from the government, which provides most of the funding. [Science Resources Statistics, 2010]

### Conclusions

When looking at enrollment statistics, the demand for higher education from a student's perspective has slightly risen over the past few years. It must be noted, however, that the statistical data backing up this claim is in part from the period before the worldwide economic downturn. Less wealthy residents may therefore have a demand for higher education that was not measured in the years after, creating the possibility that the demand for higher education has gone down a bit in the near past.

An interesting statistical fact is that female residents of the United States have a higher demand for higher education than male residents. This is apparent from freshmen enrollments and even more the case when looking at the bigger picture: figures for female participation in higher education on the whole are nearly 50% higher than male participation.

When institutional research budgets are concerned, it immediately becomes clear that the different governments create the most demand for the research done in higher education institutions. The medical sciences are considered the most important when expenditures are concerned. Both these numbers are a bit more extreme in the case of private institutions.

## 11.1.2 Factor conditions

Factor conditions are conditions of which a company can benefit. They are divided into two categories: The general factors, these could be obtained by any company; and the advanced factors, the factors individual companies profit from. These often have to be 'created' by the companies.

According to [U.S.News, 2009] The U.S. higher education institutes are high ranked on the world list. Currently, one third of the top100 is filled with U.S. institutions. Actually, the first, the third and the seventh through 16th place are for U.S. institutions. But how do the factor conditions help them to rank this good?

In Porter's Diamond are numerous general and advanced factors, but most of them are not relevant for the Higher Education sector. Therefore, the following three factor conditions will be described in detail:

- geographic position (general factor)
- capital (advanced factor)
- labour costs (advanced factor)
- quality of education (advanced factor)

### General Factors

**Geographic Position** According to [The Chronicle, 2009a] there are 4,861 colleges and universities with 18,248,128 students in 2007. These are widely spread throughout the U.S., but not equally, in fact, according to [The Chronicle, 2009b] California has 433 institutions, while Nevada only has 11. When compared to a population density map however, these differences are more logical, because the higher the density, the more institutes a state generally has [mapofusa.net, 2010].

### Advanced Factors

**Capital** The most important factor for the quality of higher education is the amount of money available. Public universities receive funding of the government. Private universities however, do not have this kind of funding, they have to generate most of their income by collecting grants from research programs, tuition fees and donations. Research grants are often provided by the government, so they actually do receive some funding from the government.

In table 11.4 and 11.5 you can see the revenue and the expenditures of the University of California. Besides the Auxiliaries and medical centers most revenue comes from grants and state educational appropriations. Almost half of the revenue is spend on instruction, research and public service [Setiawan, 2008] [Science Resources Statistics, 2010].

| Universitywide | 2005-2006 | 2006-2007 | 2007-2008 |
|---:|:---:|:---:|:---:|
| Student Tuition and Fees | \$1,761 | \$1,788 | \$1,921 |
| State Educational Appropriations | \$2,725 | \$2,875 | \$2,974 |
| Auxiliaries and Medical Centers | \$5,401 | \$5,702 | \$6,039 |
| Educational Activities | \$1,189 | \$1,286 | \$1,375 |
| Grants and Contracts | \$4,390 | \$4,442 | \$4,514 |
| Private Gifts | \$661 | \$701 | \$733 |
| Other Revenues | \$1,167 | \$1,132 | \$1,254 |
| DOE Laboratories | \$4,482 | \$2,253 | \$1,048 |

Table 11.4: Revenue by Source in Constant Inflation-Adjusted Dollars (x 1,000,000)

| Universitywide | 2005-2006 | 2006-2007 | 2007-2008 |
|---:|:---:|:---:|:---:|
| Instruction, Research and Public Service | \$7,043 | \$7,307 | \$8,105 |
| Support Activities | \$2,993 | \$3,110 | \$3,707 |
| Auxiliaries and Medical Centers | \$4,655 | \$5,037 | \$5,713 |
| Student Financial Aid | \$385 | \$418 | \$425 |
| Other Expenses | \$1,538 | \$1,554 | \$1,597 |
| DOE Laboratories | \$4,446 | \$2,233 | \$1,039 |

Table 11.5: Expenditures by Function Constant Inflation-Adjusted Dollars (x 1,000,000)

**Labour Costs** Labour costs differs between universities. Higher regarded universities often offer a higher wage. Because of this, these universities often attract higher educated professors, so the quality of education rises. The average wage for post-secondary Computer Science teachers is \$82,600. These nationwide statistics do not provide a clear view of the state differences. The average wage in Nevada is around \$61,990 dollars, thus being on the bottom end, while Alaska tops the list with \$115,090 and Rhode Island as second with \$106,640 [Bureau of Labor Statistics, 2009].

**quality of education** The quality of education can be measured in various ways, like the average number of citations per published article, reviews from students and employees etc. According to the QS world university rankings on engineering and IT, the best three universities are U.S. universities. Table 11.6 shows the U.S. universities in the top 10.

| University | Rank |
|---|---|
| Massachusetts Institute of Technology (MIT) | 1 |
| University of California, berkeley (UCB) | 2 |
| STANFORD University | 3 |
| California Institute of Technology (CALTECH) | 5 |
| CARNEGIE MELLON University | 9 |

Table 11.6: U.S. institutions in the QS world university rankings

According to the Washington College Guide, another ranking system on a different basis, the first four universities above have a good score also, respectively 12, 1, 4 and 29. This is a general score of U.S. universities and not one specific for engineering and IT universities. Other (world) ranking systems also put U.S. universities on the top of their ranking lists, so the U.S. has some excellent universities[4 International Colleges & Universities, 2009] [ShanghaiRanking Consultancy, 2009] [U.S.News, 2009] [Washington Monthly, 2010].

These and other world ranking systems generally put U.S. universities high on the list, thus it seems that quite some U.S. universities offer a very high quality.

#### Conclusions

Universities are unequally spread through the United States, this is mainly due to the population density. This is a general factor, so universities have no influence on this.

The main income of universities consists of tuition fees, grants and donations. Public universities will also get funding from the government. Generally, private universities have more money to spend and thus provide better research possibilities.

The quality of education in the U.S. is good, with quite some universities in the best position on several world ranking lists. These universities are often private universities, although there are also some very good public universities.

### 11.1.3 Firm strategy, structure and rivalry

This section is about domestic competition; the way educational institutes are created, organized and structured. Institutes that are able to attune their firm strategy and structure to the available resources can gain a competitive advantage. Porter shows that the level of competitiveness is linked to the level of innovation and development within a sector. For our sector, education, we will give an overview of the market, structure and competition.

#### Strategy

A lot of money is put into research and development. In the United states about 2.7% of Gross Domestic Product, about 390 billion dollars. [Bureau of Labor Statistics, 2010]

The numbers in the last 20 years suggest that the R&D expenses as percentage of the GDP are stable. Research can be issued by the government or the industry.

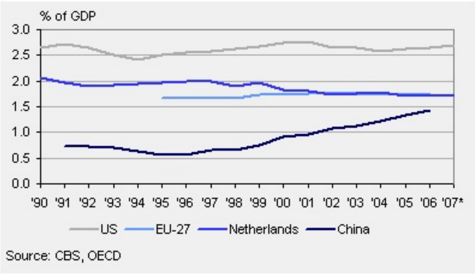


Figure 11.1: Percentage GPD spent on R&D

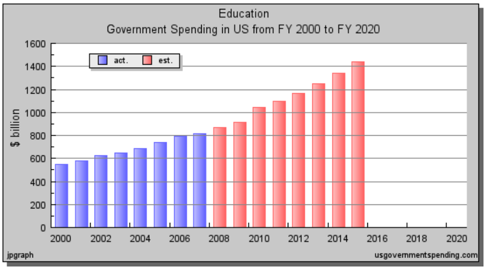


Figure 11.2: Expenses in the education sector

Industrial companies sometimes have their own research and development department. Research is also done by research institutes and universities.

The government spends about 1 trillion dollar on education every year, but only about 300 billion go to post secondary education. Looking at the amount of money the last 10 years we can see a steady increase. [US Governmentspending, 2010]

The product of universities is obvious, it is the education of new students and conducting research. To be able to "sell" this product a university needs a good reputation that attracts good students and research. Getting a competitive advantage is key. Competitive factors for universities would be location and the quality of education. Location is important because new students generally chose schools that are close, so being located in the most populated areas is a good idea. Furthermore the state a university is located in has consequences for the amount of money it receives, since some states provide more money than others. [The Center for Measuring University Performance, 2002] The quality of education is harder to measure, but The Center for Measuring University Performance tries to do this. More about relative performance of universities in the Rivalry section [The Center for Measuring University Performance, 2008].

A big factor in strategy of a university can be the choice between being a public or private university. Public universities are universities funded by the government. They accept and conduct research issued by the government that is not necessarily profitable. Private universities are funded by doing research for the industry and tuition paid by the students[Dill, 2005].

If the university is aiming at the top, conducting high payed research and gaining talented students, they might consider being a private university, only accepting students that will bring in enough money to hire excellent teachers and equipment. On the other hand, if your strategy is cheap education for the gross of the population, being a public university is probably the best choice. Free of tuition and government funded. Most public universities cannot pay enough to keep the best teachers and researchers around, so they probably live off government issued research[Dill, 2005].

**Structure**

We focus on postsecondary institutions; universities, colleges, professional schools and technical institutes. *"They provide education and training in both academic and technical subjects for high school graduates and other adults. These institutions may offer associate, bachelors, or graduate degrees, depending on the type of institution.*"[Bureau of Labor Statistics, 2010] The bureau of labor statistics describes the education industry as follows: *"The educational services industry includes a variety of institutions that offer academic education, career and technical instruction, and other education and training to millions of students each year.*"[Bureau of Labor Statistics, 2010] The education sector is a very big industry. Consisting of more than 7000 colleges and Universities and 15 million students. [BrainTrack, 2010] Relatively few of them do something in our interest area, serious games and simulations.

In general there are three types of staff on a university. Faculty staff are jobs like professor, teacher or researcher. These are the professions that would directly be associated with a university since it is the core business of the Education sector. There is also the Supportive professional staff, they make sure all the needs of the faculty staff or students are satisfied. The last are the Civil Service staff and includes a wide variety of jobs. Such as food service, clerics or tradespersons. [Northern Illinois University, 2010]

**Rivalry**

Rivalry amongst universities in America is very fierce. There is a centre for measuring university performance in the united states. They make an annual report with all data about research and students of all major universities and make a list with the top universities each year. Harvard and Yale are the two most prominent universities in the united states with rankings almost in all categories in the top 3 [The Center for Measuring University Performance, 2008].

*"The Centers Top American Research Universities is essentially a market share study. It begins with the observation that the pool of highly productive research talent is scarce relative to the number of higher education institutions competing for that talent. It continues with the observation that universities compete with each other to acquire as much of this talent as possible.*" – The Center for Measuring University Performance

Universities can gain competitive advantage over other universities by gaining research contracts and grants from the government. They compete with each other with number of graduates, students and money. Graduate percentages reflect success and draw new students, while they need money to hire talented individuals, to provide the research infrastructure or to support the institutional matching funds often required to compete for federal funding [The Center for Measuring University Performance, 2008].

The centers report does not make any ranking and since it is relatively hard to get the information you want out of the reports many students look for sites that do rank universities. And a lot of those sites exist. These sites do not give a academic ranking, but most of the time base them on information as amount of search engine hits. So it is more a popularity ranking than anything else, but it does show that having a good website and getting in on top in the search engines can have an influence on the competitiveness. As more students will chose the popular universities. [4 International Colleges & Universities, 2010]

**Conclusion**

A lot of money flows into the education sector. As a university or college you would want the government funds or conduct research for the industry. An important factor in the strategy of a university is the choice between public and private. Private universities ask tuition from their students to be able to hire the best teachers and have the best equipment. Public universities get support from the government and try to get specific research grants from them.

The competitiveness of a university has a few important factors. Most importantly is the amount of money they can get through the amount of students. Furthermore the amount of research they can conduct also reflect in the amount of money available to invest into better teachers and equipment. Another factor is location. A university positioned in a highly populated area is more likely to get a lot of students. For public universities the state is also important. The amount of subsidy can be different per state.

Universities have a lot of rivals. They constantly have to compete for the best students. Organizations like the center annually make a report about the statistics of universities and many sites (often not based on educational quality) try to rank universities. Causing the higher education sector to be a very competitive place.

### 11.1.4 Related and supporting industries

In this section, the related and supporting industries of the higher education sector will be described. Some of these related and supporting sectors are defined in the International Standard Industrial Classification (ISIC) Revision 4 [United Nations, 2008], and will have a corresponding classification code, other sectors will be a group of multiple sectors. This analyses will be carried out by looking at the value chain of higher education. Education in the U.S. starts with (pre-)primary and secondary schools. Students can choose to start working after this education, but it is also possible to continue with higher education. Because of the broad definition, also employees can choose for full or part time higher education. After graduation, most people choose to start working, and/or follow additional education.

**Related industries**

Related industries are defined as those where firms can share activities in the value chain across industries. These industries can form clusters to gain advantages of synergy effects. The following industries are related to the higher education cluster:

- Research and development
- High-tech industries
- Commercial training

**Research and development** Research and development (R&D) comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. [Organisation for Economic Co-operation and Development, 2009] The R&D sector, ISIC group 72, generates knowledge for higher education by researching new technologies.

This also works the other way around, most employees in this sector have a higher education degree. R&D can be carried out at universities, research institutes and or at commercial institutes. For R&D, specialized skills are needed, which can be obtained by following higher education. Important R&D institutes in the U.S. are NASA, Department of Defence R&D, Microsoft Research and Pfeizer R&D. Clustering of higher education and R&D institutions often occurs. This can be seen in e.g. Silicon Valley with the Carnegie Mellon University, Stanford University and Silicon Valley University.

In the academic world, the Johns Hopkins University spends most money on R&D, with a expenditure of $1,680,927,000. Government pays a large amount of academic research R&D expenditures; 67% of the total $51,908,726,000 in 2008 is funded by the federal and state government. [Science Resources Statistics, 2010] In the United States, 2.6% of the GDP is spended on R&D [Organisation for Economic Co-operation and Development, 2009].

**High-tech industries** High-tech industries use advanced technology to produce goods in a specific area. This requires high skilled people with a specific higher education background. High-tech companies are often spin-offs of universities. There is no ISIC group for high-tech industries, this is spread over more sectors. Examples are Pharmaceuticals, Aircraft & spacecraft, Medical instruments, radio, television & communication equipment and Office, accounting & computing machinery. These sectors are also closely related to the R&D sector, and are often clustered with these companies and higher education. The Silicon Valley example also applies to this sector. Examples of high-tech companies in the gaming and simulations sector are NVIDIA, manufacturer of video cards, and Xsens, delivering motion tracking sensors and software.

**Commercial training** Commercial training and other educational activities, ISIC group 8549, is education that is mostly done by specialized companies, which does not lead to a high-school diploma, baccalaureate or graduate degree. Of course, it does not necessarily only apply as a succession to higher education, but in general this kind of education is often used for extra training of employees. Serious gaming is an upcoming way of teaching in this kind of training. CyberCIEGE is an example of such a serious game, designed to teach network security concepts [Irvine et al., 2005].

### Supporting industries

Supporting industries are suppliers and service organizations. The following industries are related to the higher education sector:

- Pre-primary, primary and secondary education
- Educational support services

**Pre-primary, primary and secondary education** Primary and secondary education, ISIC groups 851 and 852, comprises all (pre-)primary and secondary schools as described in section (TODO editors: add reference to Macro cultural section). These schools educate students the required skills and knowledge to be able to follow higher education. For a good transition from secondary education to higher education, it is important that curricula are adjusted to each other, to decrease the chance of dropouts significantly.

**Educational support services** Educational support services, ISIC group 855, provide non-instructional services that support educational processes or systems. This includes consulting services, guidance services, testing evaluation services and organization of student exchange programs. This industry supports the higher education by guidance, for example via standards and quality control. An example is the Council for Higher Education Accreditation, which gives an accreditation to higher education institutions, allowing them to issue diplomas to students.

Of course, there are also other additional (smaller) industries which support the higher education sector: publishing companies, electronic learning environment developers, etc. Government also plays an important facilitating role; each state in the U.S. maintains its own public university system, which is always non-profit. Next to that, federal and local government supply fundings.

### Conclusions

The supporting industries for the higher education sector are the lower education levels (primary and secondary), providing the students with a certain level. Next to that, several Educational support services deliver services to improve the educational process, like standards, quality control and e-learning environments. Important related industries for the higher education sector are Research and development, High-tech industries and Commercial training. Higher education delivers highly skilled people, who can work in these related industries, and/or follow additional training. Concluding, especially the R&D and high tech industries related to the higher education sector support new developments in gaming and simulations.

### 11.1.5 Government

Since higher education is not supposed to be a profitable sector and it needs to be open to as many people as possible it has a great need for funding. This is how the government can play an important role in this sector. The government can also set certain standards and make policies. In this section we will outline the influence the government has on the sector of Higher Education and take into consideration the differences between both federal and state level.

#### Federal influence

A major influence on a federal level comes in the form of the U.S. Department of Education. They help with most federal assistance on education including to the president and congress. Their mission is to "promote student achievement and preparation for global competitiveness by fostering educational excellence and ensuring equal access" [The U.S. Department of Education, 2010]. They do this by performing the following four types of activities:

- Making policies on how to distribute and monitor federal educational funds. (More on this in the section *Financing*).
- Collecting data on schools and research.
- Identifiying major issues and focussing national attention to them.
- Enforcing federal laws prohibiting discrimination in programs that receive federal funds.

They only act on a national level and leave matters as developing curriculae, starting schools and determining enrollment and graduation standards to the various states, districts and relevant organizations.

#### State influence

Analogous to the U.S. Department of Education many states have their very own department of education. Unlike their national counterpart, state departments generally focus more on curriculum standards and administration of specific educational institutions.

State government can also be supported by several commissions. For example, in 1974 the California Postsecondary Education Commission was ' established as the State planning and coordinating body for higher education' [Postsecondary Education Commision, 2010]. It acts primarily as an informative and advice-giving body on 'major policy and planning issues' to legislative and executive branches of the California state goverment.

#### Financing

The first aforementioned activity of the U.S. Department of Education concerns funding. It uses three methods of funding [The U.S. Department of Education, 2009]:

*By Formula*: This enables qualified agencies to receive funding to enable support for students that meet certain criteria (e.g. being disabled). The amount of money funded is relative to the amount of students supported.

*By Competition*: Under this section we state the funding to applications *on a competitive merit*. Interestingly these applications can not only be issued by institutions as colleges and universities, but also by individual researchers. Funds are awarded to the most qualified applications.

*By financial need determination*: Postsecondary students can apply for loans, grants and fellowships.

For personal financial aid in postsecondary education the Department of Education has an office called Federal Student Aid (FSA). They ensure that all postsecondary students can benefit from financial assitance. They have issued over $100 billion in new aid each year and they oversee $500 billion of outstanding loans [Federal Student Aid, 2010]. Aid comes in three different forms:

- **Grants** A grant is a form of financial aid that does not have to be repaid. FSA awards the Pell grant of up to $5,350 to students in (provable) need of financial aid. Aditionally to the Pell grant a SMART or Academic Competitiveness grant can be issued to certain students [Federal Student Aid, 2009].
- **loans** Loans can be issued to all undergraduate and graduate students as well as their parents. They have to be repaid with interest.
- **Work-Study** The work study program provides part-time jobs for students, encouraging community service or study course related work.

The state of california deserves a special mention on funding. Figure 11.3 shows that in the year 2006-07 it issued a total of $9,233,141,000 of appropriations for public degree granting institutions, which is almost twice as much as the nation's second: Texas ($4,717,666,000).

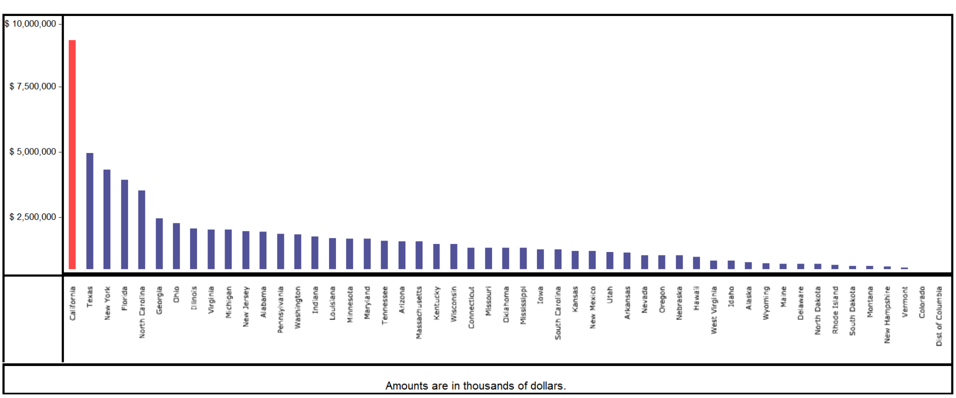


Figure 11.3: Appropriations from state governments for public degree-granting institutions (2006-07) [Postsecondary Education Commision, 2010]

**Conclusion**

It seems that federal and state incluence is acted upon the sector of education in a delegative manner. The U.S. Department of Education is a big factor on a national level. It assists in federal policy making and law enforcement but it leaves a lot of headroom for the states to fill in their educational programmes. States and agencies can apply for and receive funding from the national department of education to for example support students in poverty or with a disability. A specialized office ensures individual help to postsecondary students.

### 11.1.6 Chance

Up until now, five conditions of Porter's diamond on education have been described, leaving us with one last remaining factor. The factor chance, with its influence easily overlooked, nonetheless plays an important role in the American educational system. Driven merely by exogenous forces, its influence is perhaps most easily described as a trigger that occasionally spurs waves of change and development within the educational sector. To get an overview, the most noteworthy examples of this factor and its effects have been laid out below.

**The Space War**

For the past fifty years, there have been a series of significant space exploration events with profound social impacts. Although most of these events were initiated by the United States' own National Aeronautics and Space Administration (NASA), not all of them were. Events include the recent Space Shuttle space program (human spaceflight missions) and the Apollo space program (that landed men on the moon and returned them back to Earth), but perhaps most notably the Soviet Union's Sputnik program that launched the first human-made object into orbit and sparked a fierce technological competition between the United States and the Soviet Union. This competition was also known as the Space War and occurred because of the already existing rivalry between the two nations during the Cold War. Although the main goal of the Space War was to pioneer the launch of artificial sattelites and manned spaceflight, its influence also extended to the educational system of the United States.

The educational reform of the 1950's and 1960's, sometimes referred to as the "Golden Age" of science and mathematics education, was just starting when the Sputnik program was being developed. As such, in early 1951, a reform of the secondary school mathematics curriculum was initiated by the University of Illinois Committee on School Mathematics (UICSM). In 1956, the Physical Science Study Committee (PSSC) was inaugurated with the goal of improving science education. Yet, the historical turning point came with the launch of the Sputnik 1 in 1957 by the Soviet Union. At the time, this accomplishment symbolized a threat to the perceived American superiority in science and technology and resulted in a change in public opinion on U.S. education [Bybee, 1997].

**The National Defense Education Act**

Before the 1950's, American education suffered from a curriculum that was deemed too easy, with music and arts often playing a larger part than science fundamentals.

Although the American public had previously opposed federal aid to schools on the grounds that federal aid would result in federal control, Sputnik made clear that it was in the national interest to increase the emphasis on higher academic standards, especially in the fields of mathematics and science. This resulted in the U.S. Congress's passing of the National Defense Education Act (NDEA) in 1958 that provided up to 222 million dollars in funding for educational institutions at all levels.

For the years that the provisions of the NDEA were in force (roughly between 1959 and 1973), positive effects were seen in the educational system. College enrollments, as well as the number of attained bachelors and doctoral degrees expanded significantly throughout the years and an influx of new teachers allowed the student-to-teacher ratio to decrease despite the dramatic increase of new students [Pamela Ebert Flattau et al., 2006].

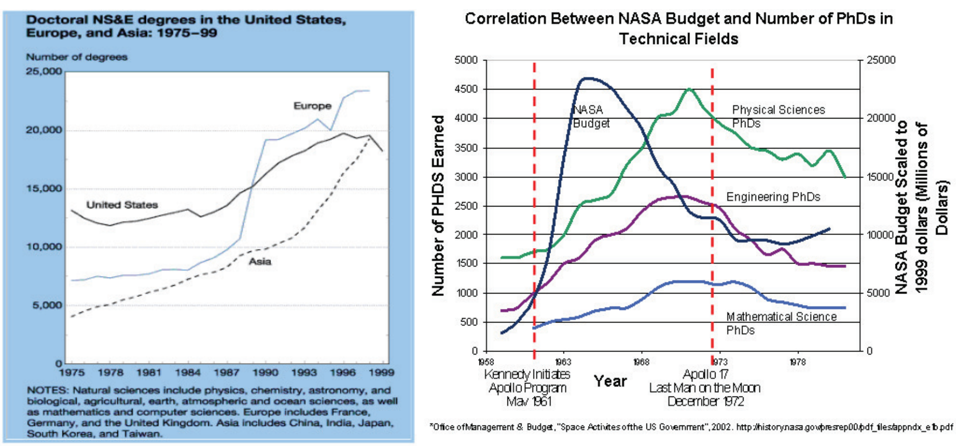


Figure 11.4: Statistics on doctoral degrees and the correlation between NASA budget and education. Source: Office of Management and Budget [Ehlmann et al., 2002].

During these years, the landing of the first men on the moon as part of the Apollo program spurred further interest for science education in the American society. Figure 11.4 shows the dramatic increase of attained degrees in the years following the successful Apollo 11 mission in 1961 up until the last Apollo 17 mission in 1972 and the decline in U.S. education.

### September 11th and the War on Terror

The terrorist attacks on September 11th, 2001 put a huge imprint on all aspects of American society. With its overwhelming effects on the society, politics and culture, it follows that its influence also spread to the educational sector. It is perhaps to no surprise that the most significant areas of impact by 9/11 have to do with changes involving the national security of the United States.

For one, it has been known that, since 9/11, government agencies and printing offices have taken out of circulation materials (both printed and digital) of value to the academic communities, often for reasons involving national security. Agencies also obtained the right to compel academic institutions to provide library circulation records and communication logs without the need of an appropriately reasoned warrant. The USA PATRIOT Act, signed into law on October 26, 2001, is an example of an act that opens the possibility of large-scale privacy invasion by the government of the United States. One practical example of this is the tracking of students through academic web services, library content and internet service providers (e.g. through network logs) on campuses throughout the nation [Kaufman and Siegel, 2002].

### Global financial downturn

Given their role and responsibility in society, colleges and universities are often described as institutions that are extraordinarily stable, regardless of political or economic situations that may otherwise affect other sectors. But despite this reputation of stability, the current financial crisis is nonetheless impacting the higher education institutions in a wide variety of ways. And although some may argue that it is not an incidental event, the global financial crisis certainly is incidental when looking at it in the context of the educational sector in the United States.

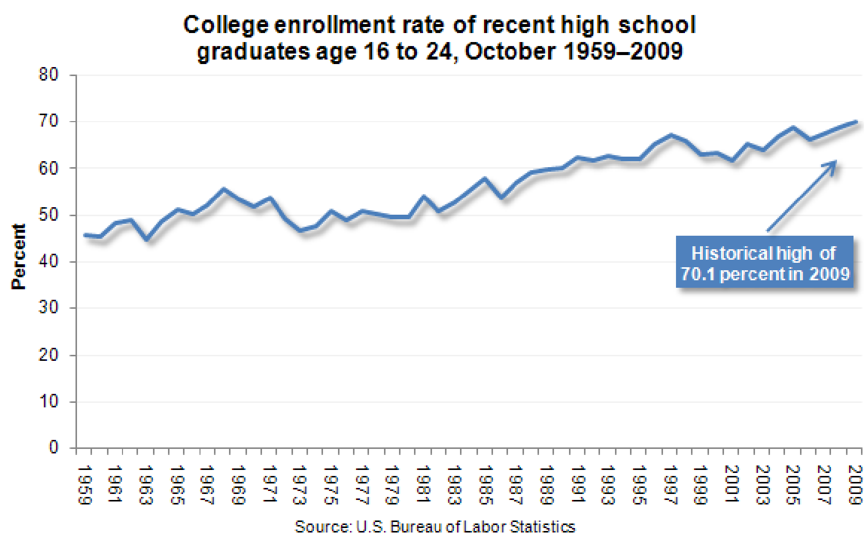


Figure 11.5: College enrollment rate of recent high school graduates age 16 to 24. Source: U.S. Bureau of Labor Statistics.

To illustrate the effects of the crisis, state budget shortfalls beginning in 2008 have forced almost half of the states to propose or implement budget cuts to public colleges and universities with reductions that range from 5 to 15 percent of previously appropriated funding. At the same time, there was a growing concern about the availability of loan capital for the Federal Family Education Loan Program (FFELP) that is used to provide student loans (by banks) that are guaranteed by the federal government. As a response, Congress had to enact legislation that was designed to stabilize the student loan market while colleges and universities had to work hard to ensure loan options for their students, at a time when many financial institutions were reconsidering their participation in the federal student loan program. Between 2006 and 2008, the market for private student loans (through companies) also declined [NACUBO, 2008]. Next to concerns involving student loans, uncertainty on the labour market has driven the college enrollment rate to a record high of 70% as can be seen in figure 11.5.

**Conclusion**

In conclusion, we can see that the factor chance has had, and will continue to have, a critical impact on the American educational system. This lies in the fact that chance, by nature, is difficult to predict and to guard against. It is proven that external forces such as political friction between nations, acts of terrorism and military policy can have a dramatic effect on science education, whether it be due to strong international rivalry, patriotism or national security. However, one should not forget that the influence of chance stretches beyond the scope of war, for example into the global financial crisis by means of indirect but nevertheless significant influences on academic institutions throughout the United States.

### 11.1.7 Relations within Porter's Diamond

As the diamond model designed by Michael Porter defines relations among the different components of the model, an elaboration on what these relations are in the case of the higher education sector will provide a better insight into the significance of the different components and create a more complete picture of the sector.

Within the diamond model, *firm structure, strategy and rivalry*, discussed in section 11.1.3, *factor conditions*, discussed in section 11.1.2, *demand conditions*, discussed in section 11.1.1 and *related and supporting industries*, discussed in section 11.1.4 are the core components, graphically alligned in a diamond shape. All of these components influence each other, a short description of their meaning follows:

**Firm structure, strategy and rivalry** The quality aim of a university as discussed in section 11.1.3 has an impact on all of the other core components: a high quality aim will increase the flow of money from third parties interested in research results, increasing both available capital and the demand for results. The quality of the research conducted by an institution therefore has also has a direct effect on the industries it supports. The rivalry between different institutions has a similar effect; the thrive to deliver better results increases the demand for and by (potential) students and research results.

**Factor conditions** It is obvious a factor condition like the geographical location of an institution has an influence on the demand from students for such an institution; a densely populated area simply offers more potential students. It also has an affect on the organizational structure of an institution; there are social differences between the west and east coast of the United States, for example. The concentration of specific industries in certain areas, will have an influence on the research done by institutions in the area.

**Demand conditions** The number of enrollments into an educational institution will have its effect on the strategy of the institution—a sudden rise or drop in enrollments can indicate a good or bad strategy—and feeds the rivalry between the various institutions. The expenditures into various research topics will find its way into the related and supporting industries.

**Related and supporting industries** Apart from profiting from research and developments made at institutions, related industries make this possible by providing funding to conduct this research. The education levels below higher education provide the potential students to create demand for higher education.

Although the model provides relations from all core components to all core components, these relations are not equally strong. In the case of higher education, for example, the rivalry between the various institutions and their social standing has a large impact on the demand for the different institutions.

The model provides an additional two components that influence the core components listed above. These final two components are government and chance, as described in sections 11.1.5 and 11.1.6. Their impact on the various core components has been discussed in the corresponding section. It should however be noted, that although the model on provides 'outgoing arrows' for these components, a sector as closely tied to the government as higher education will have its effect on the government. As this is no official part of the model, this is not discussed in further detail.

## 11.2 Comparison between the United States and the Netherlands

### 11.2.1 Demand conditions

The most striking difference between the United States and the Netherlands when demand conditions are concerned is the Gross Enrollement Rate (GER). For the United States, this rate is 82%. For the Netherlands, this rate is much lower, at 60%.

The difference between private and public institutions is another factor that differs between the two countries. In the United States, the difference in level of education is bigger than it is in the Netherlands, where the level of education is regulated by law and differences between universities are smaller.

### 11.2.2 Factor conditions

#### General factors

**Geographical Position** The Netherlands is a relative small country, especially when compared to the United States, one of the biggest countries in the world. When comparing the universities one of the important differences is the amount of campus universities. Most universities in the Netherlands have no campus, unlike the universities in the U.S. Most universities in the Netherlands offer no housing, the students live in the cities in which the universities are situated.

**Advanced factors**

**Capital** In the Netherlands there are a few private universities, but most universities are directly financed by the government and are thus public universities. The tuition fee for public universities is determined by the government, so universities can not choose their own tuition fee, unlike the U.S. universities. Like all research institutes Dutch universities apply for grants. In comparison to the U.S. the Netherlands donate relatively little [James and Wiepking, 2008].

**Quality of Education** There are a few Dutch universities listed in the world ranking lists, the best place going to delft (15th place in the USnews rankings). Although some US universities make up the top of most of these lists, the appearance of Dutch universities states that the quality in the Netherlands is also very good.

### 11.2.3 Firm Strategy, Structure and Rivalry

**Strategy**

Universities in the Netherlands use a somewhat different strategy as in the United States. All big universities in the Netherlands are supported by the government, while in the United States there are a lot of private universities that get their income primarily out of research or tuition. There are privately owned universities in the Netherlands such as the Nyenrode Business Universiteit. Nyenrode is, interestingly enough, a very prestigious private university that is ranked quite high among the business universities [Nyenrode Business Universiteit, 2010]. But in general the most and the largest universities in the Netherlands are public, while in the United States some very big private universities exist.

The way Dutch universities try to differentiate is mostly in location and focus. For example, the University of Twente has a campus, profiles itself as the entrepreneurial university and is away from the most populated areas, trying to attract students. While other universities have different focus points and methods to attract students.

**Structure**

In the Netherlands there are 13 universities and 51 colleges (excluding online institutes). At these institutes students can attain a bachelors degree in a wide variety of studies [Centraal Bureau voor de Statistiek, 2010]. In the college year 2008/09 there were about 600,000 students. In the Netherlands in 2008 about 6.3% of the GDP was spent on education. About 11 universities (all with the exception of the University of Tilburg and Wageningen) have a study in our area of interest "serious gaming and simulation" and one of our tracks. [StudieKeuze123, 2010] Compared to the United States the Netherlands have a relatively small amount of universities. The amount of students per institute should be about five times as high in the Netherlands. This, of course, does not deny the existence of very large universities in the United States.

The Netherlands spends relatively more money on education than the United states, but less on research and development.

**Rivalry**

Rivalry among universities is common. There is no real ranking of universities, other than done by foreign external parties that rank universities among the work. The Netherlands have multiple systems for aspirant students to find and compare universities. [StudieKeuze123, 2010] But none of these ranks a university. Generally a university is chosen purely based on the preferences of the student.

### 11.2.4 Related and supporting industries

The discussed 'supply chain' for higher education is almost the same for the U.S. and the Netherlands. In both systems, students follow primary ('lagere school') and secondary ('middelbare school') education before they can follow higher education ('hbo', 'universiteit'). The differences between the higher education systems of both countries are already discussed in section (TODO editors: include reference to Macro education section).

The related sectors are roughly the same, in both countries research and development industries, high-tech industries and commercial training industries play an important role. An example of the R&D industry in the Netherlands is TNO, a company that exists 'by law' and executes research for both government and commercial organizations. In the high-tech sector, companies like Philips and ASML play an important role. An example of a supporting service in the Netherlands is the Nederlands-Vlaamse Accreditatieorganisatie (NVAO), also issuing accreditations to higher education institutions in the Netherlands.

### 11.2.5 Government

The most important role of the government for the educational sector in both the Netherlands and the U.S. is funding. Both countries have an office in effect that controls student financing. At this moment, *all* Dutch postsecondary students above 18 years of age can apply for a student loan that is turned into a grant in most cases. The amount of money awarded is dependent on how much their parents make. Additionally a loan with relatively low interest rates can be issued. In comparison the U.S. only offers a grant to the students that really need it. Another difference is that the U.S. has a national program for work-study whereas Dutch government does not support such a program.

### 11.2.6 Chance

The common denominator of the United States and the Netherlands in the factor chance is the global financial crisis. As pointed out earlier in section 11.1.6, the crisis has had its effect on areas such as loans and enrollment rates. However, the uncertainty in the (private and public) student loan market in the United States plays a less important role in the Netherlands, as the loan and admission fee is strictly regulated. Nonetheless, the increase in enrollment rates can also been seen in the Netherlands, where 56.000 new students enrolled at a university in 2009 compared to 45.000 in the previous year, an increase of around 12% compared to 4–5% in the previous years. In other higher education areas such as HBO, an increase of 18% was seen [Funnekotter, 2009].

## 11.3 Technological development analysis

### 11.3.1 Current developments

According to a survey done by [Collis and van der, 2002] higher education institutions do not expect revolutionary changes from the use of ICT. In general, they see that no dramatic changes will be necessary, but that the changes will be gradual and usually slow. Despite this, there are some technologies widely adapted in the U.S., the most visible is the increase of the use of internet in the sense of 'online' classrooms.

In 1995, less than 1% of the higher education students took online courses, while this has increased to 20% in 2006 [Vignare, 2006]. There are even online only universities, like the Western Governors University and quite some other universities with an online section, like USA online of the University of South Alabama. Mostly used though, is blended learning. Blended learning is the integration of online and face-to-face learning experiences. This goes from the simple enrolling in courses to the availability of recorded colleges [Garrison and Vaughan, 2008][bll, 2004].

TOTAL AND ONLINE ENROLLMENT IN DEGREE-GRANTING POSTSECONDARY INSTITUTIONS – FALL 2002 THROUGH FALL 2008

| | Total Enrollment | Annual Growth Rate Total Enrollment | Students Taking at Least One Online Course | Annual Growth Rate Online Enrollment | Online Enrollment as a Percent of Total Enrollment |
|---|---|---|---|---|---|
| Fall 2002 | 16,611,710 | NA | 1,602,970 | NA | 9.6% |
| Fall 2003 | 16,911,481 | 1.8% | 1,971,397 | 23.0% | 11.7% |
| Fall 2004 | 17,272,043 | 2.1% | 2,329,783 | 18.2% | 13.5% |
| Fall 2005 | 17,487,481 | 1.2% | 3,180,050 | 36.5% | 18.2% |
| Fall 2006 | 17,758,872 | 1.6% | 3,488,381 | 9.7% | 19.6% |
| Fall 2007 | 17,975,830 | 1.2% | 3,938,111 | 12.9% | 21.9% |
| Fall 2008 | 18,199,920 | 1.2% | 4,606,353 | 16.9% | 25.3% |

Figure 11.6: Total and online enrollment in degree-granting postsecondary institutions [Allen and Seaman, 2009].

### 11.3.2 Technical challenges

Technology-based innovations in the U.S. education sector are often introduced as exciting new concepts to revolutionarize the educationary system. Computers with multimedia capabilities and internet access are seen as magic bullets with unlimited benefits for students and the ability to solve today's problems in schools. However, decades of practical experience with these technological innovations in the so called "island of innovations" (e.g. pilot projects on different universities) have shown that information technology can only be a cost-effective investment if it is lead by systemic reform. In practice, this means that in order to make these innovative models of teaching and learning effective, they should happen as simultaneous, large-scale innovations, overcoming difficult technical and social challenges [Dede, 1998].

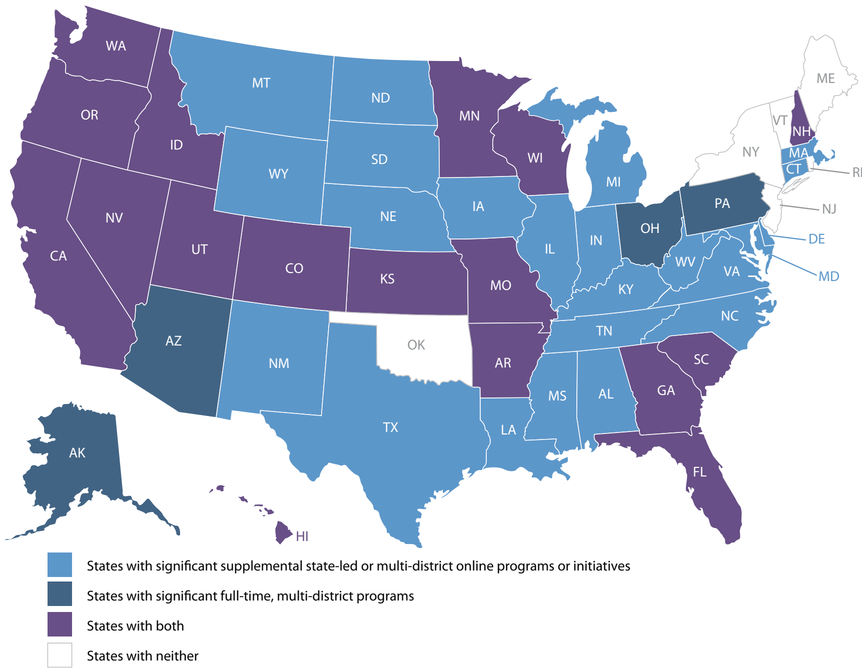


Figure 11.7: National summary of how online learning is being implemented across the country [Watson et al., 2008].

**Distributed learning** The concept of distributed learning or online learning, explained in the previous section, is an example of a novel development in the educational system. In the context of distributed learning, the first technological challenge lies in providing the "learner services" to facilitate this new way of learning. In prior years, there was no alternative but for educational institutions to provide these services themselves. However in modern times, a plethora of alternative providers (such as Embark.com, College.net, XAP, Studentonline.com, Tutor.com, Blackboard, Eduprise, eCollege, and many others) are available and could be utilized by institutions instead. Partnerships with e-learning ventures, ranging from online textbook providers to online exam applications and career services, could provide the higher education institutions the required services to facilitate distributed education in an effective way. The downside of the e-learning industry is that new ventures are constantly emerging, existing ones are being bought out or disappearing altogether, making it very difficult to keep an overview of the industry and knowing with whom to partner.

**Digital libraries** Any form of online learning will eventually have to depend on the use of digital libraries for educational works. Although various online digital libraries (such as Google Books) are emerging, no comprehensive digital library currently exists that would allow institutions to meet all the necessary information needs of students in an electronic medium. Current copyright limitations make (free) electronic access extremely difficult, making this one of the bigger obstacles in creating a complex and comprehensive set of distributed learning offerings [Oblinger et al., 2001].

### 11.3.3 Social challenges

Next to the technical challenges discussed in the previous sections, higher education also faces challenges from a social point of view. In [Altbach et al., 2005], a number of these social challenges are mention. In this section, these challenges will be discussed, and possible technical solutions will be investigated.

**Access to higher education** The U.S. has a system of "mass higher education"; in 2003, more than 60% of secondairy school graduates and more than one third of eighteen to twentyfour year olds were enrolled in higher education insitutes. However, participation in this education is still divided unequally: 64% of white Americans high school graduates were enrolled, while only 54% of African Americans high school gratuates were enrolled in 2001. Additionaly, fewer minority students complete high school, although this gap is narrowing, resulting in a changing student pool.

To let the participation of ethical minorities in the higher education grow, it first is important to decrease the drop-out of this group from high schools. The next step are the admission requirements of institutions. Also new types of higher education might help in increasing participation: completely e-learning based institutes have a lower barrier, although ethnic minority groups might not have internet facilities etc.

**Funding** State funding for universities and colleges is shrinking over the last decade. Also long term prospects for state higher education are not favorable. Figure 11.8 shows that the total number of students is growing, while the expenses per students is decreasing in the last years. This means that education must be more efficient, or more revenues from students and the commercial sector are needed, implying more 'privatization' of the higher education sector.

With less money per student, technology can be applied to make the education process more efficient. This can be achieved by introducing new education concepts, where electronic learning plays an important role. Next to these technical measures, it is important to mention that human influence in education stays important.

**Globalization** The higher education sector is operating in a increasingly globalized environment. There is a growing demand for higher education, which can roughly be distinguished into two main trends. On one hand, there is the rapidly growing need for the widening of initial access to higher education. And on the other hand, there is the increasing need for more diversified and flexible types of higher education, including lifelong learning, corporate training etc. [Van der Wende, 2003].

To facilitate globalization, institutions apply several technical facilities. The introduction of virtual classroom enables a larger audience, from multiple locations. E-learning can also be applied in this case.

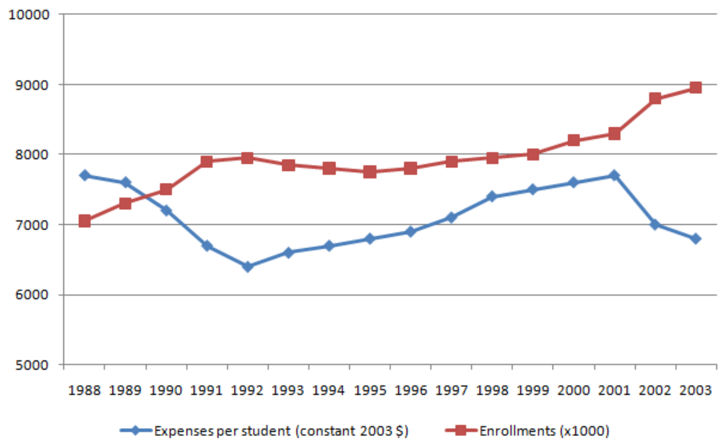


Figure 11.8: Public higher education enrollments and state appropriations to higher education per student, 1998-2003, in constant 2003 dollars [Altbach et al., 2005]

## 11.4 Conclusions

To reach a satisfactory answer to the research question, *what actors and factors can be found in the higher education sector that support or inhibit games and simulation developments?* we researched the higher education sector in general, based on porters diamond. We also looked at some technical factors and how they inhibit or support games and simulations.

### 11.4.1 Sector analysis

When looking at demand conditions one can identify three main factors. Overall student enrollment, the male to female ratio and the demand of research by the government. Student enrollment and the demand of research are both factors that could support or inhibit games and simulations.

On the other hand, looking at the factor conditions we can see different factors. Namely, geographical location, the amount of money available and the quality of education. None seem directly involved in games and simulations, but for example e-learning can decrease the importance of the geographical factor. Furthermore, money is always important for new research.

Even more factors can be identified when looking at structure, strategy and rivalry. Like the difference between public and private universities or having a competitive advantage over other universities. The existence of rivalry between multiple universities can promote research and the quality of education.

Related industries are also an important factor that inhibit games and simulations. For example the commercial training or the research and development industry. Both of them can support or promote games and simulations.

The government provides the most money for the research sector. This makes them an important factor for games and simulations as well. In America the influence of the government can be split into two different levels. At federal level and state level. Both can provide the higher education sector with money and research.

Finally chance also has factors that contribute to the games and simulations development. Most noteworthy money. Events like wars and financial crises can have a huge impact on the amount of money available for research.

### 11.4.2 Technology development analysis

When looking at the current ICT developments in the education sector we do not see any revolutionary changes going on. They are slow and subtle. Most noteworthy is the introduction and growth of online learning.

In the future this is expected to grow even further and the providers of this technology are changing ownership rapidly, making it difficult to keep track of the industry. Online learning is also plagued by the lack of librarys that contain the necessary information to effectively implement e-learning.

Statistics show that *access to higher education* is still unequally divided. The *funding* by state and federal government for higher education also decreases, with growing numbers of students. Finally, there is a high demand for widening of initial access to higher education and flexible types of higher education. With regards to the games and simulations theme, possible technical solutions for these problems can be the introduction of virtual classrooms, new education concepts and e-learning. The upcoming use of these solutions supports new developments in gaming and simulations.

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# Chapter 12

# Millary

*Section by Nils van Kleef, Oğuz Meteer, Sjoerd van der Spoel, Thomas Stols, Steven Sybenga and Ruud Welling*

### 12.0.1 Demand Conditions

This section will cover the demand conditions on U.S.' military forces. It will make a comparison with the demand conditions of the Netherlands' military forces. The market share is described in the section "Factor Conditions". Exports are described in section "Related and supporting industries".

#### Composition

The composition of the U.S. military per May 2009 is as shown in table 12.1 [Department of Defence, 2009a]. DOD is the Department of Defence.

| *Component* | *Military* | *Enlisted* | *Officer* | *Female* | *Civilian* |
|---|---|---|---|---|---|
| Total Active | 1,445,000 | 1,174,563 | 224,144 | 200,337 | 580,049 |
| Total Reserve | 850,000 | | | | |
| Other DOD Personnel | 97,976 | | | | |

Table 12.1: The United States Military Personnel Composition

Table 12.2 comparing the U.S. army size to that of China, Russia and the Netherlands. (The numbers are from 2002. Note that the U.S. army has increased in size between 2002 and 2009.)

#### Imports and exports

The U.S. historically obtained defence products in the defence sector by producing them overseas. Raw materials are also imported, when the U.S. does not have them in its own soil. However, manufacturing exports have been higher than imports. In comparison, the Netherlands have been very dependent on defence imports, since its military sector is only small.

Exports are described in section "Related and supporting industries".

| Rank | Country | Size of armed forces |
|---|---|---|
| 1 | China | 2,810,000 |
| 2 | Russia | 1,520,000 |
| 3 | United States | 1,366,000 |
| 66 | Netherlands | 52,000 |

Table 12.2: Size of armed forces [Nationmaster, 2002]

### Trends and forecasts

President Barack Obama of the U.S. has proposed an increase of 4% [U.S. Government, 2010] in Department of Defence spending in the fiscal year 2011 budget. He wants to decrease this in the fiscal year 2012 by 9% [U.S. Government, 2010], the budget is constant the next three years [U.S. Government, 2010]. This shows that the U.S. military will grow a bit in 2011, while being decreased the subsequent years. Military spending will probably remain constant the next coming years in most important countries, barring a major war. The U.S. defence spending might decline a bit, because of the economic crisis, having an effect on demand for U.S. military. Still, the U.S. are engaged in a lot of military activities (such as in Afghanistan and Iraq), which require a lot of military spending.

### Current military activities

Interesting to see is the recent deployment of both the U.S. military and the Dutch military. We will first discuss the U.S. personnel and later the Dutch deployments. The more important deployments of Dutch military are described further below.

**Recent deployments of U.S. troops** In Afghanistan and Iraq, U.S. presence is at an all time high, with around 59,000 troops in Afghanistan and 171,500 troops in Iraq. This is because of Operation Iraqi Freedom and Operation Enduring Freedom. Apart from Afghanistan and Iraq, the U.S. have 1,131,974 personnel stationed in U.S. including its territories, 79,830 in Europe, 45,009 in East Asia and Pacific, 5,571 in North Africa, Near East and South Asia, and 1,547 in Sub-Saharan Africa, and 1,995 in the rest of the Western Hemisphere. Furthermore 151,673 troops are in undistributed lands. This brings the total number of troops in foreign countries (excluding Afghanistan and Iraq) to 285,773 and the total number of personnel to 1,417,747. [of Defence, 2010]

**Recent deployments in the Netherlands** In *Bosnia-Herzegovina*, Dutch army troops have been deployed as part of an international protection force since early 1992. In *Kosovo*, Dutch army troops have been deployed as part of the NATO Kosovo Force since 1999. In *Southern Iraq*, 1,345 troops have been deployed in 2003. In March 2005 the troops were pulled out again. In *Afghanistan*, Dutch army has been present since mid 2006. In 2006, the majority of 1,400 troops was deployed to the Uruzgan province. They have been involved with some of the most intense battles in southern Afghanistan. This includes Operation Medusa and the Battle of Chora. On 10 August 2008, the Netherlands had 1,770 troops in Afghanistan, excluding special forces troops. Currently, the Netherlands is withdrawing from Afghanistan and the province of Uruzgan.

### Expenditure

One of the most important factors of demand for military is expenditure. Table 12.3 shows the expenditure of the U.S. as well as the Netherlands [sip, 2009], ranging from 2001 to 2008. The military expenditure is converted to constant (2005) million US$. This means that it takes inflation into account and converts all prices to $ 1 in 2005. It shows that the expenditure of the Netherlands has increased by a small amount (about $ 500 Million from 2001 to 2008, whereas the U.S. expenditure has increased by about $ 200 Billion from 2001 to 2008. This is 400x as much for the U.S. as it is for the Netherlands.

Under Factor Conditions there is a table with budgeted defence spending in 2010.

| | *2001* | *2002* | *2003* | *2004* | *2005* | *2006* | *2007* | *2008* |
|---|---|---|---|---|---|---|---|---|
| U.S. | 344,927 | 387,297 | 440,806 | 480,444 | 503,353 | 511,171 | 524,591 | 548,531 |
| NL | 9,355 | 9,347 | 9,482 | 9,552 | 9,568 | 10,017 | 10,152 | 9,866 |

Table 12.3: The United States & Netherlands Military Expenditure, converted to millions of dollars (2005)

Table 12.4 displays military expenditures of the U.S. and the Netherlands from 2001 to 2007, as percentage of gross domestic product [sip, 2009]. It shows that U.S. military expenditure has increased from a big 3% of the U.S. GDP in 2001 to 2004, and stayed about the same from 2004 to 2007. In the Netherlands it stayed at around 1.5% of the GDP from 2001 to 2007.

| | *2001* | *2002* | *2003* | *2004* | *2005* | *2006* | *2007* |
|---|---|---|---|---|---|---|---|
| U.S. | 3.1 | 3.4 | 3.8 | 4 | 4.1 | 4 | 4 |
| NL | 1.5 | 1.5 | 1.6 | 1.5 | 1.5 | 1.5 | 1.5 |

Table 12.4: The United States & Netherlands Military Expenditure, as percentage of gross domestic product

### Conclusion

The U.S. army is about 15 times as large as that of the Netherlands (1,445,000 total active as compared to the 27,000 total active personnel of the Netherlands). The U.S. also has the advantage in expenditure: the U.S. spends far more, in absolute terms.

### 12.0.2 Factor Conditions

#### Capital availability

In both the Netherlands and the U.S. the amount of money that the defence sector can spend is determined by the government. This determines the budget that the U.S. department of defence or the Dutch ministry of defence can spend on R&D, salary, training, health care of military personnel, equipment, operations and maintenance. Table 12.5 shows that the U.S. spends a much bigger percentage of the GDP than the Netherlands. The total amount of money spent on military by the U.S. is so high, that the U.S. is the leading country in total military expenditures, far ahead of others. Figure 12.1 compares the U.S. military spending to the rest of the world. The U.S. expenditures are this high because a lot of money is spent on the ongoing wars and missions (these expenditures are not included in defence budget). It should also be noted that a lot of money is spent on the production on arms that are exported and thus earned back. Another reason why the U.S. spending is so high is because the U.S. is a global superpower. Since the cold war, the U.S. maintained a high budget and strengthened its position as sole super power, so a high budget is needed to stay strong. [Shah, 2009]

| Country | Amount (billions) | (% of GDP) |
|---|---|---|
| United States | $687 | 4.8 |
| Netherlands | €8.46 | 1.4 |

Table 12.5: Defence budget 2010 [IMF, 2010][Ministerie van Defensie, 2009][Office of Management and Budget, 2009]

#### Labour

In both the Netherlands and the U.S. people can volunteer to join the military. In times of war recruiting may become very challenging because people who enlist in the military know that the chance that they will be asked to serve in hostile environments is high. Military recruiters also compete with higher education. Many graduates choose to enroll in colleges or universities. [Lee and Mather, 2008].

Table 12.6 shows the available manpower that is of the right age for military service and not disqualified for health reasons. These people could all serve their country in desperate times. Note that since there is no conscription in the U.S. or the Netherlands, most of these people have no military experience. Table 12.2 in section 12.0.1 shows the size of the armed forces. this table shows the actual size of the military. These people undergo extensive training, which makes them very skilled. In porter's diamond skilled labour is an advanced factor. This training allows the defence sector to create their own advantages in terms of skilled labour.

#### Modern Infrastructure

The U.S. Department of Defence spends a lot of resources to make sure defence installations and facilities are in the right place at the right time. The Defence

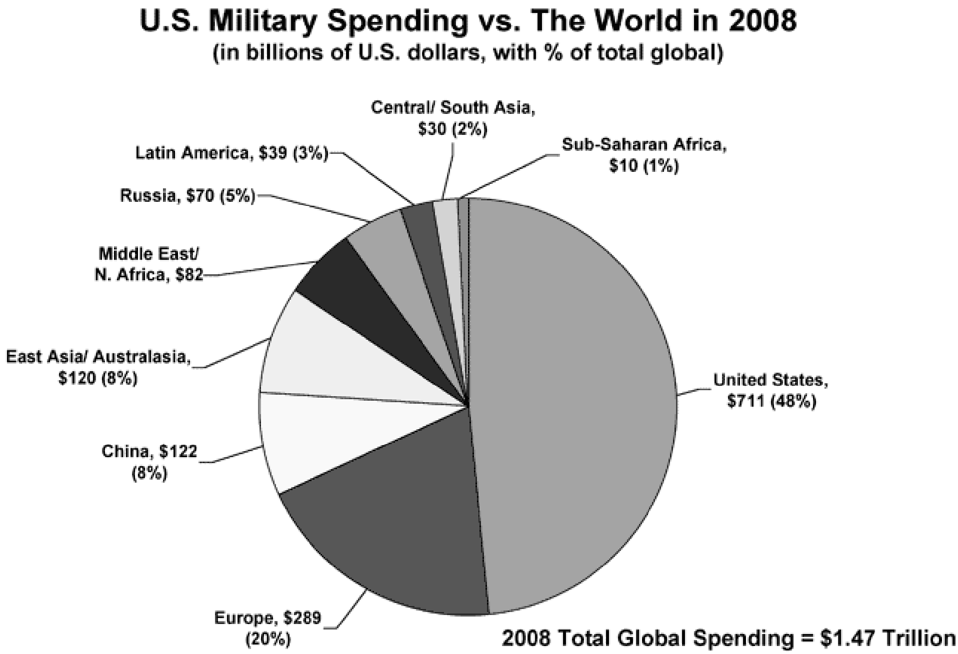


Figure 12.1: U.S. military spending compared to the rest of the world. [Hellman and Sharp, 2008]

| Country | Males age 16-49 | Females age 16-49 | % of population |
|---|---|---|---|
| United States | 60,388,734 | 59,217,809 | 38.6 |
| Netherlands | 3,213,954 | 3,133,972 | 37.8 |

Table 12.6: Manpower fit for military service [CIA, 2010]

Department manages an inventory of installations and facilities for national defence. The physical plant consists of several hundred thousand individual buildings and structures and is located at more than 5,000 different sites. The total area of all these sites is over 120 thousand square kilometers. [Department of Defence, 2009c]

A wide spread over the globe is important, whenever the U.S. or the Netherlands operates in a foreign location. A base or camp will be needed there to make sure that the location becomes reachable. The infrastructure is the first thing that is built up at a new operation site.

**Research institutes**

Both the Netherlands and the U.S. have research institutes which are a part of the Ministry of Defence, or Department of Defence.

In the Netherlands, the Netherlands Defence Academy (NDLA) takes care of military academic education and research. The NDLA was formed in 2005 when several military research and educations institutes joined forces. These institutes are still part of the NDLA organization structure. The NDLA specializes in strategy, commanding and leading military operations, ethics, civil-military cooperation and military logistic and technical topics. The NDLA also cooperates with civilian universities. [Ministerie van Defensie, 2010a]

In the U.S. the Defense Advanced Research Projects Agency (DARPA) is the research and development office for the Department of Defence. DARPA can spend money to fund innovative research projects though the private sector, academic and other non-profit organizations and also government labs [DARPA, 2010a]. More on DARPA in section 12.1.

**R&D Expenditures**

Both the Dutch and the U.S. defence departments spend a lot of money on research and development. The U.S. R&D spending as seen in figure 12.2, is roughly 25% of the total U.S. defence budget! This high percentage means that Research and Development is very important for the defence sector, which is very understandable since state of the art technology may give a huge tactical advantage.

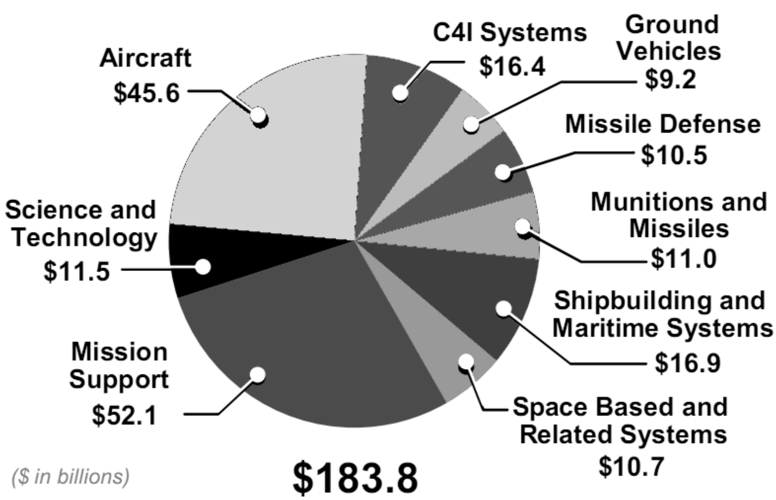


Figure 12.2: The U.S. department of defence spending on research, development, test & evaluation for strategic modernization. [Department of Defence, 2009b]

An example of one of the programmes that both the U.S. and the Netherlands are working on is the Joint Strike Fighter (JSF) program. A lot of the big military development and manufacturing projects, like the JSF project consist of a collaboration between different countries, consisting of the U.S. and its allies. The countries agree to invest a lot of money into parts of the development. Companies in those countries are then allowed to bid and then develop and/or produce (a part of) the project. They then get a return on their investments when countries buy the finalized product of which they had produced a part. The investments of countries are being won back by bringing employment as well as high tech development and production to their country.

The countries currently supporting the development of this fighter are[F-35 Joint Strike Fighter Program Office, 2010b]:

- **United Kingdom** signed Jan 17, 2001 for $2B
- **Italy** signed Jun 24, 2002 for $1B
- **Netherlands** signed Jun 17, 2002 for $800M
- **Turkey** signed Jun 11, 2002 for $175M
- **Canada** signed Feb 7, 2002 for $150M
- **Australia** signed Oct 31, 2002 for $150M
- **Denmark** signed May 28, 2002 for $125M
- **Norway** signed Jun 20, 2002 for $125M

#### Conclusion

The factor conditions section tells us that both in absolute and relative term, The U.S. spends far more than the Netherlands (4% opposed to 1.5% of GDP) on the Military. Both countries have an almost equal percentage of the population that are deemed fit for military service, however with a population about twenty times as large as that of the Netherlands, the U.S. has far more absolute manpower than the Netherlands. Even when compared to the rest of the world, the U.S. dominates military spending in 2008, with almost 50% of the global military spending done by the U.S.

### 12.0.3 Firm strategy, structure, and rivalry

In this section we look at the way military institutes determine their strategy and structure. Rivalry and domestic competition influences the strategy and structure of the institutes. To gain a competitive advantage, institutes will adjust their strategy and structure. Porter shows that the level of competitiveness is linked to the level of innovation and development within a sector. We will discuss the strategy, structure and competition of our sector, military. Finally, we will compare the strategy, structure and rivalry of the United States military with the Dutch military.

#### Strategy

A lot of money is spent on federal defence and with a growing U.S. GDP, the amount spent is still increasing with each year. Over the period 1998 to 2007, the percentage of the U.S. GDP that is spent on federal defence has risen from 3.67% to 4.64% [US Government Spending, 2010]. In 2008, almost 730 billion dollars was spent on defence, which is over 5% of the U.S. GDP [USGovernmentSpending]. For the 2010 fiscal year, the total expenditure for defence is expected to be between 880 billion dollars and 1.03 trillion dollars [Higgs, 2007].

According to the budget division of 2010 [U.S. Government, 2010], the budget for military expenditure for 2010 has increased once again with 3,0%. This is mainly because of ongoing wars in Iraq and Afghanistan.

**Defense Spending Chart**
**Fiscal Years 1998 to 2010**

| Year | GDP-US $ billion | Defense -fed $ billion | |
|---|---|---|---|
| 1998 | 8793.5 | 323.10 | a |
| 1999 | 9353.5 | 333.24 | a |
| 2000 | 9951.5 | 358.69 | a |
| 2001 | 10286.2 | 366.29 | a |
| 2002 | 10642.3 | 421.82 | a |
| 2003 | 11142.1 | 483.15 | a |
| 2004 | 11867.8 | 542.58 | a |
| 2005 | 12638.4 | 600.08 | a |
| 2006 | 13398.9 | 621.23 | a |
| 2007 | 14077.6 | 652.64 | a |
| 2008 | 14441.4 | 729.58 | a |
| 2009 | 14258.2 | 821.71 | b |
| 2010 | 14728.8 | 871.89 | b |

Legend:
a - actual reported
g - 'guesstimated' projection by usgovernmentspending.com
b - budgeted estimate in US fy10 budget

Figure 12.3: Defense Spending Chart

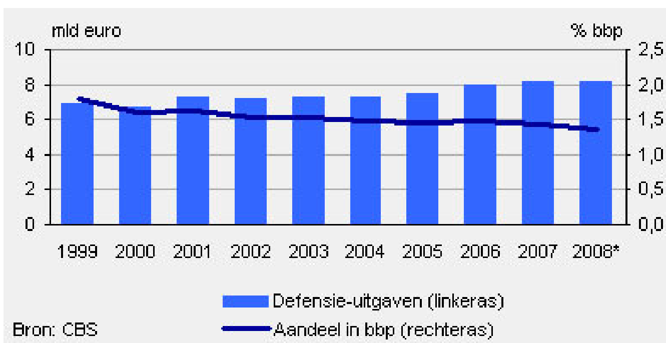


Figure 12.4: Dutch Defense Expenses

In the military budget table of the United States [U.S. Government, 2010] we can see that the United States spend 79 billion dollars on research, development, testing and evaluation in 2009. This huge amount (nearly 12% of the total base military expenditure) shows that the U.S. is putting a lot of money and effort in research to gain and keep a competitive advantage over other nations.

The Dutch military doesn't spend as much money on military as the United States, mainly because the Dutch military is much smaller in numbers and does not participate in current wars as active as the United States does. In 2008, the Dutch defence expenses were 8.2 billion euros, which is 1.4% of the Dutch GDP. The defence expenses over the last ten years show a decline from 1.8% to 1.4% of the GDP(see figure 12.4).

For 2010, the budget for military expenditure is 8.0 billion euros [van Defensie, 2010], a decline of 2.5%. The strategy that the Dutch have is to suffice the minimum NATO standard for budget, but still try to spend as little on military as possible.

The product of the military is essentially everything that has to do with protecting the United States and its interests. This can be the training of new soldiers,

| Components | Funding | Change, 2009 to 2010 |
|---|---|---|
| Operations and maintenance | $283.3 billion | +4.2% |
| Military Personnel | $154.2 billion | +5.0% |
| Procurement | $140.1 billion | −1.8% |
| Research, Development, Testing & Evaluation | $79.1 billion | +1.3% |
| Military Construction | $23.9 billion | +19.0% |
| Family Housing | $3.1 billion | −20.2% |
| **Total Spending** | **$685.1 billion** | **+3.0%** |

Figure 12.5: Federally budgeted military expenditure for 2010 [U.S. Government, 2010]

**Table 1. Federal Government civilian employment, except U.S. Postal Service, November 2008 (Employment in thousands)**

| | United States | Washington MSA |
|---|---|---|
| **Total** | 1,909 | 320 |
| | | |
| **Executive departments** | 1,664 | 238 |
| **Defense, total** | 652 | 68 |
| **Army** | 244 | 20 |
| **Navy** | 175 | 25 |
| **Air Force** | 149 | 6 |
| **Other** | 84 | 17 |

Figure 12.6: Defense department employment

conducting research in new technologies and weapons, or the gathering of intelligence. In order to sell this product to the public, the military needs a good reputation, a great diversity in jobs and good job conditions and health care. Beside this, the U.S. government has made the military into a status symbol of pride and honour. Serving your country is prestigious and rewarding. Employees are proud of their jobs and find fulfillment simply by working for the military.

### Structure

The military sector consists of overall unified military forces of the United States. The management style is traditional hierarchical and is made up of ranks. The biggest departments in this sector are the Army, Navy, Marine Corps, Air Force and Coast Guard. While the President is the overall head of the military, the United States Department of Defence is the main coordinator of all military policies and carries out most of the decision making.

The Dutch military consists of four branches: the Royal Dutch Army, the Royal Dutch Navy and Marine Corps, the Royal Dutch Air Force and the Royal Dutch Military Police. The Minister of Defence, the State Secretary of Defence and the Chief of Defence form the head of the military [Ministerie van Defensie, 2008].

The United States military is the second largest in the world [Department of Defence, 2010], after the People's Liberation Army of China [Center for Strategic and International Studies, 2006], and has troops deployed all over the world. The military has a lot of employees. Figure 12.6 shows that in November 2008, 652.000

employees were enrolled over all the defence departments. [Bureau of Labor Statistics, 2010] Since the defence department has to be able to fully attract and support its own employees, the job functions are very diverse. A lot of public jobs in society are available as military jobs. Some examples are jobs in administration, public relations, aviation, combat, computers and technology, electronics, intelligence, law enforcement, legal, mechanics, medical, logistics, etc. [Military.net, 2010]

Around 75 public and private military schools are deployed all over the U.S.. These schools offer middle school, high school or tertiary-level college in which it instructs its students in military-style education, discipline and tradition. By teaching students more than just military officer training, the United States military gains additional knowledge and a competitive advantage.

The Dutch military is relatively small. Currently there are 68,160 active employees over all the defence departments [Ministerie van Defensie, 2008]. Military education is provided by the NLDA, that coordinates military education in all its forms [Ministerie van Defensie, 2010b]. The NLDA also conducts scientific research for the military. This type of combined education is unique and will contribute to competitive advantage over other countries.

#### Rivalry

Since all the military departments are working for the same cause, there is no real domestic rivalry in the United States. Interservice rivalry between departments however can occur over topics such as the military budget, prestige or the possession of certain types of weapons [The Oxford Essential Dictionary of the U.S. Military, 2010]. But since all the departments are centrally operated by the United States Department of Defence, this rarely ever happens.

The U.S. military obviously has rivalry with other countries. According to Porter, intense competition spurs innovation. This is indeed the case with the U.S. military. Since the U.S. military is big in numbers, big in budget, uses premium technology products, has a big R&D department and has a well structured organization, the competitive advantage of the U.S. is enormous.

#### Conclusion

Because of the ongoing wars in Afghanistan and Iraq, the budget for military expenditure has been increasing since 2001. The Dutch military expenditure has declined from 1.8% to 1.4% in the last 10 years.

Competition is an important aspect in the U.S. military manufacturing process. Not only rivalry with other countries, but between U.S. companies as well is important.

### 12.0.4 Related and supporting industries

This section focuses on the competitive advantages of the industries supporting military activity in the U.S., and compares this sub sector of the military industry to that in the Netherlands. According to the ISIC definition of the military industry (more precisely, “Defence activities”), the following non-exclusive list makes up the tasks of the military supporting industry:

- engineering,

- transport,
- communications,
- intelligence,
- material,
- personnel

Obviously, not all of these services are handled by non-military personnel, as they are either too critical to be outsourced, or are an integral part of the military itself, respectively the case for intelligence and personnel. Services such as material production and transport however are suitable to be outsourced to other parties than the military itself. This section aims at finding what services are outsourced to the supporting industries, and what those industries are. To start, we'll discuss the military supporting industry in the U.S. as a whole, and compare it to the same industry in the Netherlands. After that, this section will zoom in on the different types of industries that make up the supporting sub sector. The traditional Porter's diamond analysis also states that competitors are to be mapped. As the military *de facto* has no competitors, this is omitted from this section. Competitive forces in the supporting industry will however be brought to focus.

**Size of the U.S. and Dutch military industry**

The U.S. military has budgeted to spend $ 165,006,000,000,000 on procurement for the fiscal year 2010 [U.S. Department of Defense, 2010]. This figure makes up the total turnover for the defence supporting industries, such as weapons manufacturers. The Dutch budget on military procurement is not as clearly defined as the U.S. information, as the details are deemed classified. However, the Stockholm International Peace Institute (SIPRI) states that for 2000 the spending on military material was 3 billion guilders [Stockholm International Peace Research Institute, 2004], more recent information is not publicly available. What is clear, is that the Dutch military expenses are altogether more modest that the U.S. expenses.

A further note on the reliable of this data is that besides weapons and other material purchases, the military also uses so-called private military companies (PMCs) for any number of tasks, including basic security. The most well-known of the latter is private security company Blackstone, whose operations in Iraq have become controversial. These PMCs will be treated in more detail further on in this section.

Another statistic that is interesting to assess the comparative size of the Dutch and U.S. military industry is the size of exports. Looking only at weapons and weapon systems, the total U.S. export is estimated at $11,5 billion [United States Government Accountability Office, 2007], making the U.S. the largest weapons exporter in the world. The Dutch weapons exports amount to around $ 1 billion [Stockholm International Peace Research Institute, 2004]. All in all, purely based on size the U.S. military supporting industry has the competitive advantage over the Dutch.

The following table summarizes the statements above:

An interesting fact appears directly from this table: The exports as a part of the total military procurement costs is much greater for the Netherlands than for the U.S.. This goes hand in hand with the much larger military apparatus,

| | *U.S.* | *NL* |
|---|---|---|
| Total military procurement costs | 165,006 | 1,360 |
| Exports | 11,500 | 1,000 |
| Exports as percentage of total procurement costs | 7% | 74% |

Table 12.7: The United States & Dutch Military Supporting Industry core figures, in millions of dollars (converted if necessary)

directly leading to larger expenditures for materials, vehicles, weapons and so on. The smaller military armed forces in the Netherlands require fewer materials, but factories still produce, creating an overcapacity. This is than handled by exporting the goods. A note on these figures is that they are estimates, most countries do not disclose information on weapon exports, as not all transactions are necessarily "politically correct".

### Major players in the U.S. military industry

The previous section discussed the key figures belonging to the U.S. and Dutch military industry, this section looks at what sorts of companies make up the industry in both countries, divided amongst the elements described in the ISIC classification. Table 12.8 shows what sorts of companies belong to the different sectors (for the U.S.), and what major (or well-known) players are amongst those companies.

Table 12.8 clearly shows, most civilian companies operate in the manufacturing industry, a service the military itself cannot provide. Therefore, the rest of this section will focus on the sector of the military supporting industry that is involved in the production of materials. Providers of communication equipment are included, as it can be argued they also produce materials for the armed forces. Materials used by the military are, amongst other things weapons (systems), ammunition, land vehicles, air planes & helicopters and ships & submarines. Table 12.9 shows important companies per type of material in both the U.S. and the Netherlands.

**Competitive position of major players** The table above (table 12.9) shows some of the major companies in the manufacturing of military material. What this does not show is what the competitive position of these companies is. The top 10 list of largest manufacturers of military material provides the answer [Stockholm International Peace Research Institute, 2010]:

1. BAE Systems, United Kingdom
2. Lockheed Martin, U.S.
3. Boeing, U.S.
4. Northrop Grumman, U.S.
5. General Dynamics, U.S.
6. Raytheon, U.S.
7. European Aeronautic Defence and Space Company, European Union

| *Sector* | *Description* | *Major players* |
|---|---|---|
| Engineering | All industries involved in the shaping of the physical operating environment for the military, such as bridge building. | Civil engineering companies are not used on any scale by the armed forces [army-technology.com, 2010]. |
| Transport | Industries involved in moving military equipment and personnel | The U.S. armed forces do not use civil contractors for transportation, all transports are handled by the military itself. |
| Communications | All companies involved in providing communication equipment and services | Major and well-known companies include Motorola and Bose |
| Intelligence | Companies involved in supplying military intelligence | As military intelligence is considered classified, no civil companies provide intelligence for the military. |
| Material | All industries involved in creating material for the armed forces, such as vehicles, weapons, clothing and so on | Major players are Lockheed Martin, Northrop Grumman, Boeing, General Dynamics, Colt's Manufacturing Company |
| Personnel | All industries providing personnel services to the U.S. armed forces | Civil companies providing personnel services are not used on any scale by the armed forces |

Table 12.8: Sectors of the U.S. Military supporting industry & Major players

8. Finmeccanica, Italy
9. L-3 Communications, U.S.
10. Thales, France

What this top 10 clearly shows is that the U.S. military supporting industries are dominant worldwide, as six of the ten are U.S. companies. The sheer size of the U.S. military industries provides a competitive advantage over the Netherlands, and in fact to most of the world, providing a stable basis for the U.S. armed forces.

**Conclusion**

Again, the U.S. military is a far greater industry than that of the Netherlands. Most civilian companies operate in the manufacturing industry, a couple of big players in the U.S. are 's Manufacturing Company, General Motors and Boeing, in the Netherlands some big players are Thales, DAF and Stork.

| *Type of Material* | Major player (U.S.) | Major player (Netherlands) |
|---|---|---|
| Weapons (systems) | Colt's Manufacturing Company | Thales |
| Ammunition | Federal Cartridge | None applicable |
| Land vehicles | General Motors | DAF |
| Airplanes & Helicopters | Boeing, Northrop Grumman, General Electric | Stork |
| Ships & Submarines | General Dynamics | Damen Schelde Naval Shipbuilding |

Table 12.9: Major players in manufacturing for the armed forces, per type of material

### 12.0.5 Government of the Armed Forces

This section aims to shed light on the administration of the armed forces of both the U.S. and the Netherlands, focusing on military law, command structure and international treaties influencing the military. To start, we'll discuss how the armed forces are commanded.

#### Command Structure

The U.S. Armed Forces consist, as mentioned before, of four main branches: Navy, Marines, Air Force and the land-operating Army. The branches all fall under the U.S. Department of Defense, and are therefore under the control of the secretary of Defense, currently Dr. Robert Gates. He does not however have the ultimate political responsibility for the Armed Forces, this position is for the President, the so-called Commander in Chief. The same structure roughly holds for the Netherlands, where the Minister of Defense is politically responsible. The Dutch head of state is, just as the American president, the Commander in Chief. However, as the Dutch head of state is of course the King or Queen, this is a purely formal position. The actual political end responsibility falls on the Cabinet as a whole.

The command structure of the U.S. and Dutch armed forces can be divided into two parts: the political command structure, which dictates high level strategy and the military structure, which is responsible for the operation of the political commands and visions and directly leading the military. The military structure of the U.S. can be seen in figure12.7 [Joint Chiefs of Staff, 2010]. What the figure shows is the top level organization of the Armed Forces; the Joint Chiefs of Staff. These generals and admirals are responsible for translating political vision into military operation, through the ten "commands" of the U.S. military. The Dutch organization is similar at the highest level, with the position of Commander of the Armed Forces being equal to that of the Joint Chief of Staff. He or she is in command of the commanders of the branches: Royal Navy, Royal Army, Royal Air Force and the Royal Military Police (Marechaussee) [Ministry of Defence, 2010]. The Dutch armed forces are not divided into different commands, as the organisation is smaller than the U.S.'s. The end conclusion still is, that both Armed Forces have a largely similar structure, and that differences that exist are mostly caused by a difference in scale.

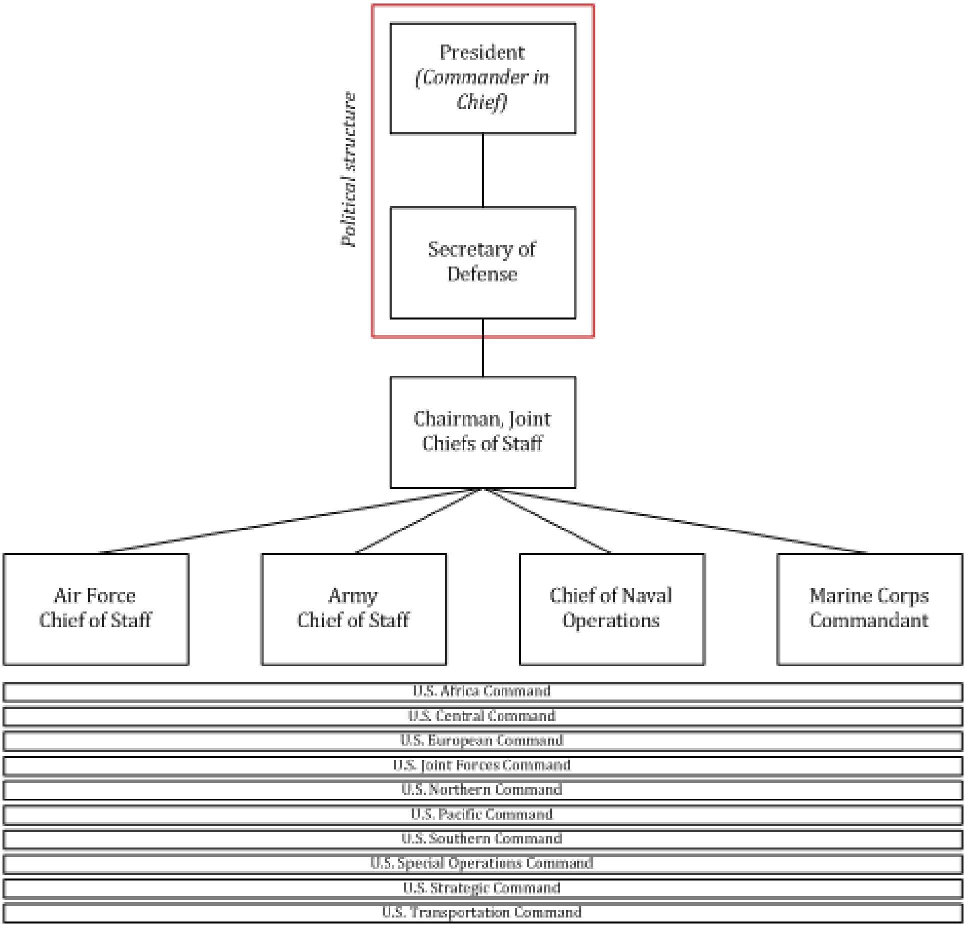


Figure 12.7: The U.S. Military Command Structure

### Military Law

A second element important to the government of the Armed Forces is law. The most important law bill influencing the U.S. military is the *Uniform Code of Military Justice (UCMJ)*, which makes up the foundation of all American military law. The UCMJ comes forth from Article 1, Section 8 of the Constitution of the United States. It states "Congress shall have power(...)to make Rules for the Government and Regulation of the land and naval Forces"[Constitution of the United States, 1787]. Every member of the uniformed services (the four branches) falls under the jurisdiction of the UCMJ. Among other things, the UCMJ dictates how soldiers are to be tried, for what they can be punished and how they are to be punished.

The comparative Dutch set of laws is divided in two: military disciplinary law (*"Wet militair tuchtrecht"*) and military penal law (*"Wet militair strafrecht"*). Unlike the UCMJ, these laws do not state how the trial of a soldier should take place, at least not to the same extent. Furthermore, the U.S. Court Martial (the military tribunal, "Krijgsraad") does not have a direct equivalent in the Netherlands. The

Court Martial is a completely separate tribunal, Dutch military penal law is handled by the Military Chamber of the Court of Arnhem [Ministry of Defence, 2009]. The fact that the U.S. has a separate tribunal for the military can most likely be attributed to the difference in size between the Dutch and American uniformed services.

### International Treaties

The final aspect of the government of the Armed Forces this section will discuss is the international influence on the military, in the form of international treaties. Below (table 12.10) is a list of important international treaties that involve the military, and their ratification status by the U.S. and the Netherlands. What the

| *Treaty* | *Start date* | *Ratification status U.S.* | *Ratification status Netherlands* |
|---|---|---|---|
| *Geneva Convention.* The Geneva Conventions give general rules of combat, injured troops and prisoners of war. | 1864 | ✓ | ✓ |
| *Charter of the United Nations.* The Charter states how the U.N. is composed and defines how the UN function. | 1945 | ✓ | ✓ |
| *North Atlantic Treaty.* The North Atlantic Treaty is aimed at providing safety for its member states, formerly allied in World War II, combined with Russia and Germany. | 1949 | ✓ | ✓ |
| *International Criminal Court.* This treaty is concerned with the prosecution of international war crimes, among other things. | 2002 | *X* | ✓ |
| *Strategic Arms Reduction Treaty.* The START treaty between the U.S. and the Union of Sovereign Soviet Republics is aimed at reducing nuclear proliferation . | 1991 | ✓ | *X* |

Table 12.10: International Treaties concerning the Armed Forces

table tells, is that the U.S. usually ratifies international treaties, in fact, it often takes initiative. Exception to the rule is the International Criminal Court, as the U.S. will not allow a limitation of the rights of its citizens by any foreign power.

**Conclusion**

A simple conclusion of the competitive advantages of the government of the U.S. cannot be made. The military apparatus of the U.S. is immensely complex, and so is how it is commanded. On one side, a well structured organization that is bound to clear rules could be interpreted as beneficial, on the other hand, it also means the organization will be slow to adopt to change and may be overly bureaucratic. As there is no military that can be compared directly to the U.S. in terms of size, but mostly in terms of how broadly it is deployed, it is (nearly) impossible to say if the U.S. structure of military government is the best possible.

### 12.0.6 Chance

This sector looks at possible major incidents or events that are likely to influence the sector and related industries. Since the military is mainly influenced by conflicts, both national and foreign, this section looks at conflicts that will influence the military sector. These conflicts are either present now, or may occur in the near future. Table 12.11 shows a list of current conflicts that are likely to keep influencing the military (industry) in the near future. After that, we'll discuss conflicts that are may occur in the near future.

| *Conflict* | *Since when* | *Deployment* |
|---|---|---|
| *Afghanistan (War on Terror)*. Since 2001, the U.S. Armed Forces (primarily the Army and Navy) have been active in Afghanistan, first to overthrow the Taliban government, and later fighting off Taliban rebels. Recently, president Obama has sent 30.000 more troops to Afghanistan, but starting in 2011, the U.S. want to start the withdrawal of troops [CNN, 2009] | 2001 | 9,500 (2001) - 65,000 (2009) - 100,000 (2011) [Washington Post, 2009] |
| *Iraq (War on Terror)*. Starting in 2003, the U.S. have been deployed in Iraq, again in the fight against terror. The U.S. have, together with their allied nations. Overthrown Saddam Hussein and have since then been actively trying to exterminate the Al Qaida terrorist organisation. | 2003 | 90,000 (2003) - 125,000(2009) |

Table 12.11: U.S. Military Deployment, 1990-present

The table (12.11) above shows the major conflicts the U.S. is currently involved in. These two conflicts continue to create opportunity for the U.S. defense industry, however unwanted the conflicts may be.

**New conflicts and Threats**

At the moment, there are no indications of new conflicts arising in the near future. However, over the past years some trouble has been brewing in, among others, North Korea and Iran. Both nations have or are suspected of creating nuclear weapons, something that would be considered a major threat to the security of the U.S.. If one of these countries should provoke the U.S., military interference is not out of the question.

## 12.1 Technologies related to games and simulations

This section will discuss technologies used by the United States military that are related to games and simulations. First we will look at who the major players using or developing these technologies are and discuss the maturity of these technologies. We will also discuss the challenges of developing and using these technologies. Finally, we will give a comparison between the United States military and the Dutch military.

The United States Department of Defense is responsible for coordinating and supervising all of her agencies relating to the United States armed forces. Its annual budget for 2010 is $663.8 billion [Office of Management and Budget, 2010a] of which $79.3 billion (almost 12%) is reserved for research, development, testing and evaluation in the military [Office of Management and Budget, 2010b].

One of the key players in military development is the Defense Advanced Research Projects Agency (DARPA), which is an agency of the United States Department of Defense (DoD). They are responsible for the development and funding of technology intended for military use. While these technologies are intended for military use in the first place, many of these are used outside of the military today like the Global Positioning System (GPS) and computer networking. A part of the DARPA's mission is "to maintain the technological superiority of the U.S. military" by "sponsoring revolutionary, high-payoff research bridging the gap between fundamental discoveries and their military use" [DARPA, 2010b].

While this chapter focuses mainly on section L-7522, this section will take section K-73 (Research and development) into account because R&D is important to find out how the technologies we discuss are being used in the U.S. military.

### 12.1.1 Current Developments

This section will describe the current developments of different technologies related to games and simulations that are used or developed by the United States military.

**Artificial Intelligence**

Artificial Intelligence can be used for many purposes and in many systems, ranging from hardware like robots, airplanes and helicopters to software like simulations. Bill Thomasmeyer, head of the National Center for Defense Robotics, expects the government to spend around $1.7 billion on such ground-based military robots between 2006 and 2012[Press, 2007].

Boston Dynamics is an engineering company that specializes in building dynamic robots and software for human simulation. They are developing different kinds of robots that are funded by DARPA. One of them, the LS3, is a rough-terrain robot that will be able to carry gear up to 400 lbs and go everywhere soldiers can go on foot. It will use Artificial Intelligence to find paths to follow a leader. It will also use A.I. to go to designated locations using sensors and GPS [LS3, 2009].

IRobot corp. is a company specialized in building UGV (Unmanned Ground Vehicles) and in UUV (Unmanned Underwater Vehicles). One of their UUV, called the Transphibian can find its way completely autonomously for mine detection, harbor defense and other surveillance or reconnaissance missions [IRo, 2010a]. Other robots that they are developing are the LANdroid, a mobile communications relay node [IRo, 2010c] and the Daredevil, an all-weather perception payload for another robot that IRobot is developing [IRo, 2010b]. One interesting research area IRobot corp. is currently working on is HRI. "Human-Robot Interaction (HRI) is a broad area of study covering robot command and control, how information is presented to the user and how data from one unmanned system fuses into the situational awareness of the overall mission. Several Research Group projects focus on multi-robot control and natural HRI."[IRo, 2010a]. In 2006, IRobot corp. gain approximately $76 million only on military business [Press, 2007].

Northrop Grumman is a global security company covering numerous business sectors. The sector most interesting for this section is Aerospace Systems, which is a merger of former Integrated Systems and Space Technology sectors. This sector is a "premier provider of manned and unmanned aircraft, space systems, missile systems and advanced technologies critical to the nation's security" [Grumman, 2010] and is responsible for the development of two unmanned aircraft vehicles (UAVs): the RQ-4 Global Hawk and the MQ-8B Fire Scout. The last mentioned is an unmanned autonomous helicopter designed to provide situational awareness and precision targeting support [fir, 2010].

Another product of Boston Dynamics is DI-Guy, which is "software and content for adding lifelike human characters to real-time visual simulations" [dig, 2009]. DI-Guy AI is the part of the DI-Guy software that adds Artificial Intelligence to the characters in DI-Guy [dig, 2007a]. Characters are therefore aware of their environment, display signs of human behavior and react appropriately to different situations.

### Serious Games

DI-Guy Scenario is a toolkit and delivery platform for serious games, which are used for training purposes [dig, 2007c]. The Navy Seals, that are responsible for de-mining very shallow water regions and they use DI-Guy Scenario to give commanding officers and others who are not knowledgeable with these operations insight into missions, involved tasks and techniques used by the Navy Seals [dig, 2007b].

Virtual Warrior is a serious games product that enables "Individual Combatants" to take part in a simulated virtual environment. It can be used by soldiers for different kinds of training like leader training and individual/squad-level mission training, but it can also be used to rehearse missions and to measure mission performance [vir, 2010a]. For example, when Virtual Warrior is used for leader/squad-level mission training, a squad leader is placed in the simulation and a couple of computer generated squad members are added to the simulation. The squad leader provides the squad with intelligence information and is able to communicate with them through voice communication [vir, 2010b].

Another serious game is America's Army [arm, 2010], produced by the United States military and is an initiative to help with recruitment of young Americans [Kennedy, 2002]. Later, several departments of the United States army asked the developers of America's Army to adjust it for training purposes. For example, the U.S. army uses the Common Remotely Operated Weapons Station (CROWS) system in armored vehicles and buildings to protect them from enemy fire. A gunner sitting in the CROWS can remotely fire weapons that are for example attached on top of a vehicle. America's Army developers developed a basic skills trainer for soldiers that will use the CROWS and after being introduced in 2006, it is now the required training method [Testa, 2008].

**Augmented Reality**

Augmented reality is very important for modern warfare. Take for example fighter planes, which are equipped with screens that display various types of information. Also used in fighter planes are the head-on display, which also displays crucial information. With the help of sounds and optics a fighter pilot is able to avoid possible treats or able to lock on to an enemy. Without the square around its target he might have a lock on his ally.

One of the aircraft that uses the Helmet Mounted Display System is the F35 JSF (figure:12.8). It also has a sophisticated cockpit with "unsurpassed situational awareness, positive target identification and precision strike under any weather condition."[F-35 Joint Strike Fighter Program Office, 2010a]

Also ground troops use augmented reality more and more to provide soldiers with critical information. A good example is the Land Warrior system. Soldiers use a single eye display to see maps of the battlefield or other tactical information, images from a teammate his helmet, he can see where the enemy is, he can use it to aim with the camera on his gun and many, many more. These features help soldiers to stay out of sight as they can look around the corner by turning their gun around it. A similar system currently being developed is the ULTRA-viz (Urban Leader Tactical Response, Awareness & Visualization)[Paul, 2008][IPT, 2010]. With this system:

- a squad leader can give an order while pointing at the location. This location will be marked and easy to find for his team members by looking through their glasses.
- team members are marked as well.
- maps are displayed inside the glasses.
- and many more

With this system the team members and the leader can keep their eyes on the situation.

### 12.1.2 Maturity of Developments

In this section we will discuss the maturity of the developments of these technologies, and possible future improvements.

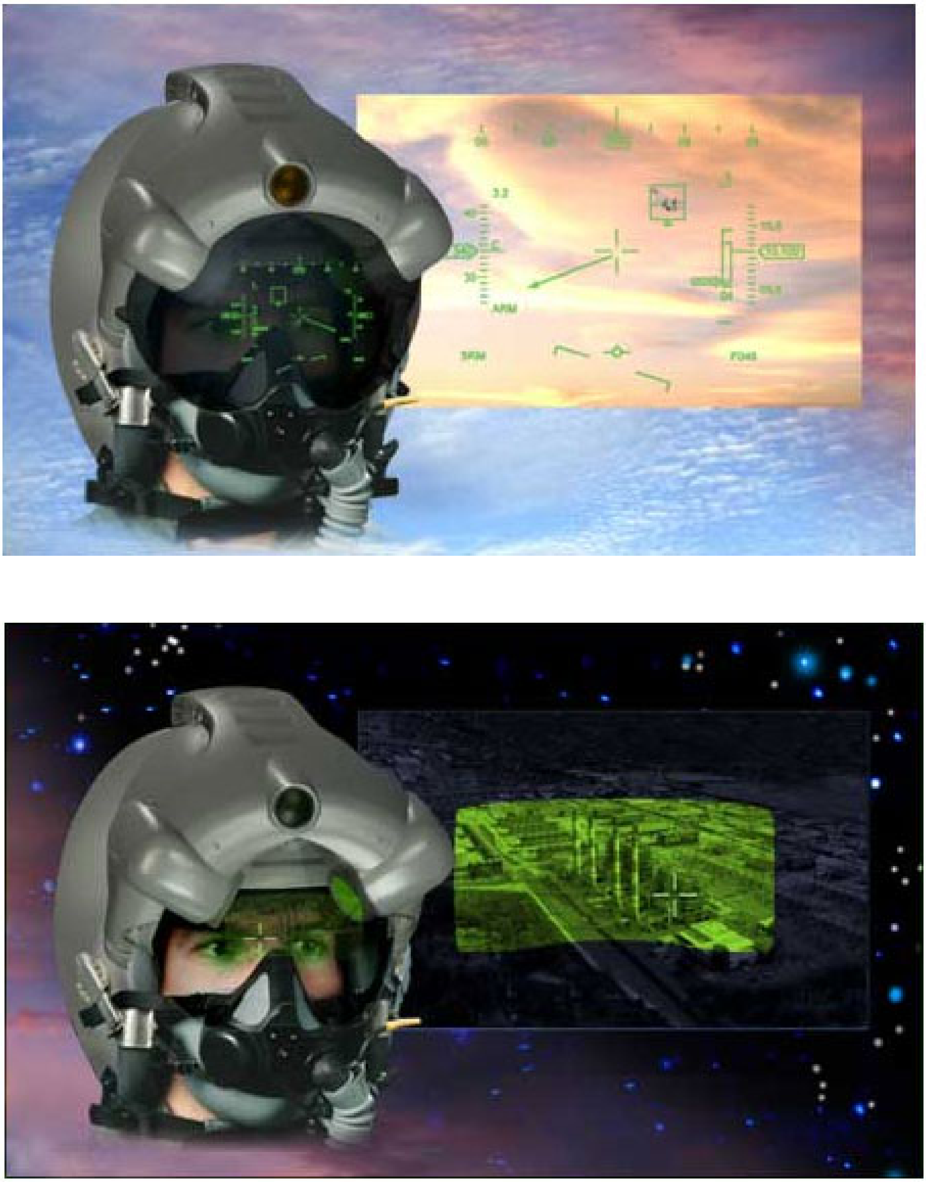

Figure 12.8: F35 head mounted display used in the Joint Strike Fighter

### Artificial Intelligence

Describing the maturity of Artificial Intelligence can be quite complex, because it is used in many systems and in many forms for different purposes. It is therefore easier to describe the maturity of the different forms of A.I. instead of describing A.I. as a whole.

*Path finding*: path finding is used to find the best route between two points. There are many path finding algorithms available, like A*, B*, Dijkstra's algorithm, Depth-first search, Breadth-first search and many more. These algorithms are tested and proven to work, so A.I., concerning path finding, is a mature technology and is used in many products such as games, navigation systems and robots. Future improvements could be in the form of faster or less resource using algorithms. The LS3 robot from Boston Dynamics, being in its early development phase, is being designed to follow a leader or go to designated locations and it uses A.I. to find the best path. The Daredevil robot from IRobot is also in its initial development phase while they have made a prototype of the LANDroid robot. An example of a fully functional product that is on the market would be the Transphibian robot, also from IRobot.

*Human behavior*: Artificial Intelligence is also used to simulate human behavior, which can be divided in subtypes. One way to test A.I. is the Turing test, where a judge "chats" with an A.I. using a keyboard and a screen, and aims at fooling a judge into thinking that he/she is chatting with a real person. This type of A.I. is not what is used in products we described in section 12.1.1. A.I. showing human behavior in a *physical* sense is used in products like *DI-Guy AI*, which is on the market. The purpose is to realistically simulate the behavior of virtual actors in simulations, which can help planning missions because of the added information obtained by these simulations. Expected future improvements are a higher degree of realism, but accomplishing this is quite a challenge.

### Serious Games

Some parts of Serious Games are dependent on other technologies like Artificial Intelligence, because some of these games also contain virtual actors that need to display realistic human behavior. The Serious Games described in section 12.1.1 are all available on the market and have many users, ranging from the United States Army to civilians. They are used for simulating Air Force base security, Launch Officer training, nuclear power plant operator training, water mine de-mining training, CROWS training and many more. Future improvements rely mostly on the development of Artificial Intelligence if it is used. Other improvements are added features and ease of use.

### Augmented Reality

Head-up displays in airplanes have been used by the United States military for a long time. The first prototype was the Buccaneer HUD built in 1958 [?]. Today all fighter planes in the military have HUD's, as do commercial airplanes, so it is a very mature technology that is continuously in development.

The Land Warrior system was being tested by the United States army until February 2007, when it was canceled by the United States army because of it not being the best use of limited resources in the future [Rogin, 2007]. Despite its cancelation, it was used by the soldier of the 4th Brigade in Iraq [Rogin, 2007].

### 12.1.3 Technological challenges

For every technology used by the military it is a must to have it operating as silent as possible (with a few exceptions). Precision and reliability are also essential for these technologies, it can be the difference between life and death.

In section 12.1.2 we mentioned already the challenge of making realistic behavior for virtual actors. To be able to fully simulate human behavior it is important to know how the human brain works. Even if we are ever able to understand it, simulating the brain might still be near impossible.

To be able to enhance the reality as natural and precise as possible some elements are critical. The position and orientation of the subject have to be very well calculated. Adding a virtual object representing something close by can be misplaced if this is not done properly. Nowadays, especially in open areas and for military use, GPS can be very precise but orientation tracking is still a technological challenge [You et al., 1999]. Even a miscalculation in orientation by one degree can show a virtual object far from where it was meant to be. Furthermore, the use of a computer is unavoidable. For the comfort of a soldier it is useful to have computers and power sources (e.g. batteries) as light as possible.

### 12.1.4 Social challenges

The most important social challenges are about the amount of authority of artificial intelligent. [Bekey and Abney, 2008] describes some of these challenges like what to do when a robot refuses an order or should a robot attack an enemy without the order of a human being. Other challenges are concerning the safety of the friendly forces: what consequences can a malfunction or programming error have and what happens if the enemy captures and hacks the robot.

### 12.1.5 Comparison

Het Nederlands Lucht- en Ruimtevaartlaboratorium (The Dutch Aviation and Space Laboratory) is currently developing systems for the Dutch ministry of defense using artificial intelligence and augmented reality. In 2009 the NLR made an autonomous parachute system. This system is able to drop heavy loads from a distance of 40km to a specified area with a maximum deviation of only 50m. This quiet system is for the military very interesting to be able to drop goods out of range of enemy fire.

Another project mentioned in the year report of 2009 is a system to help a helicopter pilot to land on a aircraft carrier. The waves can make it very hard and dangerous to land a helicopter on a ship but augmented reality displayed on the head mounted display and artificial intelligence should make it safer. This system is still in development and testing [NLR, 2009].

Even when we look at the development of simulation for military purpose the NLR is a key player. With their simulation software is it possible the calculate the effect of certain weapons in any situation or to train pilots to cope with difficult situations [NLR, 2010].

Other companies and research centers worth mentioning are TNO and Xsens. They made a training environment where trainees see a virtual world through their goggles. Thanks to the live motion caption it is even possible to add a real life person to this virtual world as an enemy or ally [Xse, 2010].

## 12.2 Conclusion

U.S. military spending is huge. The U.S. is waging war in Afghanistan and Iraq, and are present in many bases situated in loads of countries globally. Because the U.S. military is such a complex device, it is hard to say whether it is the 'best' military in the world; however it is certainly among the most prevalent in the world.

In absolute terms as well as in terms of GDP. The U.S. has a bigger military expenditure than the Netherlands. In every way, the U.S. has competitive advantages over the Netherlands. Situated against each other, the Dutch army would most likely be routed. A war between the two countries is an extremely unlikely scenario, but a comparison can be made anyways. Overall we can say that the U.S. has a bigger military apparatus than the Netherlands, in every possible way. Also in terms of manpower, the Dutch army size does not come close to the U.S. army size.

### 12.2.1 Relation to games and simulation

Many technologies concerning gaming and simulations are used and developed by the United States military, and is mostly financed by DARPA. All of these technologies are being researched and although there are a lot of projects that are still in their prototyping phase, there are also are also products that are on the market. Augmented Reality is mostly used in aircraft, but there are developments in adapting this technology and creating gear usable by the infantry. Serious Games are used quite a lot in the military for training purposes, like de-mining, *CROWS* system training and virtual warfare. Artificial Intelligence plays a big role in the developments of robots that rely on A.I. to function autonomously. A good example is the *Transphibian* robot that is used for harbour safety detecting mines.

We think that in ten years from now, some of these technologies will change the way of warfare, because the U.S. military spends a great deal of money and effort in research and development. There will also be many challenges that will be a big obstacle in the usage of autonomous systems. One of the social challenges is if we should grant authority to autonomous systems to attack enemies. But there will also be technical challenges like making autonomous systems that never make mistakes. This is especially hard, because it is often considered impossible to write completely bug-free software of any real complexity and it could have severe consequences like machines accidentally injuring civilians or allies. This shows that the technical challenges influence the social challenges and could be one of the reasons why the U.S. military invests heavily in research and development. By solving the technical challenges, the social challenges can also (partly) be overcome, making it possible for the U.S. military to use advanced technology and gain military superiority.

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# Chapter 13

# Healthcare

*Section by Yme Joustra, Marije de Heus, Ties de Kock, Gijs van Veen and Thomas Visser*

## 13.1 Introduction

In this chapter, the results of a meso-analysis of the healthcare sector on the development of games and simulations are given. The following research question will be answered:

> *What actors and factors can be found in the healthcare sector that support or inhibit games and simulations developments?*

Both the healthcare practise and education will be taken into account as they are connected firmly. The applications of games and simulations, on the one hand in practise and on the other hand in education, differ greatly but together, these two facets of the healthcare sector make use of a broad spectrum of game- and simulation applications and to game- and simulation related applications.

First, the current technologies and technological developments in the healthcare sector related to the research question will be discussed. Then, the sector will be discussed using the National Diamond analysis by Porter. The chapter will conclude with a comparison of the healthcare sector in the U.S. and The Netherlands.

## 13.2 Technology development analysis

### Education, training and assessment

Simulation and serious games are used a lot in medical training and education. We will first discuss medical education. Secondly, we will discuss the possibilities and types of medical simulation. Afterwards we will discuss some examples and evaluate the future of medical simulation.

**Effectiveness of simulation in medical education** In the following sections we give a brief history of medicine, introduce the methods historically used in medical training, introduce simulation methods for use in medical training and give a brief evaluation.

We will first give a overview of medical education and training. Afterwards, we will discuss the possibilities and usage of simulation and gaming to solve ease these problems.

## Current medical education

**History** Medicine has a long tradition in education. In ancient Greece the Temples of Health were erected to care for the sick. A trainee of this tradition was Hippocrates, sometimes referred to as the father of western medicine. The Hippocratic School of medicine established medicine as a seperate discipline from religion philosophy and made it a real profession. Francis Adams [1849] The influence of Hippocratic medicine on medical professionalism, discipline and the hippocratic oath are still visible today.

**Structure** In the Netherlands, the structure of medical training has hardly changed since Boerhaave. The main concept of Boerhaave is that it is impossible to teach techniques in lectures, and thus techniques should be learning through a Master-Apprentice relationship. This structure causes a long lead time in training and places a lot of responsibilities on the instructor. Furthermore, learning by doing has the potential to hurt patients. An example of the problems this structure brings is education in interventional cardiology. Interventional cardiology deals with the catheter based treatment of heart diseases. The current generation of intervention cardiologists is the first generation and this means that they learned through doing. The fast advances in the field, and large impact of mistakes make it very hard to train new specialists.

**Competencies** According to a working group of the *Royal College of Physicians and Surgeons of Canada* (RCPSC) modern medical specialists need the following competencies:

- Medical Expert/Clinical decision-maker
- Communicator
- Collaborator
- Manager
- Health Advocate
- Scholar
- Professional

The role of medical expert is different from the roles of communicator, collaborator, manager, health advocate, scholar and professional. However, the medical field is recognizing that proficiency in these latter roles is essential to success as a medical expert. The RCPSC concluded that learning methods should closely match the actual practice circumstances (contextual learning), and that new methods of

| Factor | No. of Events With | % of All Events ($n$ = 584) in Which Factor Was Reported |
|---|---|---|
| Failure to follow policy or protocol | 273 | 46.8 |
| Communications problem | 131 | 22.4 |
| Error in charting or documentation | 78 | 13.4 |
| Labeling error | 56 | 9.6 |
| Poor teamwork | 50 | 8.6 |
| Inattention | 157 | 26.9 |
| Distraction | 69 | 11.8 |
| Inexperience | 59 | 10.1 |
| Inadequate training | 35 | 6.0 |

Table 13.1: Factors That Contributed to Events [Suresh et al., 2004]

e-learning would be required to learn these newer skills. Learning these competencies through experiential learning is not possible, and the RCPSC adviced to teach these aspects through more progressive learning strategies. Frank JR, Jabbour M, Tugwell P, et al. [1996]

**Effectiveness** The quality of medical training is hard to measure. Academic quality does not guarantee improvements in patient care, and latest research does not match the care patients currently receive. However, the quality of medical care and number of accidents is relatively easy to measure.

An anonymous study of medical errors in neonatal care showed that failure to follow protocol, and various crew resource management issues were the major contributors to medical errors. Suresh et al. [2004] Specific training which emulates the actual situations which occur in practice is said to reduce these errors. Table 13.1 shows the factors. The section on simulation in medical training will evaluate the simulation types against the errors they reduce.

**Medical simulation** The field of medical simulation is rapidly expanding and there are some differences between 'regular' simulation and 'medical simulation'. We use the following definition for simulation: "a simulation is a person, device, or set of conditions which attempts to present

$$educationand$$

evaluation problems authentically. The student or trainee is required to respond to the problems as he or she would under natural circumstances. Frequently the trainee receives performance feedback as if he or she were in the real situation. Simulation procedures for evaluation and teaching have several common characteristic..." [Issenberg et al., 1999]

This definition focuses on the following items:

- Trainees are subjected to authentic situations
- The trainee needs to act as they would in the real situation

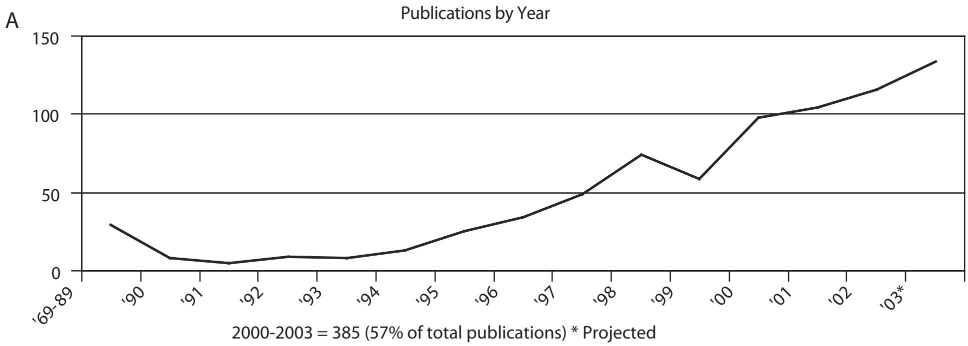


Figure 13.1: Amount of publications per year

- The trainee can be subjected to complex situations
- Simulation is isomorphic to the real world (costs, technological limits, danger, ethics, time)

The usage of simulation in medical education is growing because of limited instruction time and patient availability, and simulations are becoming a integral part of medical education. [Issenberg et al., 1999] The amount of publications on medical simulation is also steadily rising, as seen in figure 13.1. [Barry Issenberg et al., 2005]

Although simulation does not necessarily include automation, we will focus on medical simulation that uses computer technology.

**Types of medical simulation** Meller [Meller, G., 1997] provides a typology framework for simulators in medical education. The framework analyzes the following elements:

- $P_1$ = the patient and/or the disease process
- $P_2$ = the procedure, diagnostic test, or equipment being used
- $P_3$ = the physiscian or paraprofessional
- $P_4$ = the professor or expert practitioner
- $p$ = passive element
- $a$ = active element
- $i$ = interactive element

Each element of the simulator can be passive, active or interactive. Passive elements enhance the realism of the simulator, and active elements change during simulation, according to a programmed way. These elements change the simulation and influence the student. In most simulations the $P_3$ element is the student.

Simulations are being used to train all six competency categories described by the RCPSC.

According to [Barry Issenberg et al., 2005] the featurs in table 13.2 lead to effective learning when using a high-fidelity simulator.

| Features and uses | No. of studies | Comments |
|---|---|---|
| Feedback is provided during learning experience | 51 | Slows decay in skills over time; Self-assessment allows individual to monitor progress |
| Learners engage in repetitive practice | 41 | Primary factor in studies showing skill transfer to real patients; Shortens learning curves and leads to faster automaticity |
| Simulator is integrated into overall curriculum | 27 | Simulator fully integrated into overall curriculum |
| Learners practice with increasing level of difficulty | 15 | Increasing degree of difficulty increases mastery of skill |

Table 13.2: Features and uses of high-fidelity simulators that lead to effective learning [Barry Issenberg et al., 2005]

**Currently used simulations** There are a lot of types of medical simulations that currently are in use. We will present an overview of different simulations, classify these simulations their elements, and analyse which features and uses they have.

**Laerdal SimNewB™** The Laerdal SimNewB is an interactive simulator that fills different roles. The simulator emulates a lot of symptoms seen in real neonatal patients, which you can see in figure 13.2. The main role is creating an educational environment where teamwork, leadership and communication skills are trained. The SimNewB represents a baby that can have a variety of conditions. These conditions include the possibility to apply artificial respiration. The simulator provides both standard training and customizable scenarios with realtime instructor control [Laerdal, 2010a].

The SimNewB is a $P_1aP_2i$ simulator, which includes realtime feedback en facilitates repetitive practice. When used properly, the simulator would match the other aspects of effective high-fidelity simulators.

**Simbionix LAP Mentor** The Simbionix LAP Mentor (Figure 13.3) is a combination of hardware and software that enables the training of surgeons in laparoscopic surgery. The LAP Mentor enables the training of basic tasks and skills alongside the simulation of complete procedures [Simbionix, 2010]. The LAP Mentor provides high-fidelity simulations for learners, with or without tactile feedback and provides a safe environment for training.

The LAP Mentor is a $P_1pP_2i$ simulator, which includes the most important features of a high-fidelity simulator. Simbionix has multiple other products that provide a $P_1pP_2i$ simulation of procedures.

**Haptica ProMIS Laparoscopic Colectomy** Even though both the ProMIS Laparoscopic Colectomy (LC) and Simbionix LAP Mentor both simulate laparoscopic surgery, there is a important difference between the products. The ProMIS LC uses virtual/augmented reality in combination with real instruments and haptic feedback, as you can see in figure 13.4. During training, the ProMIS LC will

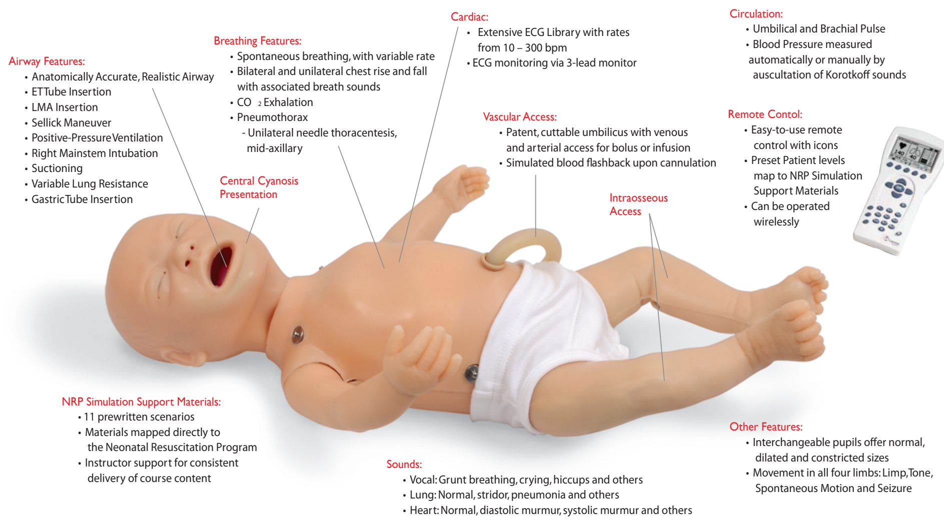


Figure 13.2: The features of the SimNewB

Figure 13.3: The Simbionix LAP Mentor Express

Figure 13.4: A user operating the Haptica Promis LC

overlay augmented reality layers over the video of the laparoscopic camera, which is operating a model human analog. Haptica [2010]

The ProMIS LC $P_1pP_2a$ simulator, that provides training using the tools that will be used in practice. It has most features of an effective simulator, but lacks the ability to simulate dynamic cases. In our opinion, this is the reason the ProMIS LC is marketed mostly for training goals instead of simulating real procedures.

**Laerdal UMedic** In contrast to the surgical simulator mentioned earlier, UMedic is a software package that simulates a cardiological, case-based patient encounter. The interface between the user and UMEdic is a regular computer program, that initially shows bedside findings, based on which the user should evaluate the case. While diagnosing the user can request laboratory data and simulate a treatment. UMedic uses real photos and video [Laerdal, 2010b].

UMedic is a low-fidelity medical simulator, that enables users to simulate a patient encounter. Even though it is a low-fidelity simulation, UMedic transfers a lot of knowledge to the user. UMedic is a $P_1p$ simulator, which when in explanation mode acts as a $P_1pP_3p$ simulator.

**University of Kansas Medical Center Virtual Operating Room** Until recently most crew training in the field of medicine was done by simulating accidents with a dummy in a real operating room, filming the interactions between the participants and then evaluating the recording. Since the 1950's, pilots have been trained in flight simulators.

Recently there has been progress in the direction of a digital simulation of a operating room. One of these initiatives is the University of Kansas Medical Center (KUMC) second life virtual operating room (Figure 13.5. Building a virtual operating room introduces a lot of abstractions and user interface choices. The

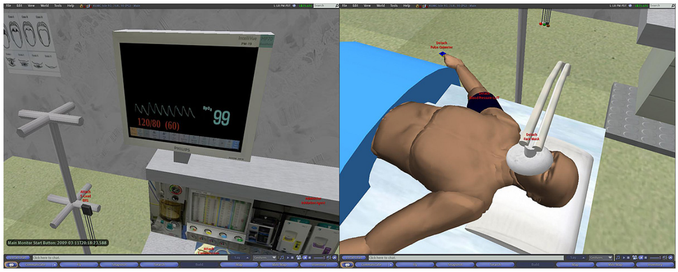

Figure 13.5: University of Kansas Medical Center second life operating room simulator

main reason to create the virtual operating room was to reduce the amount of time needed in a real operating room. Educause Quarterly [2009]

At the moment, the KUMC virtual operating room is a $P_1pP_2p$ simulator which does not allow for a lot of interaction. However, there are multiple projects in this direction and we suspect that 3d, virtual reality simulation of the interactions in a operating room will soon become possible.

**The future of medical simulations** There are no technical problems preventing the adoption of simulation in the medical industry. The quality of medical simulations will improve because of the incremental development of computer graphics and speed.

At the moment medical simulation is being adadopted. Medical simulation has already found it's place in education. Simulation is used to practice procedures before operating on animals, and when fully proficient a trainee will operate on real patients.

The adoption of medical simulation in education, combined with the evolution of computer hardware will create a market for additional simulations. These will either be more immersive, or in a different submarket.

### Surgical applications

In recent history, robotic technology found its way to the hospitals, into the operating rooms [Howe and Matsuoka, 1999]. In this section, the current and recent developments in this area will be discussed. Two products by two major companies will be treated, showing the technological aspects that play a role in the relevant field. Finally, several technologies that have not yet found their way to the practice but are currently being developed and subject to clinical trails are discussed.

**Robotic-assisted surgery** In the past three decades, a new trend in the surgical field has risen: robotic-assisted surgery. Where in traditional open surgery large incisions were required for the surgeon to execute the procedure, with robotic-assisted surgery (RAS) the procedures could be executed through small incisions. The new trend came as a revolution in the field of minimally invasive surgery (MIS). MIS aims at minimising patient trauma by making the incisions as small as possible, reducing post-operational pain and decreasing recovery time [Darzi and Munz,

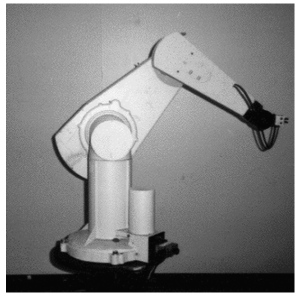

Figure 13.6: The PUMA 560 robotic arm was used in the first robotic-assisted surgery.

2004]. Tiny cameras and instruments are inserted in the patient's body through the small incisions. MIS however has some drawbacks compared to traditional open surgery. The surgeon has to operate using the 2D image captured by the camera inside the patient, flattening the natural image and losing information on depth. The tiny instruments are less flexible than the human hand, limiting the surgeons control over the procedure. Also, surgeons that perform MIS procedures suffer from work related injuries more regularly.[Park et al., 2009] These drawbacks reduce the applicability of the technique but were overcome when RAS was introduced.

**History of robotic-assisted surgery** The first use of robot technology in a surgical procedure was in 1985, when the PUMA 560 robotic arm (see figure 13.6) was used in a neurosurgical biopsy, a non-MIS surgery. In 1987 the first MIS was conducted using the same system. [Samadi, 2010] At the beginning of robotic surgery, following the previous mentioned earliest systems, the focus lied on the development of autonomous systems. Such a system would perform the procedure based on a pre-operative plan that was created using a CT-scan of the surgical field. The surgeon only had to supervise the procedure and hold an emergency-off button. Application of these autonomous systems was limited to areas where tissue movement between the CT scan and the procedure was insignificant. In recent years, a transition from these systems developed by enthusiastic technologists towards more cost-effective systems with a broader surgical application was observed. The shift from technology push to surgeon demand resulted in more advanced systems under the direct control of the surgeon. y Baena and Davies [2010]

**The da Vinci Surgical System** In 1999, Intuitive Surgical launched the da Vinci Surgical System, one of the leading RAS systems. It was the first robotic surgical system to be approved by the Food and Drug Administration for use in laparoscopic procedures Samadi [2010]. It consists of a surgeon's console with ergonomically designed controls and a patient-side cart with four robotic arms (see Figure 13.7), controlled by the surgeon. The hand movements of the surgeon are scaled, filtered and translated into precise movements of the robotic arms. One arm controls the camera (the endoscope), the other three can be used to perform the procedures.

The da Vinci's endoscope actually consists of two cameras, feeding a 3D image of the surgical field to the surgeon's console. The improved visualisation enables the


Figure 13.7: The four robotic arms of the da Vinci Si Surgical System

surgeon to perform precise procedures even in confined spaces [Intuitive Surgical, 2010a].

The combination of ergonomic and smart controls and advanced robotic instruments results in an accuracy that exceeded the former definition of surgical precision. The instruments, EndoWrists, have seven degrees of freedom, mimicking the human wrist. The controls are designed to improve the ambidexterity of the surgeon: a usually right-handed surgeon will be able to use his/her left hand through the da Vinci system with dexterity comparable to its right hand. The surgeon will effectively be able to control the instruments that normally would require an additional assistant (to hold the camera) and second surgeon (to operate the fourth instrument). In this way, the da Vinci Surgical System supports solo surgery.

Due to the instrument's size, an incision of only one to two centimetres is needed. Also, due to the high precision that is achieved, overall less tissue is damaged. Patients benefit from these advantages as, besides less post-operational pain and decreased recovery time, there will be less scarring, smaller risk of infection, less blood loss and overall quicker return to normal activities [Intuitive Surgical, 2010b].

Another advantage of the da Vinci Surgical System is its relatively high ease of use. Research has shown that a laparoscopically naïve yet well trained open surgeon successfully transferred open surgical skills to a laparoscopic environment in 8 to 12 cases using the da Vinci system. After these 8 to 12 cases, the surgical skills of the surgeon using the da Vinci system are comparable to a surgeon experienced in non-robotic laparoscopy after over 100 cases [Ahlering et al., 2003].

Intuitive Surgical provides extensive data on the performance of their system in medical procedures. On davinciprostatectomy.com, a website by Intuitive Surgery, a comparison is made between three different approaches to radical prostatectomy (i.e. the removal of the prostate): using the da Vinci surgical system, open surgery or minimally invasive laparoscopy. The comparison, based on thirteen independent scientific research papers, decides in favour of the da Vinci system (see figure 13.8). Using da Vinci, the estimated blood loss is the lowest of the three, the length of stay is less than half of the second best option (i.e. laparoscopy) and the chance of major or minor complications is much lower than with the two alternatives [Intuitive Surgical, 2010d].

**da Vinci® vs. Open vs. Conventional Laparoscopy**

| Outcome | da Vinci® | Open | Lap |
|---|---|---|---|
| **Cancer control** | | | |
| T2 margin status | 2.5[1] | 5.9[2] | 7.7[3] |
| **Complications** | | | |
| Estimated blood loss (EBL) | 109 ml[4] | 1355 ml[5] | 380 ml[6] |
| Length of stay (LOS) | 1.2 days[4] | 3 days[5] | 2.5 days[13] |
| Major | 1.7%[4] | 6.7%[5] | 3.7[6] |
| Minor | 3.7%[4] | 12.6%[5] | 14.6%[6] |
| **Urinary function** | | | |
| 3 month | 92.9%[7] | 54%[8] | 62%[9] |
| 6 month | 94.9%[7] | 80%[8] | 77%[9] |
| 12 month | 97.4%[7] | 93%[8] | 83%[9] |
| **Sexual function** | | | |
| 12 month | 86%[10] | 71%[11] | 76%[12] |

Figure 13.8: A comparison between the da Vinci Surgical System, open surgery and minimally invasive laparoscopy for radical prostatectomy. The superscript numbers refer to publications that back the data. See Intuitive Surgical [2010d]

Research on the downsides of robotic-assisted surgery resulted in the formulation of several principal drawbacks. Murphy et al. [2009] concluded from an extensive literature study on the da Vinci Surgical System that, among others, a device failure occurs in 0.2-0.4% of the cases, the evaluation of the system is unsatisfactory because it can not be correctly assessed using a current standardised system and that the approach does not reduce the difficulty associated with e.g. obese patients or patients that previously had surgery.

**The MAKOplasty procedure** In 2009, MAKO Surgical launched the MAKOplasty procedure. MAKO Surgical is an innovative orthopedic medical device company developing advanced solutions for orthopedic surgery. MAKOplasty is a procedure with which early to mid-stage osteoarthritic knee disease can be treated. The RIO Robotic Arm Interactive Orthopedic System (see figure 13.9), developed by MAKO, is used to prepare the bones for installation of the prothesis. The prothesis, replacing part of the knee joint that is affected by the osteoarthrisis, is also developed by MAKO and is named the RESTORIS MultiCompartmental Knee System. Together, the resurfacing using RIO and the placement of a RESTORIS prothesis is called MAKOplasty.

The preparation of the surgery consists of the creation of a patient specific plan. Based on a CT scan, the surgeon determines how the prothesis should be placed and consequently what part of which bones should be cut away. This plan is then used during surgery by the RIO to guide the surgeon. The surgeon controls the instrument that is equipped to the robotic arm directly, but the RIO provides tactile feedback to prevent the surgeon from cutting away bone other than in the area that was defined by the pre-operative plan. As the RIO already registers the surgeon's movements, it could also be stored to enable a visualisation of the surgical

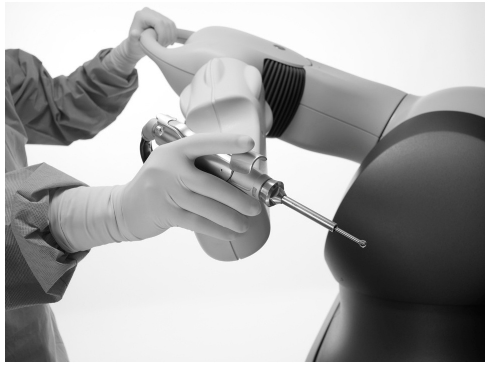

Figure 13.9: The RIO Robotic Arm Interactive Orthopedic System by MAKO Surgical

field. During the MAKOplasty, the surgeon works based on a visualisation of the knee, making a minimally invasive procedure without using an endoscope possible.

### New technologies and future developments

**Autonomous surgical tools** As a continuation of the research on autonomous robots prior to robotic-assisted surgery, a new field of research has evolved. The new autonomous robots do not simply follow a predefined plan, but are based on decision making using artificial intelligence. These robots overcome the problems of the previous generation by being able to interpret input from on-board sensors and change the planning, thus allowing the execution of procedures in changing environments, e.g. with moving tissues.

An example of a smart autonomous robot is a surgical robot developed in 2009 at Duke University. It was designed to locate shrapnel, tiny pieces of metal, within flesh and guide an instrument to the exact location, without human assistance. Rudimentary experiments have been a proof-of-feasibility, leading the researchers to believe that the technology will find its way to real applications in the near future, e.g. on the battlefield.

The robot detects the shrapnel using a 3D ultrasound sensor which was invented at Duke in 1991. An electromagnet attached to the sensor will cause the shrapnel to vibrate just enough to make it clearly visible on the sensor image. The image is then analysed by the robot's brain, an artificial intelligent program, which establishes the coordinates of the pieces of metal. The researchers see lots of possibilities for improvement to the prototype and expect a broad applicability of their smart autonomous robot. Merritt [2009]

Another example of new smart autonomous robots is a drilling robot used in a cochleostomy. Cochleostomy is one of the key steps in the procedure for installing an implant in the ear to improve hearing. It is the hole in which the implant is placed. In Brett et al. [2006], the results of a clinical trail of an autonomous drilling robot are presented. The robot was designed to drill the hole in the right place and until the right depth. If the cochleostomy is too deep, it will expose the inner delicate internal structures of the cochlear, which can lead to complication. Also, digging too deep can cause bone can contaminate the internal fluids and will increase the risk of post operative infection or lead to decreased hearing.

The robot is equipped with a sensor to measure the torque and force at the drill tip. Based on this information the robot can distinguish between different situations such as patient or tool movement, the approach to tissue boundaries, tissue hardness and stiffness, and drill breakthrough. The robot can detect the critical breakthrough event before it happens and therefore is able to place the implant at the best position while leaving the inner membrane intact. Fewer complications and higher hearing performance are expected when using the autonomous robot Brett et al. [2006].

**The future of robotic-assisted surgery** Future robotic surgery will become even more precise, allowing the most delicate medical procedures. The current advantages of RAS will be expanded upon, resulting in even smaller incisions and less patient trauma. Also, the distance between the surgeon's console and patient-side cart will increase, eventually resulting in remote surgery. This development could result in a situation where patients can undergo surgery in a clean room nearby their homes while the surgeons are working from a central hospital. Another advantage of having a clean operating room, either in a remote surgery situation or not, is the decreased risk of infection [Samadi, 2010].

The development of the RAS technology is however hindered by the nature of the medical field. The time it takes to evaluate new procedures or new approaches to existing procedures can well be several years. For example, it may take 15 years to accurately measure the difference in durability of robotic versus manual hip replacements. And before it can be tested in clinical trails, the system should be safe. To ensure safety, the system should be verified to work correctly in all circumstances. This is however a task that, for these kind of systems and most complex computer systems in general, is very difficult. There will always have to be mechanisms that enable the surgeon to shut down the system in case of emergency, without doing harm to the patient [Howe and Matsuoka, 1999]. This requirement affects the complete architecture of the system and will remain a challenge for RAS developers in the future.

## 13.3 Sector analysis

### 13.3.1 Commercial

According to the North American Industry Classification System there are over 824 thousand companies in the Healthcare and Social Assistance sector in the United States. This sector not only includes offices of physicians and other doctors, hospitals and clinics, but also medical research labs and companies specializing in specific medical care. Another 22 thousand companies are responsible for selling Medical, Dental and Hospital Equipment and a thousand companies are responsible for manufacturing pharmaceutical products [North American Industry Classification System, 2010].

An oversight of the industry can be seen below:

- **32** Manufacturing
  - **325412** Pharmaceutical Preparation Manufacturing

- **42** Wholesale Trade
  - **423450** Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers
- **62** Healthcare and Social Assistance

Though not all of these companies play a part as major players with respect to United States Healthcare and Simulation and Gaming in Healthcare in particular, they all play a role in the Healthcare industry. For the scope of the research however, companies focusing on using simulation and gaming for healthcare and companies that they interact with will be the main focus. Since some markets might have several smaller companies or only a few large ones, the selected major players are considered either the largest in their market or the companies that have the most influential product of their sector. The analysis of the commercial sector is divided into three segments: simulation, serious gaming and medical robots. These three segments will be discussed consecutively below.

### Simulation

Simulation devices for training and other medical purposes have been introduced to the market over the last several years. Companies selling these products however are still relatively small, as can be seen by their profits and the number of people they employ.

**Medical Simulation Corporation** The Medical Simulation Corporation (MSC) claims to be the largest supplier of full-service medical simulation training and education. The Denver based company was founded in 1998 and has mainly sold their SimSuite Clinical Educators product. This simulation tool can be used to educate users in several different medical applications [Medical Simulation Corporation, 2010].

Even though the Medical Simulation Corporation is the largest supplier of full-service simulation training products, the company only employs 75 people. Since the company is private, estimations of the revenue differ widely. Some estimate the Medical Simulation Corporation's revenue at 750.000 U.S. Dollars with 76 employees [BNet Industries, 2010], while other estimates show a revenue of 3.3 million Dollars [Manta, 2010a].

**Medical Education Technologies, Inc.** Medical Education Technologies Incorporated (METI) is a Florida based company developing tools for training future doctors. Products include multiple patient simulators and surgical simulators. Currently more than 250 people are employed by METI [METI, 2010]. Though METI does not sell full-service products like the Medical Simulation Corporation, her revenue is much larger, at an estimated 50 million U.S. Dollars [Manta, 2010b].

### Serious Gaming

Over the last few years health games have seen an increase in sales and popularity. This is not just limited to commercial fitness games like Wii Fit and EA Sports

Active, but serious games are now also used for education and psychological healing [Reuters, 2009].

In many cases, the difference between serious games and simulation are hard to determine. As such, much of what applies to the simulation sector in healthcare also applies to the sector of serious gaming. A difference has to be considered between the types of serious games however. For example, HumanSim is very similar to the training simulations produced by the Medical Simulation Company and METI. Other games, such as Re-Mission, are more patient oriented and do not share the same market.

**Virtual Heroes** Software studio Virtual Heroes, Inc. rose to fame when it developed the game America's Army for the U.S. Military force in order to attract players to join the real army. Recently however, the company has been developing HumanSim, a serious game that trains physicians, nurses, emergency medical personnel and students in proper and fast reactions to different situations. Other games from the developer include Zero Hour: America's Medic, training military field medics the same way HumanSim does [**?**].

Recently, Virtual Heroes was acquired by Applied Research Associates, Inc (ARA) [BNET, 2009]. ARA is a research and engineering company employing over 1200 people. Products not only include software, but also robotics and security sensors. As such, the company is not only focused on healthcare but other sectors where itś expertise can be used as well [Applied Research Associates, 2010].

**HopeLab** Though HopeLab is a Non-Profit organization, it has become an important player in helping young adults and teenagers recover from cancer through the use of video-games. Their videogame Re-Mission lets the player battle cancer cells and shows as an effective tool to help players battle real cancer. As of April 2009 Re-Mission had been shipped 142.000 times across 81 countries worldwide [HopeLab, 2010].

### Medical Robots

In the United States only one company actively produces surgical robots, Intuitive Surgical [FDA Consumer, 2005].

**Intuitive Surgical** Intuitive Surgical is the market leader and only producer of minimally invasive robotic-assisted surgery equipment in the world. Their da-Vinci Surgical System is used to offer surgeons a better view of the operated area, an improved dexterity and greater precision [Intuitive Surgical, 2010c]. Though the da-Vinci system had competition from the Zeus Robotic Surgical system until 2003, Intuitive Surgical became sole supplier of robotic equipment for medical purposes after it acquired Computer Motion, the company developing the Zeus system [FDA Consumer, 2005].

Intuitive Surgical currently employs a little over one thousand people and had an revenue of over one billion U.S. Dollars in the 2009 fiscal year ending December 31th 2009, resulting in a Gross profit of 750 million U.S. Dollars. Despite the financial crisis, revenue increased by twenty percent when compared to the fiscal year 2008. By the end of 2009 almost 1400 da-Vinci systems where in use worldwide, completing over 200.000 surgical procedures [Intuitive Surgical, 2009].

**MAKO Surgical Corp.** MAKO Surgical Corp. is a company that markets the RIO Robotic Arm Interactive Orthopedic system and their RESTORIS implants for minimally invasive orthopedic knee procedures. The FDA-cleared RIO system allows surgeons to provide a precise, consistently reproducible tissue-sparing, bone resurfacing procedure called MAKOplasty to a large, yet underserved patient population suffering from early to mid-stage osteoarthritic knee disease. MAKO has an intellectual property portfolio of more than 250 licensed or owned patents and patent applications relating to the areas of robotics, haptics, computer assisted surgery and implants. [mak, 2010]

The main difference between MAKO and Intuitive is that MAKO only produces a robotic tool used for a specific purpose, while Intuitive Surgical produces for a general market.

### 13.3.2 Non-commercial and Academic

In this section we will focus on non-commercial and academic firms. We will examine some universities like Stanford School of Medicine and the University of Rochester Medical Center. We will discuss the educational programs that both universities provide and what research they have done.

#### University of Rochester Medical Center (URMC)

The university of Rochester Medical Center is one of the top academic medical centers. They spend more than $145 million in federal research funding. Their mission is to use education, science and technology to improve health. The university was one of the first twelve to receive a $40 million Clinical Translational Science Award from the National Institutes of Health (NIH) and they have in the past ten years, more than twenty new companies formed with URMC technologies.[The University of Rochester Medical Center, 2010]

**URMC educational** The University of Rochester Medical Center is dedicated to train future physicians/scientists/humanists who will become leaders in their professions. The objective for the university students is professional competence in all areas. If this goal is completed their excellence is attained.[The University of Rochester Medical Center, 2010]

Some areas of professional competence they emphasize are:

- Knowledge of core concepts and principles of biological sciences from molecular to systems levels;
- Knowledge of social sciences basic to medicine and skills needed to provide care to culturally, ethnically and ecologically diverse populations;
- Development as physicians who teach, not only patients and their families, but also students, residents, colleagues and society at large;

- Research skills to formulate a hypothesis and outline an experimental design to gather data to test the hypothesis.

In the university's educational process, they combine evidencebased medical science with the relationshipcentered art of medicine.

Some programs you can follow at the university are, Ph.D. Programs, Residency Programs, Fellowship Programs, and Master's Programs.

**URMC facts** Some facts about the University of Rochester Medical Center are:

- The university has an overall budget of almost $2 billion;
- The university approximately 1,400 full-time faculty members and 650 voluntary clinical faculty members organized into 32 departments and centers.
- Research faculty have attracted external funding totaling approximately $300 million during the last fiscal year (2009);
- Their student rosters include approximately 400 medical students, 550 graduate students, and 600 residents and fellows.

[The University of Rochester Medical Center, 2010]

**URMC finance** Also URMC came in contact with the effects of the market crisis. They noticed that there were losses on investments and they had a unfavorable mark-to-market adjustment on swap transactions. But nevertheless they invested more than $109 million in property, physical plant, and technology upgrades. With these investments they help to ensure that URMC continues to provide high quality care, conducts breakthrough research, and attracts the very best faculty, students, and residents.[The University of Rochester Medical Center, 2010]

**Research Spending** Here you see two figures of research spending.

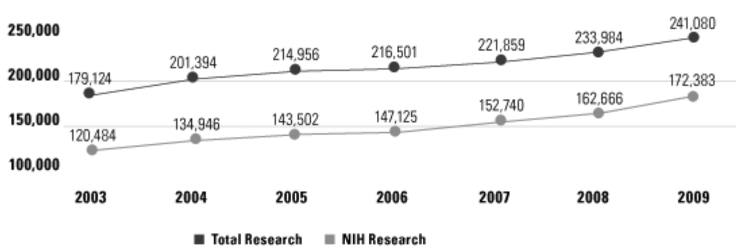


Figure 13.10: Research Spending School of Medicine and Dentistry (in thousand Dollar) [The University of Rochester Medical Center, 2010]

**URMC Research - robotic-assisted surgery** The first transoral robotic procedure was performed on February 8 2010. This procedure expands the Medical Center's robot-assisted surgery capabilities to include procedures for head and neck, urologic and gynecologic conditions.

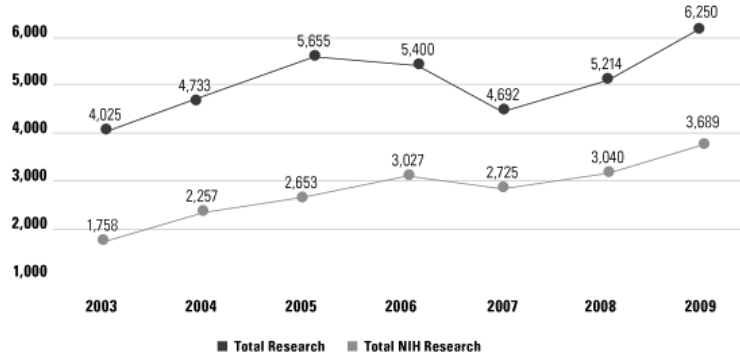


Figure 13.11: Research Spending School of Nursing (in thousand Dollar) [The University of Rochester Medical Center, 2010]

At this moment the Medical Center is creating a Center for Robotic Surgery and Innovation to expand the use of robotic technology and expand research into its use.[University of Rochester Medical Center, 2010]

**Benefits**

People with head and neck cancers have benefits by this kind of surgery, because the surgeries can be done, without incisions and offer faster recovery time and a reduced risk of infection or other complications. These benefits have an impact on the quality of the patient's lives.[University of Rochester Medical Center, 2010]

### Stanford Medicine

Stanford Medicine is vast in physical scale and its impact on human health. It consists out of three main components called, Stanford school of medicine, Stanford Hospital and Clinics and Lucile Packard Children's Hospital. Stanford school of medicine is a premier research-intensive medical school that has a goal to improve health through leadership, collaborative discoveries and innovation in patient care, education and research. Stanford Hospital & Clinics belongs to the top hospitals in the nation for advanced care. Lucile Packard Children's Hospital internationally recognized for advancing family-centered care of children and expectant mothers. We will focus here on Stanford School of Medicine[Stanford School of Medicine, 2010a].

**Stanford Educational Programs** Stanford School of Medicine offers for all students and trainees Educational Programs and Services (ESP). The goal Stanford School of Medicine is to be a school with experience that is worthy for the talents, aspirations and dedication of the students and trainees. They try to serve all kind of students and trainees who participate the school's programs. The kind of educational programs Stanford offers are Graduate (MS and PhD) Bioscience Programs, a Master of Science in Medicine Program, a MD program, a Medical Scientist Training Program - MD/PhD Program, and Non-degree Programs. Graduate (MS and PhD) Bioscience Programs are Biosciences Administration and Admissions,

| Year | Tuition |
|---|---|
| 1920 | $50 |
| 1960 | $335 |
| 1980 | $2,446 |
| 2000 | $9,902 |
| 2005 | $12,765 |
| 2009 | $14,463 |

Table 13.3: Tuition fees per year in the U.S.

Biosciences Diversity Programs, Cancer Biology Interdepartmental Program, Immunology Interdepartmental Program, Neurosciences Interdepartmental Program, and The Biomedical Computation Training Program. Non-Degree Programs are Continuing Medical Education and Office of Postdoctoral Affairs [Stanford School of Medicine, 2010a].

**Stanford Research** In the Technology sector we have spoken about the 'Da Vinci surgery.' Stanford school of medicine does research to Da Vinci surgery. Myriam Curet, M.D. (General Surgery) has the first robotic laparoscopic gastric bypass with the Da Vinci robotica system. They are currently studying the use of the robot in bariatric surgery (this kind of surgery aims to decrease weight). They compare this technique to a pure laparoscopic hand-sewn technique and evaluate the learning curve of the robot and investigat the benefits of the robot.

The Da Vinci surgery technology is a realistic technology that will be used in the future. This kind of technology has its advantages. Patients but also surgeons will benefit from this technology. If the robotic technologies improve and become more user-friendly, more surgeons will try to perform more operations they would not have done, because of their lack of laparoscopic skills. Also is Da Vinci surgery faster and accurate than a human hand, which will benefit for the patient [Stanford School of Medicine, 2010b].

**Stanford Statistics**

**Student statistics (2008/2009)** The total enrollment of students in 2008/2009 was 2501. This number consisted out of 465 MD candidates (all classes), 586 MD/PhD, PhD, MS candidates, and 1450 Postdoctoral scholars. The statistics of the MD candidates in the first year were a total amount of 6,567 students that applied and just 86 of them enrolled. Which consisted of 40 men and 46 women. In 2008 an amount of 193 students did graduate. This consisted out of 73 students with MD degree, 98 students with PhD degree, and 22 students with Master's degree [Stanford School of Medicine, 2010a].

**Tuition**

Over the years the tuition per quarter has grown rapidly [Stanford School of Medicine, 2010a].

**Research funding**

In 2008 the National Institutes of Health (NIH) has given a total funding of $236,192,682. We will talk about NIH in the section Governmental Role.[Stanford School of Medicine, 2010a]

## 13.4 Porter's Diamond

In order to get a proper insight into the sector, Porter's Diamond has to be applies to it. Based on the four determinants of the diamond as well as the factors chance and government an analysis of the healthcare sector can be made. Since simulation companies and robotic surgery equipment differ on several properties, these company directions have to be discussed individually as well.

### 13.4.1 Demand Conditions

The demand condition deals with both national and international demand of the product and gives an insight into the popularity of a product.

#### Simulation

The market for medical simulation is still relatively young and since most major companies are private insights into the economical developments of the sector are hard to find. Based on the Medical Simulation Corporation and Medical Educational Technologies Incorporated however, it seems likely that current simulation techniques will mostly just be improved, instead of being revolutionized by an entirely new technique.

With no actual figures, it is hard to give a proper oversight of the expected demand on these simulation techniques. Profits of both companies examined are relatively low and as such, it seems probable that current demand is still low. The advantages of medical simulation seem strong however and it is likely that demand of medical simulation will grow in the following years.

When looking at the size of the current companies and the market as a whole, it can be concluded that the market in itself has not yet grown into adulthood. As such, the following years might prove crucial to the companies dedicated to medical simulation in that they will help define the market standards and allow some companies to become the biggest players in the market. Though both the Medical Simulation Corporation and METI are currently the biggest players, the market is still too young to determine whether these companies will turn into the market leaders once it has grown into adulthood.

#### Serious Gaming

**Training games** Serious games that are close to training simulations will most likely see a similar market effect as analysed before. There are some key differences however that should be taken into account. Most importantly, serious games where considered the products where training only occurred by in-game input and graphical feedback. That is, a player sees a medical simulation represented in a virtual environment and uses a keyboard and mouse to give input. With medical simulation however, products that train not only through virtual representation, but through other products such as fake patient dolls as well.

When taking this difference into account, there are a few possible results with respect to market demand, costs and future. Since only software would be required for serious games, it seems probable that a serious game is cheaper to produce than a full-service medical simulation tool. If this is the case, the product would sell for less money and thus has a higher chance of being acquired by hospitals and medical training facilities.

The drawback of serious games when considering the difference with medical simulation as defined however, is that a serious game does not train a physician or surgeon to do manual work. In order to train these skills, a full-service medical simulation tool might be required. It is still hard to tell which of the two techniques will have the preference of medical training facilities and since all companies are private, current sales numbers are not conclusive of a trend in a certain direction. Based on the size of the current major companies however, full-service medical simulation seems to be preferred overall however.

**Patient-oriented games** With respect to patient-oriented serious games, demand seems to be growing rapidly. This can be noted by the successes of the Games for Health Project, an initiative that promotes serious games in healthcare [Games For Health Conference, 2010]. The recent 2010 edition of the Games for Health Conference had over forty five sessions, though no exact numbers on attendance have been published.

When including healthy games such as Wii Fit and Dance Dance Revolution, the worldwide retail revenue for serious games in healthcare was well over two billion dollars in the 18 months between winter 2007 and summer 2009. The audience for serious games has been considered to be growing for a while [Gamespot, 2005], though no exact numbers are currently available. Despite the lack of numbers however, it seems safe to say that demand for serious games will see a rise in the following years.

### Robotic Surgery

**Intuitive Surgical** Despite the economic crisis, Intuitive Surgical saw a profit increase over the 2009 fiscal year [Intuitive Surgical, 2009]. Since Intuitive Surgical is a monopoly company and thus oversees the entire market, this means that demand of the product is still on the rise. With only 1400 da-Vinci systems in use worldwide, the market still seems open for large growth, as in theory any hospital is a potential customer.

Due to the high requirements for a new company to enter the market, it is likely that Intuitive Surgical will be the sole supplier for surgical robots in the years to come. This being a medical product however, improvements have to be made constantly if Intuitive Surgical does not want to be caught up by more advanced academic research.

**MAKO Surgical Corporation** Over the last few years MAKO has seen an enormous growth in revenue and profit. In 2006 the company saw a revenue of 63 thousand dollars and a gross loss of 14 thousand dollars. By the end of 2009 the revenue had increased to 34.2 million dollars, resulting in a profit of 12.5 million dollars [mak, 2010]. This suggests that demand is on the rise for MAKO.

### 13.4.2 Factor Conditions

The factor conditions give insight into the nationś position with respect to production of the product. This includes material, research and development and (skilled) labour.

#### Simulation

Since all medical simulation companies are private, there is no proper view on material, labour and r&d costs. Some assessments can be made however.

With respect to the workforce it is noticeable that all companies have only a small amount of employees. Whether this workforce is located in the research and development or sales is still unclear however. Production of the simulation tools is done by the own workforce, which suggests that the production is a high quality work, since only a few people are responsible for the production.

Since there is no proper insight into the production of the simulation tools, not much can be said on the material costs. The same is applied to research and development, a field both MSC and METI keep in secret.

#### Serious Gaming

Much of what can be applied to medical simulation also holds for serious gaming. It should be noted however that material costs are different, since the production of a game requires less material than a full medical simulation tool. The same holds for personnel, which has other requirements for serious gaming companies than for medical simulation as games mostly require programmers to be developed.

#### Robotic Surgery

The robotic surgery industry benefits from the presence of the vanguard of software development and technical research. Many of the best universities in the world can be found in the United States as well as Silicon Valley, where many large software companies reside, which is located near San Francisco. Other parts of the world depend on the developments that take place in these industries in the United States, creating an advantage for other U.S. companies. But the internet enables easy cooperation over long distances, which weakens the advantage.

Electrical engineering and robotics do not have its center in the United States as with the aforementioned software development. Japanese firms like Honda, Toyota and Sony play an important role in the development of the field of robotics.

At its current scale, the companies can satisfy the current demand by in-house construction of their products. There is enough expertise and workforce to compose development departments and manufacture the products. But as the market grows, the manufacturing process might be outsourced to facilities in e.g. China which can handle a higher demand.

### 13.4.3 Firm Strategy, Structure and Rivalry

These factors deal with the internal structure of companies and their interaction with similar companies.

### Simulation

**Medical Simulation Corporation** As a private company the Medical Simulation Corporation is relatively closed concerning its corporate strategies. The strategy of the Medical Simulation Corporation however seems to be aimed at further development of the SimSuite product. Future plans for the MSC are mostly based on developing new training courses for the SimSuite. These trainings include cardiac and peripheral vascular procedures that deal with open chamber diagnostic and interventional procedures [Medical Simulation Corporation, 2010].

Due to the relatively small size of the company, not much is known about the corporate structure. The management staff has worked in various fields of the healthcare sector for multiple years before founding the company. MSC has delivered their products to over 900 locations worldwide and can thus be considered as a company with an international focus [Medical Simulation Corporation, 2010]. Goals of the MSC seem to be not only profit, but improved medical care as well. This was evidenced by the decision to support the Stroke Awareness Month earlier this year.

**Medical Education Technologies, Inc.** Much like the Medical Simulation Corporation, METI is focused on worldwide sales. The company has branches in Europe and Asia besides the head office in the United States. Just like the MSC however, METI is a private company and thus shows little insights into their future plans and corporate structure.

Since both the Medical Simulation Corporation and METI are currently selling their products worldwide, the sector is most likely to expand globally, rather than just domestically in the United States. This will also lead into competition from foreign companies. Since all companies worldwide are competing with each other, there is a large possibility of the market growing faster than it would have if the focus of all the companies would just be domestically.

Since most simulation companies are still relatively small, the rivalry between them is still relatively restricted. Over the next few years however, when the companies are expected to grow, rivalry will help determine the which simulation companies are the most successful.

### Serious Gaming

**Training games** For training games, the most of the company structure and competition are similar to the other simulation companies. Corporate structure is closed and as such valid conclusions are hard to be made. It would seem logical however if the corporate structure of these companies is similar to the simulation techniques companies.

Rivalry for training games is thus partly located in companies discussed as simulation companies. Demand will determine which of the two techniques will be favoured by the customers.

**Patient-oriented games** Strong competition between patient-oriented serious games is considered highly unlikely, because of the wide variety of possible games. As with all industries, serious game design may see several companies with a similar idea, but overall, the sector will most likely benefit the most if different companies produce different products, as long as the quality of the individual products is good. When different serious games are produced, different problems can be solved by their help while at the same time different companies will be able to grow in a specialized sector, instead of just a few companies that control a less specialized sector.

#### Robotic Surgery

**Intuitive Surgical** Since Intuitive Surgical is the worldś only supplier of minimally invasive surgical robots that can operate on any body part, a monopoly is formed. This monopoly has its potential effects on the market. Though the monopoly will allow the products to be sold for a higher price than in a perfect competition where supply meets demand, market performance will follow roughly the same pattern.

Though it is considered a possibility that a monopoly will result in less innovation for the product, even companies that are in a monopoly position will improve upon their product, albeit more slowly. For new competition however, it is hard to enter the market, as the company with the monopoly position usually holds a large share of the potential market [Encyclopaedia Britannica, 2010]. With respect to robotic surgery, this is even more difficult due to the large time a product needs to be deployed on the market.

**MAKO Surgical Corporation** MAKO is a company selling a specific surgery tool. This makes them a competition to Intuitive Surgical in some ways, but in many cases this could be the other way around. Since Intuitive can sell a product that works for multiple procedures instead of one for a specific goal, most of the competition is one directional.

It should be noted however that MAKO cold be the example of multiple companies dedicated to specific robotic tools. MAKO would be unable to rival Intuitive on its own, but multiple companies could. Since the demand of both Intuitive and MAKO are growing, it is still undetermined whether the market will see a few companies producing surgical robots for any cause or multiple companies that are specified to some surgical expertise.

### 13.4.4 Related and Supporting Industries

These factors deal with the external structure of companies.

The healthcare sector as a whole is supported by many other industries, e.g. the pharmaceutical industry, medical instrument manufacturers and IT. This also goes for simulations and gaming in healthcare. The appropriate hardware and software is required to run simulations or control medical robots. This includes new input devices, operating systems, application software and output devices. An example of a new input device company that supports medical robots is the haptic technology marketed by Immersion Corporation [Immersion, 2010].

Immersion Corporation develops touch feedback technology that is used in MAKO's RIO system. Immersion's technology guides the surgeon during the procedure, resulting in optimal bone sparing. Haptic feedback is also used in simulations, increasing the realism by making the user feel the tissue resistance [Immersion, 2010].

## 13.5 Governmental Role

In this section we will talk about the what kind of role the government plays in Healthcare. Thereby we will discuss the goals they want to reach, the research they support, the amount of funding they offer and the requirements a medical device needs.

#### U.S. Department of Health and Human Services

The Department of Health and Human Services (HHS) is the United States government's principal agency for protecting the health of all the Americans. The human services helps those Americans who are least able to help themselves [U.S. Department of Health & Human Services, 2010].

#### U.S. Food and Drug Administration (FDA)

If a new medical device has been developed it has to meet the requirements the U.S. Food and Drug Administration (FDA) has set.

The requirements a medical device has to meet are [FDA U.S. Food and Drug Administration, 2009]:

- Establishment registration;
- Medical Device Listing;
- Premarket Notification 510(k), unless exempt, or Premarket Approval (PMA);
- Investigational Device Exemption for clinical studies;
- Quality System regulation;
- Labeling requirements;
- Medical Device Reporting.

Thereby the medical devices are classified into three different classes. The device classification regulation defines the regulatory requirements for a general device type. Most devices belong to Class I, this means that these devices are exempt from Premarket Notification. If a device belongs to Class II the device requires Premarket Notification and if a device belongs to Class III the device has to be Premarket Approval. All the three classes have to be coded with 510(k) which means that a device has the approval to be marketed as safe and effective [Medical Device School, 2007].

#### National Institutes of Health (NIH)

NIH is a part of the U.S. Department of Health and Human Services. It is the primary Federal agency for conducting and supporting medical research. The mission of NIH is to get fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to extend healthy life.

The goals of NIH are as follows [National Institutes of Health, 2010]:

- Foster fundamental creative discoveries, innovative research strategies, and their applications as a basis to advance significantly the Nation's capacity to protect and improve health;
- Develop, maintain, and renew scientific human and physical resources that will ensure the Nation's capability to prevent disease;
- Expand the knowledge base in medical and associated sciences in order to enhance the Nation's economic well-being and ensure a continued high return on the public investment in research;
- Exemplify and promote the highest level of scientific integrity, public accountability, and social responsibility in the conduct of science.

In realizing these goals, the NIH provides leadership and direction to programs designed to improve the health of the Nation by conducting and supporting research:[National Institutes of Health, 2010]

- In the causes, diagnosis, prevention, and cure of human diseases;
- In the processes of human growth and development;
- In the biological effects of environmental contaminants;
- In the understanding of mental, addictive and physical disorders;
- In directing programs for the collection, dissemination, and exchange of information in medicine and health, including the development and support of medical libraries and the training of medical librarians and other health information specialists.

With expanding the knowledge and creating innovative research strategies the NIH might be capable of discovering new techniques to improve health. With new developments the healthcare sector could be interesting for other countries, which is positive for the companies in the United States, because in this way they can get a better position on the market. The chance of developing new techniques or technology will increase if you focus on many areas, like NIH does.

**Funding** Here you see a table of funding of the NIH Research and Development Contracts: [OER, 2009]

As you can see in the table the funding over the years are over the two billion dollars.

### Healthcare and Business

The United States is a member of Organisation for Economic Co-Operation and Development (OECD). The mission of the OECD is to bring governments together to compare policy experiences, seek answers to common problems, identify good practice and coordinate domestic and international policies.

According to OECD the United States spent more than 17 percent of its GDP (Gross Domestic Product) in 2009 on healthcare. GDP is "the market value of all

| | 2006 | 2007 | 2008 |
|---|---|---|---|
| Higher Education | $523,753 | $663,796 | $679,469 |
| Research Institutes | $265,275 | $220,640 | $229,768 |
| Independent Hospitals | $72,471 | $76,874 | $71,126 |
| Other Domestic Nonprofit | $0 | $145,217 | $40,406 |
| Domestic For-Profit | $1,174,691 | $1,120,421 | $1,206,078 |
| Foreign (includes institution types listed above) | $105,903 | $10,216 | $65,701 |
| Total | $2,142,094 | $2,237,585 | $2,292,551 |

Table 13.4: Research funding over the years

the goods and services produced by labor and property located in" the region, usually a country [Econterms, 2010]. This percentage is higher than any other member of the OECD. Also the employers' healthcare costs are high and rose with 7.3 percent in 2009. This has a competitive disadvantage for the business in the United States in the international marketplace, because the companies running a business in the United States have to pay a high amount of money for the healthcare of the employees, which is a heavy burden. Small startup companies have the disadvantage that it is difficult to find the best workers, because workers mostly choose for the company with the best offers. Workers choose rather for a company with co-payments and preexisting conditions, and other minutiae of health insurance, which are mostly provided by the larger companies[Johnson T., 2010][Pearson M., 2009].

**New Health Care plan 2010**

Barack Obama president of the United States and Joe Biden's have a plan to make the healthcare system better. Here there plan is to lower health care costs and ensure affordable, accessible health coverage for all people. In The United States, more than 45 million people are uninsured, because of the rising costs they have to pay to be insured. Eighty percent of those people are in working families. Barack Obama and Joe Biden want to lower this amount by making a new health care plan. They want to redesign the health system to reduce inefficiency, waste and improve health care quality. By improving efficiency and lower costs in the health care system they want to [OBAMA BIDEN, 2010]:

- Adopting state-of-the-art health information technology systems;
- Ensuring that patients receive and providers deliver the best possible care, including prevention and chronic disease management services;
- Reforming our market structure to increase competition;
- Offering federal reinsurance to employers to help ensure that unexpected or catastrophic illnesses do not make health insurance unaffordable or out of reach for businesses and their employees.

The way Obama and Biden want to provide affordable health insurance options are by:

- Guaranteeing eligibility for all health insurance plans;
- Creating a National Health Insurance Exchange to help Americans and businesses purchase private health insurance;
- Providing new tax credits to families who can't afford health insurance and to small businesses with a new Small Business Health Tax Credit;
- Requiring all large employers to contribute towards health coverage for their employees or towards the cost of the public plan;
- Requiring all children have health care coverage;
- Expanding eligibility for the Medicaid and SCHIP programs;
- Allowing flexibility for state health reform plans.

Obama and Biden think protecting and promoting health and wellness is a important task to complete. Everybody in the United States has to collaborate and do their own part to complete this goal. In this way, the inhabitants are being encouraged and allowed to adopt healthy lifestyles [OBAMA BIDEN, 2010].

**Subsidies** Barack Obama and Joe Biden believe that they have to pay the amount of subsidies it would cost to treat the patients under regular Medicare to the Medicare Advantage plans instead of excessive subsidies.

## 13.6 Chance

In this section we will discuss the factor Chance on healthcare.

### Climate factors

In the United States the climate has influence on the human health. With extreme temperature the air and water pollution will increase, which is harmful to human health. Also the spreading of parasites can increase the spreading of infectious diseases. It is important for the healthcare to take these factors into account [U.S. Environmental Protection Agency, 2010].

### Economic Crisis

The economic crisis of 2008 could potentially influence the market in several ways, mostly negatively. With many companies and people spending less money, each sector including the healthcare sector could face a financial step back [Galen E., 2009].

**Export** Since the focus of the market appears to be worldwide, international trade is of vital importance for the growth of the market. Due to the economic crisis and the recent fall of the Euro however, exchange rates and companies unwilling to take risk could result in less sales. This has been shown to happen in other markets earlier, such as the Japanese Yen crisis in 2008 [BBC New, 2009].

**Expense of health and hospital budgets** Due to the economic crisis many countries, including the United States have seen an increase in unemployment rates. Since unemployed people will have less money to spend and might not be insured, especially in the United States where the new healthcare plan has not been in use yet, their budgets will go down.

With less money to spend, people will be unable to afford more expensive forms of healthcare. Should new techniques such as robotic surgery be more expensive than traditional surgery, many patients are likely to opt for the cheaper traditional surgery.

Hospitals might face similar problems themselves. Though the majority of the 3.900 hospitals in the United States are non-profit, only 20 percent of the hospitals is ran by the government. Eighteen percent of the hospitals even aims to make a profit [Walker, 2005]. Even for non-profit hospitals however, only a select budget is available for new equipment. Without governmental support this budget could suffer under the economic crisis and result in hospitals holding back on acquiring new techniques.

### Public Opinion

Since the lives of people are potentially in the hands of new technology, public opinion plays of these technologies play a major role in their success. For if many patients refuse treatment by a surgical robot or by a doctor trained mainly in medical simulation, the technologies will not be used enough to justify their purchase. Should the public prefer the new technologies over traditional forms of surgery and training however, techniques will settle into the market more quickly.

**Media** The media play an important role in the general perception of a technology. The opinion the media has on these technologies will influence the views of their public as well. This was evidenced recently when former Alaskan-governor Sarah Palin claimed that the new Healthcare bill would result in death panels that would decide whether someone deserved help by doctors. Though the statement was not true, the media attention resulted in some people actually believing this and many conservative media even claimed the statements to be true [Media Matters, 2009].

**Accidents** As with any medical procedure, new medical techniques have a risk of causing accidents. Should these new techniques result in more accidents than normal or in accidents that get a large amount of attention, public opinion of them will become unfavourable. If less accidents happen however, public opinion will possibly prefer new techniques of the old ones.

## 13.7 Comparison to the Netherlands

Having analysed the sector and technology of healthcare, we will now compare the US to the Netherland. Since the new health care bill was signed by Barack Obama in March 2010, a lot will change in the near future, like 32 more million Americans will be insured. This will likely have a big impact on the health of Americans, the prize of health care and possibly the amount of research done in this sector. However, since new data is not yet available, we will use information from before this bill, and we will make predictions whenever we think things will change soon.

In this section we will answer questions like: where is health care most developed? Are there any typically American infleunces on the US sector? Is the motivation behind some of the products uniquely American?

## Health

In this subsection we will compare the health of Americans to the health of Dutch people. We use statistics from the World Health Organization [WHO, 2009], a specialized agency from the United Nations, whose objective "is the attainment by all people of the highest possible level of health. " [WHO, 1946] . In order to do so they first have to get a clear picture of every countrys current position, which is why they anually collect data about causes of death, diseases, et cetera.

To get a good overview on the similarities and differences between the US and the Netherlands, see Figure 13.12. In the next paragraphs we will discuss the most striking differences and draw conclusions from them.

| Statistics | The Netherlands | The US |
|---|---|---|
| Under-5 mortality rate (promille) | 5 | 8 |
| Measles immunization coverage among 1-year-olds (%) | 93 | 96 |
| Maternal mortality ratio (per 100 000 births) | 11 | 6 |
| Births attended by skilled health personell (%) | 99 | 100 |
| Adolescent fertility rate (per 1000 girls aged 15-19 years) | 41 | 4 |
| Prevalence of HIV (per 100 000 population) | 452 | 134 |
| Access to improved drinking-water sources (%) | 99 | 100 |
| Access to improved sanitation (%) | 100 | 100 |
| Life expectancy at birth, females | 82 | 81 |
| Life expectancy at birth, males | 78 | 76 |
| Healthy life expectancy at birth | 73 | 70 |
| Neonatal mortality rate (per 1000 live births) | 3 | 4 |
| Infant mortality rate (probability of dying between birth and age 1 per 1000 live births) | 5 | 6 |
| Adult mortality rate (probability of dying between 15 and 60 years per 1000 population) | 68 | 108 |
| Measles (number of cases) | 10 | 30 |
| Pertussis (number of cases) | 7325 | 8739 |
| Tuberculosis (number of cases) | 187 | 4864 |
| Immunization coverage among 1-year-olds (%) | 96 | 93 |
| Physicians (density per 10 000 population) | 37 | 26 |
| Nursing and midwifery personell (per 10 000 population) | 146 | 94 |
| Dentistry personell (per 10 000 population) | 5 | 16 |
| Expenditure as % of GDP | 9,4 | 15,3 |
| Government expenditure as % of total expenditure | 80 | 45,8 |
| Government expenditure as % of total government expenditure | 16,4 | 19,3 |
| External resources for health as % of total expenditure | 0 | 0 |
| Social security expenditure as % of general government expenditure on health | 95,1 | 28,7 |
| Out-of-pocket expenditure as % of total private expenditure | 29,3 | 23,5 |
| Per-capita total expenditure on health in $ | 3872 | 6719 |

data.png

Figure 13.12: Data US and the Netherlands. [WHO, 2009]

As can be seen in the table, the Dutch are overall a little more healthy than the Americans. Their life expectancy is slightly higher (1-2 years), their healthy life expectancy (the average number of healthy years, free from disability or disease) is longer and few young children die. Also, fewer people suffer from diseases like measles, pertussis, tuberculosis and HIV, and more children are vaccinated against diseases like the measles. Compared to most poorer countries, the US does pretty good, but when you compare it to the Netherlands or other Western countries, the US clearly falls behind.

So what could be the reason for this? The most obvious reason is that there are a lot of uninsured people in the US. Before the new health care bill was signed in March 2010, an estimated 43 million people were uninsured, leading to 18,000 unnecessary deaths every year in the US [IOM, 2004]. Other calculations show that uninsurance causes even more deaths, around 100,000 people [Himmelstein and Woolhandler, 1997]. Uninsured people often have no money to pay for their treatment, so they get no treatment at all. On the contrary, in the Netherlands, every inhabitant has to have insurance, and insurance companies cannot refuse anyone [Rijksoverheid, 2010].

We expect that the health of Americans will slowly increase due to the new health care bill. More people will be insured, making it easier for them to go to the hospital when they are in need of treatment. However, the law will only be fully implemented in 2014, and the main thing the law says is that insurance companies cannot refuse anyone. People still do not have to get insurance, so the poorest people, the ones that could benefit most from it, will remain uninsured. Therefore we expect America's health will stay behind on other western countries' (like the Netherlands') health.

## Cost of Healthcare

So now we know that Dutch are healthier than Americans. But does this mean they also pay more for health care? The short answer to this question is 'no'. In Figure 13.12 we can see that the US not only spends a larger part of their GDP on health care (15.3% against 9.4% for the Netherlands) but also per capita they pay more: 6719$ where the Netherlands spends 3872$. Even though the Dutch are healthier, they spend only a little more than half the amount Americans spend on health care.

What is the reason for this big difference? According to [Times, 2007], there are two main reasons: Americans are wealthier than most other people, and they pay their doctors and hospitals more than other countries do. Americans rely more on costly specialists and use of advanced technologies like CT scans and M.R.I. machines. Most money (54%) comes from private expenditure, whereas in the Netherlands 80% comes from the government. Therefore, the government's influence on the price of health care in the US is a lot less, allowing doctors and hospitals to raise their prizes as long as patients are willing to pay.

This high cost seems to contradict the degree of health in the U.S., but it really does not. Although the rich have access to all of these technologies and specialists, the relatively large group of poor people has very little money for health care at all, disabling their access to healthcare and therefore lowering the overall health of Americans.

## Research in this sector

Unlike the cost of healthcare and the health of the inhabitans, the amount of research done is difficult to measure. In order to compare this we first made an effort to make a good list of the major players of healthcare in the Netherlands and find out what they are researching. After a short description of those major players the actual comparison will be made. For this research we focused on the academic instutions that do research in this area, and we also found a congres on simulations and serious games in health care

**Academisch Centrum Tandheelkunde Amsterdam** The ACTA trains its future dentists with the SIMODONT, a simulator that is used to train students in operative dental procedures in a virtual reality environment [ACTA, 2010]. The simulator can be seen in Figure 13.13. At this time Simodont can be used for manual dexterity training, dental decay and placing crowns. In september 2010 there will be 50 Simodonts in use.

**METS center** The Medical Training and Simulation Center creates training and simulation opportunities in order to better educate medicin students [METS center, 2010]. They use Crew Resource Management in their simulations to recognize wrong decisions and actions and situations that may cause them and to avoid human mistakes. The METS center offers many courses like reanimation of children and adults and advanced life support (optimalising the urgent help for reanimation patients). They have 1600 square meters that is used for these courses, including five simulation rooms and four observational rooms. About a hunderd people can be trained simultaneously.

**Wenckeback institute** The Wenckeback Institute from the University of Groningen uses many different kinds of simulations to train their students. They have simulation dolls (male, female, children, and even pregnant women that can give birth to baby simulation dolls) and devices to train eye-hand coordination.

**Nederlandse Vereniging voor Medisch Onderwijs** The NVMO is a congres with a workgroup for skills and simulation techniques, open to anyone who is occupied with simulations or serious gaming in the healthcare. Its objectives are to improve the knowledge of simulation techniques and knowledge in the Netherlands and Belgium, improving research in this sector, and to create a network and stimulate better communication between everyone working in this sector. This workgroup is closely related with another organisation, the Dutch Society for Simulations in Healthcare.

From this research we can conclude that most Dutch medicin faculties use simulations and serious games to train their students, but the same can be said for

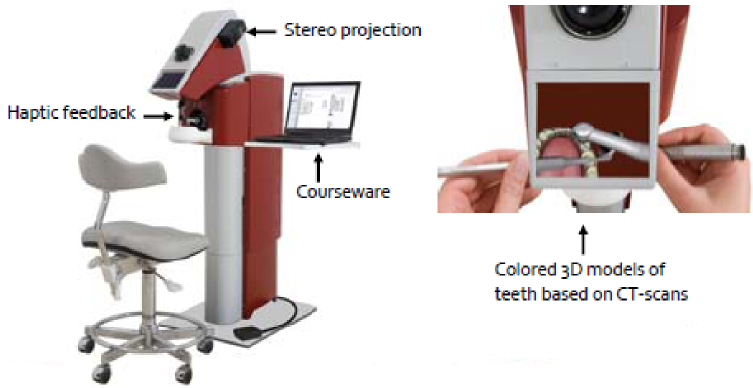


Figure 13.13: SIMODONT [ACTA, 2010]

American ones. However, we did not find any Dutch company that develops anything related to games and simulations in health care, but there are some American companies that do. Therefore, the US seems to be more developed here.

**Conclusion of this comparison** In conclusion, the Dutch are more healthy than the Americans, even though Americans spend a lot more on health care. However, the US is more involved in research and development of games and simulations for health care.

## 13.8 Conclusion

In this chapter, a meso-analysis of the healtcare sector was presented in the progress of answering the following question:

> *What actors and factors can be found in the healthcare sector that support or inhibit games and simulations developments?*

This chapter will now conclude by summarising the most important findings and by answering the research question.

Healthcare has been around for a very long time. The co-existence with computer science only marks a small part of its history, but an interesting one. In the last few decades, a revolution in healthcare, caused by the upcoming and advancements in hardware and software, can be perceived. The healthcare sector is being influenced by computer science and electrical engineering. These fields of research are rapidly changing and so are simulations and gaming in healthcare, changing the healthcare education and improving surgical procedures.

With respect to the market, some conclusions can be made with respect to its current state and its expected growth. Though many companies, mainly the ones focussing on medical simulation are private and thus share little information about their current state, it is highly likely that the market will see an enormous growth over the next few years.

Especially with respect to the surgical robot tools the market is expected to grow rapidly over the following years. Though Intuitive Surgical currently holds a monopoly position on surgery assisting robots for any type of surgery, it seems possible that more specialized robots will take over some part of the market. The long development time however makes it unlikely that multiple companies will share the market in the close future.

Both Intuitive Surgical and Mako show large growth in revenue however, despite the economic crisis. This suggests that the market is ready for advancements in medical simulation and robotics. The exact trends in techniques will only show in the following years as the market is still to young to see a general direction.

The market for medical simulation and gaming is worldwide, as is evidenced by the focus on the world market by all examined companies. Competition will thus show on a global scale and is not restricted to the United States, despite the possibilities of differences in local laws on allowing medical equipment.

It takes a long time to develop new medial devices. This is because first the development has to be done by research in the specific sector in healthcare and when a medical device has been developed it needs the approval by the government (FDA). The government is involved with the research of medical devices by funding more than two billion dollars annually on research. These fundings are done by NIH.

In comparison to the Netherlands, US is a better place to develop games and simulations for use in health care. A lot more money is spend on health care (even per person) in the US which allows for better techniques and use of simulations and games. We expect the situation will be even better for the US in the next decade or so since the new health care law was accepted recently so more people will make use of the hospitals.

Without a doubt, the healthcare sector will see a large influence of simulation and gaming companies over the following years. The results of this influence are still undetermined, making the next few years of interest to the sector.

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# Chapter 14

# Manufacturing

*Section by Ernst Fluttert, Joeri van der Lei, Mark Oude Veldhuis, Jasper Stoop and Steven van der Vegt*

## Introduction

This meso research is focused on the sector manufacturing in the U.S., where we will take a closer look at the manufacturing sector of consumer electronics. The central research question during this meso research is:

> *What actors and factors can be found in manufacturing that support or inhibit games and simulations developments?*

The manufacturing sector in the United States is huge, as anything that produces something is in fact a manufacturer. To give an indication about the domestic market size: around 13 million people are employed in the manufacturing sector, which has a sales and shipment volume of over 5,000 billion dollars by domestic establishments. To narrow the scope towards the games and simulation topic, we have chosen to go with the manufacturing sector of consumer electronics. This section employs over a million people in the U.S. and has a total sales volume of 412 billion dollars (by domestic establishments). [U.S. Census Bureau, 2007]

For clarification purposes the United Nations: International Standard Industrial Classification of All Economic Activities (revision 4.0), is used to define what is included (and excluded) in this meso research. [United Nations, 2010a]

Section C: Manufacturing

- Class 2640: Manufacture of consumer electronics
- Class 2620: Manufacture of computers and peripheral equipment
- Class 2610: Manufacture of electronic components and boards

Our scope includes all the manufacturing of consumer electronics, computers and electrical components. This practically is the whole manufacturing chain from chip to end-product for consumers. For example televisions, video game consoles, computers, computer components, microprocessors, LED's and more.

This means that the manufacturing of software and games (class 3240), is excluded from our scope. Although it is very much related to the general topic of games and simulation, it would not fit within the manufacturing sector as multimedia software and digital games are considered to be a service instead of a physical product.

This chapter will consist of four parts, in order to answer the main research question:

- Technology: The current developments and the (social) challenges of the consumer electronics market
- Sector analysis: Give the overview of the manufacturing consumer electronics sector with their commercial organizations, but also academic, non-commercial and government organizations.
- Porters Diamond: The Porter's diamond analysis of the manufacturing sector.
- Comparing: In the conclusion there will be an overview which compares the results found for the U.S. with the Netherlands

## 14.1 History

This section will briefly discuss the history of manufacturing. It is divided between an overview of developed manufacturing concepts throughout the last decades and an enumeration of important inventions regarding simulation and games specifically.

**Manufacturing concepts**

| Manufacturing concept | Characterized by | Since | Notes |
|---|---|---|---|
| Mass production | mass production of a certain item | 1910 | popularized by Henry Ford |
| Just-in-time | inventory control | 1910 | initially used by Henry Ford, expanded by Toyota |
| Lean manufacturing | ultra-efficiency, cutting redundant costs | 1990 | introduced by Toyota |
| Flexible manufacturing | machine production and routing flexibility | 1965 | centrally computer controlled |
| Mass customization | postponing product differentiation | 1996 | preproduction of semi-manufactured goods |
| Agile manufacturing | company and supply chain wide response to change | 1990 | lean manufacturing plus intra-company partnerships |
| Rapid manufacturing | direct production or prototyping from computer data | 2001 | also known as rapid prototyping or 3D printing |

**Games and simulation breakthroughs**

| Invention | Year | Notes |
|---|---|---|
| CRT screens | 1907 | commercialized by Western Electric in 1922 |
| Magnavox Odyssey | 1972 | first TV set connectible video game console |
| Fairchild Video Entertainment System | 1976 | first real cartridge based console |
| LCD screens | 1980 | thinner and lighter than CRT |
| Computer mouse | 1981 | first shipped in 1981 as part of a computer |
| Commodore Amiga | 1985 | first mass-market computer with graphic processor |
| Nintendo Entertaiment System | 1985 | the Duckhunt light gun |
| Sony PlayStation | 1994 | first system to sell over 100 million consoles |
| Microsoft Xbox | 2001 | first console with hard drive |
| Microsoft Xbox 360 | 2005 | Xbox live online gaming network |
| Sony Playstation 3 | 2006 | first Blu-ray Disc drive |
| Nintendo Wii | 2006 | motion sensing controller |

## 14.2 Technology

This section will discuss the current development of the consumer electronics manufacturing sector and will have a closer look at the technological and social challenges it faces. We will start by examining the economical changes in the sector and the causes for these changes, as well as looking at trends in the production of electronics and the possibilities brought by these changes. We will conclude this section by looking at future issues in both technological and social directions, examining environmental and employment problems.

### 14.2.1 Current developments

**Workforce changes**

When we look at the manufacturing sector of the U.S. we must first notice its size. The U.S. has the largest manufacuring industry in the world[United Nations Statistics Division, 2010], though the size of the industry is rapidly declining. Over the past thirty years the sector has lost more than 5 million jobs, halving its total amount of jobs as percentage of the total nationwide employment[Deitz and Orr, 2006]. A fair amount of these job losses can be attributed to more efficient production processes and an increase in international trade.

The output of the manufacturing industry has not declined and a recent survey by the U.S. Bureau of Census[Deitz and Orr, 2006] shows an increase in the percentage of high-skilled workers which may have to do with this. Almost all manufacturing sectors in the U.S. have a larger fraction of high-skilled workers, but the changes differ greatly from sector to sector. In two sectors relevant to the meso main question, the professional equipment and the electrical machinery sector, the share has nearly doubled. The change in percentage of high skilled workers also greatly increased productivity per worker over the past decade, as is shown in Figure 14.1.

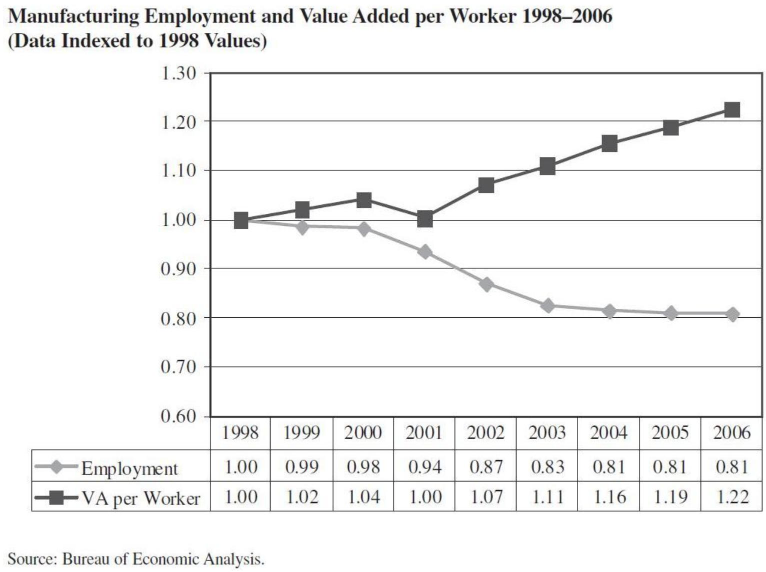


Figure 14.1: Manufacturing employment and added value per worker.

The change in share of high skilled workers is caused by the need for shorter product cycles and fast innovation within the consumer electronics manufacturing sector[Bureau of labor statistics, 2009]. Competetiveness within the sector is achieved by being the first to market a new product, creating a high pressure on research and development.

### Focus on research and development

As mentioned, there has been an increase in demand for high-skilled workers in the manufacturing sector for the past few years. The need for highly skilled research and development workers is in turn a product of shorter life cycles for electronic consumer goods, whereas shorter life cycles are a result of a relatively greater number of technological advances in recent years. In addition, the frequency with which consumers buy electronics is higher than ever today[LaPlante, 2009].

### Outsourcing

Outsourcing is the process of deferring services or processes to another company, often in order to decrease costs. In this section we will look at a subgroup of outsourcing: Offshoring, which is outsourcing to a foreign company or business. We look at this phenomenon because the decline in size of the manufacturing sector was accompanied by a rise in outsourcing to foreign companies and affiliates [Houseman, 2007]. According to [Mann, 2003], the globalization and outsourcing of manufacturing of IT products "accounts for perhaps 10 to 30 percent of the dramatic decline in

IT hardware prices", which heavily contributed to widespread diffusion of consumer electronics.

In U.S. politics the benefits and negatives of offshoring are a major point of debate. To understand why, we look at offshoring from the viewpoint of companies and the U.S. government. For companies the main advantage is cost reduction [Houseman, 2007]. In the U.S. the average net monthly salary is 2,372 Dollar, whilst in a popular country to outsource to like China the average is only 134 Dollar. [worldsalaries.org, 2007]. Counterarguments from a company's point of view are more expensive shipping costs as well as language and culture barriers.

From the government's point of view, the loss of jobs as illustrated by the decline in the manufacturing sector is a major counterargument to loosening trade barriers for offshoring. Opinions are divided however, as not only job are lost due to offshoring. According to [Bartlett, 2009] the growth of insourcing to the U.S. is growing at a far faster rate than offshoring. He futher argues: "Restrictions on outsourcing may save a few jobs in the short run, but they will come at the expense of better jobs in the future - jobs that will not be created.We can put quotas and tariffs on goods that cross our borders, but it is impossible to stop people from importing software and data from other countries over the Internet when it makes sense to do so. The only reasonable response is to adapt, innovate and stay ahead of the curve."

Whether outsourcing to will be benificial to the U.S. in the long run may be up to debate, but it has already impacted the manufacturing industry by cutting the costs of consumer electronics and helping today's widespread diffusion.

### Comparing Current Developments to the Dutch Manufacturing Industry

As part of the meso research question, we looked at the two major changes described in the previous section and compare those to the development of the manufacturing industry in the Netherlands.

- A higher percentage high-skilled people in the workforce
- More money expended on Research and Development

As shown in Figure 14.2, the productivity in the industrial sector in the Netherlands has increased in similar proportion to the increase in the U.S.. Recently the Netherlands has lost terrain but looking at the whole 1987 -1998 period the trend of less employment and more added value is present in both countries. Furthermore, the R&D expenditures in the Netherlands have increased from 1992 onwards [CBS, 2009]. We can therefor conclude that, although the size of the manufacturing industries differs greatly between the Netherlands and the U.S., trends within the sectors are quite similar.

### Current Trends in the consumer electronics manufacturing industry

The trends in consumer electronics seem to have been driven by miniaturization of components. Past decades consumer electronics have gotten significantly smaller. Electronics that needed the space of a big room a few decades ago, fits in our pocket todays. This miniaturization can lead to ubiquitous computing: electronics get embedded in more and more products, and we are less aware of their existence.

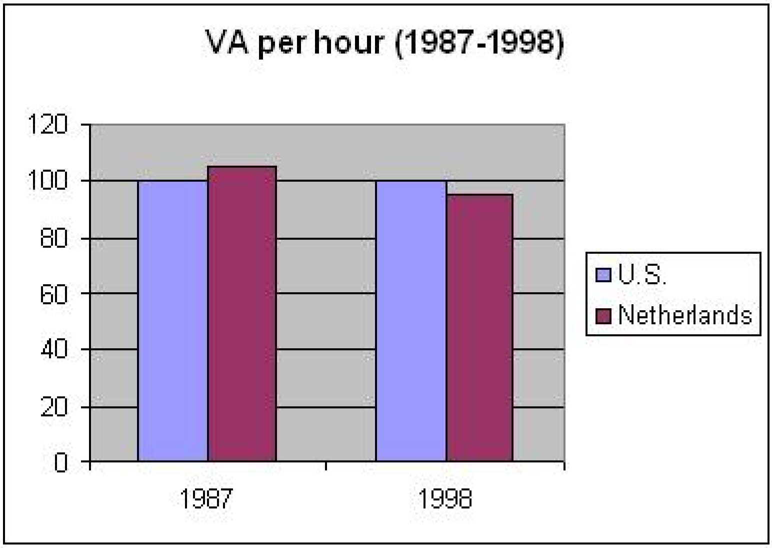


Figure 14.2: Added value per hour comparison between the U.S. and the Netherlands [van Ark and Timmer, 2001].

They will help us with the daily things of life. Therefor we get closer to the 'internet of things'. More products get wireless communication devices and can interact with each other[Anderson, 2003]. Batteries contain more energy[SMH, 2009] and devices consume less energy. This development enables us to make electronics which last longer and require less maintenance.

### 14.2.2 Technological and social challenges

There are many challenges in manufacturing of consumer electronics. In this section we will look at the technical and social challenges.

#### Technical challenges

A big technical challenge is the environment. Due to climate changes and public pressure, governments enforce stricter regulations. Environmental laws are put into place to try to reduce the footprint that people and businesses are leaving on the environment and to prevent more irreversible environmental damage. Most of these laws are written and enforced by the Environmental Protection Agency (EPA) which began operation in 1970. Common environmental laws which apply to manufacturing are about waste like solid waste, air pollution and drinking water waste. In February 2003 the European Union adopted the Hazardous Substance Directive [wikipedia, 2010]. This directive restricts the use of hazardous materials in the manufacturing of various types of electrical equipment. It also contains a program for better recycling of products like batteries. Manufacturers have to change their plants and products to make it comply to the new laws. For example, the restriction of using lead in solder required expensive retooling of assembly lines.

In the future is likely that these laws will get stricter. For this reason we can assume that the environment will continue to be a technical challenge.

### Social challenges

We just took a look at the technical challenges of manufacturing, but what kind of social challenges does manufacturing have? According to an article written in 2010 by Courtney L. Vien, many companies are having trouble finding talented and skilled workers. This can be seen in Figure 14.3. In this article it is speculated that the shortage of skilled workers might be the reason why the U.S. world market share in manufacturing is declining. An important factor herein is that many of the current employees working at factories are from the baby-boom generation. They are rapidly reaching their retirement age. The new generation does not want to work in the manufacturing sector and prefer service jobs.[Vien, 2010]

At the moment of writing the world is in a financial crisis. People are losing their jobs and have less money to spend on luxurious items such as consumer electronics. As this crisis is still continuing, we can only speculate what the impact of this global crisis will be. We will revisit this social challenge later in this chapter.

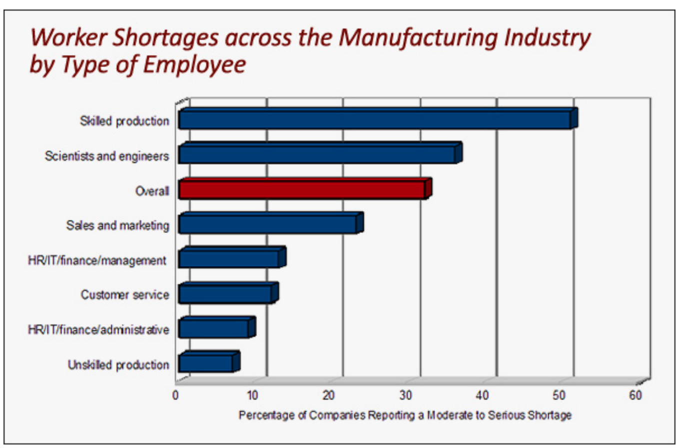


Figure 14.3: A 2009 people management practices survey of the manufacturing industry [Deloitte Consulting, 2010].

### Technological influence of games and simulation

After the introduction of simulations a lot has changed in the manufacturing world. When software packages like AutoCAD and SolidWorks were introduced, designers were able to virtually design and assemble products.

This software in combination with 3D printers leads to very rapid prototyping. This has lead us to beautiful designed consumer products which would not be possible without this software. But simulations are not only beneficial in the designing of a product. Robots also make use of a lot of techniques used in the gaming world to assemble products, such as 3D positioning.

## 14.3 Sector Analysis

This section will perform an analysis of organizations in the manufacturing sectors as depicted in the the introduction of this chapter. First we will investigate the commercial organizations: major players, market demands, economic factors and the relation between the commercial sector and the study tour theme. After the commercial part, an analysis of the non-commercial and academic part of the sector is provided. Here we will look at different organizations and associations, academic institutions and how the U.S. patent system may be interesting to academic institutions.

### 14.3.1 Commercial organizations

This section analyzes major suppliers in the sector and their strategies. After this, the demand conditions are described; how the shape of the current market and customer expectations. Next up is the organization structure and rivalry between them. Especially in the industry of electronic components manufacturing there is a lot of collaboration between firms. After looking at some economic factors that have effect on the sector, we conclude this section by relating it to the games and simulations.

Consumer electronics companies in the United States generate a huge amount of stimuli for their nation's economy with the manufacturing of consumer electronics devices, but also by delivering new and innovating services. A report for the Consumer Electronics Association by PricewaterhouseCoopers measured the influence of the consumer electronics sector to the U.S. economy. In their report, consumer electronics are defined to be (1) the actual manufacturing of electronics and related products, (2) the supply of content and services to these products and (3) wholesale and retail distribution of products, services and content. In 2008 the U.S. consumer electronics sector provided work for more than 15.3 million Americans. People in the sector were responsible for generating a direct output of $1,352 billion dollars in 2008. Next to that, the consumer electronics sector purchases products and services from other domestic industries which produces an indirect output of $432 billions dollars. Finally there is the induced output of the sector, which is generated by employees spending their earnings, totaling $846 billion dollars. This means that the total output of the consumer electronics sector sums up to $2,630 billion dollars, and accounts for 10.4% of GDP. [PricewaterhouseCoopers, 2008]

An interesting thing to mention is that the delivery of services, i.e. services that are available on consumer electronics such as telecommunications or radio and television broadcasting, is responsible for the largest percentage from the sector its earnings from personal consumption. In 2004, consumer electronics industries sold $33.3 billion worth of goods and $269.7 billion worth of services, about 11% and 89% respectively of the industry's $303 billion total [PricewaterhouseCoopers, 2008].

#### Strategy

There are several big players in the United States that are involved in the manufacturing of consumer electronics. This chapter will take a look at different large companies that are involved in manufacturing consumer electronics, or hardware components that are required in consumer electronics such as central or graphical processing units.

Today, most people own a mobile phone. There are some U.S. based companies that manufacture mobile phones such as Apple and Motorola. From figure 14.5 we clearly see that Nokia dominates the global mobile phone market because in every quarter since 2008 it sold the most phones. In July of 2008 the long awaited iPhone 3G from Apple was launched [Gizmodo, 2008] causing Apple to increase its sold units between Q2 and Q3 of 2008 from respectively 3 to 23% of the total, taking it away from Nokia. As we can conclude, there are practically no U.S. based mobile phone manufacturers that have a serious market share, except for Apple that has seriously entered the market after the launch of the iPhone 3G in 2008.

The top 10 LCD monitor manufacturers of the world shipped more than 32 million monitors in 2008 [DisplaySearch, 2008]. The largest company in this industry is the South Korean company Samsung with a market share of about 19.6%, just slightly larger than the number two of the industry, which is a U.S. manufacturer: Dell, with a market share of 19%. In the top 10 there are two more American companies, namely HP and ViewSonic. LCD manufacturers from the United States together occupy a little over a third, 38%, of the total market share of LCD monitors. A related industry to LCD monitors are televisions. In this industry, the top 5 companies in 2009 are all Asian based companies [CNET, 2010]. Samsung is leading with 17.2% of the total market share, followed by LG, Panasonic, TCL and Sony. There are no major television manufacturers in the United States.

We see that there are a few prominent U.S. based manufacturers of consumer electronics. But U.S. companies involved with manufacturing do not always manufacture. ATI and NVIDIA for example design graphical processing units and have other companies manufacture the video card boards that use these designs. We will emphasize on this matter a later in this section.

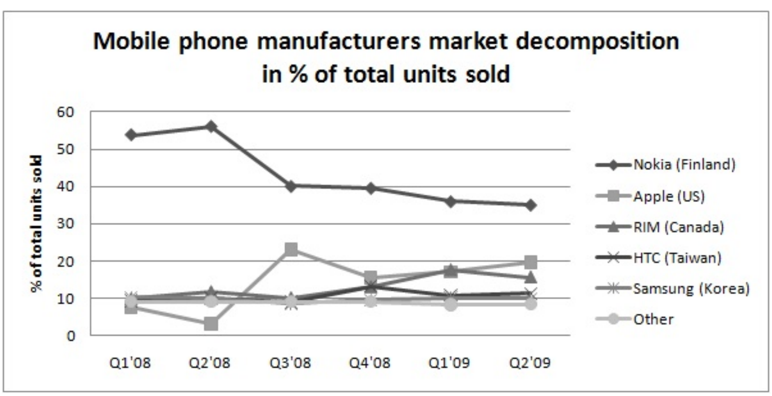


Figure 14.4: Percent of total mobile phone sold by manufacturers [CNET, 2009]

### Demand Conditions

With the rapid developments of the past 20 years, especially the rise of the internet, the market for consumer electronics has changed drastically. Nowadays, at least

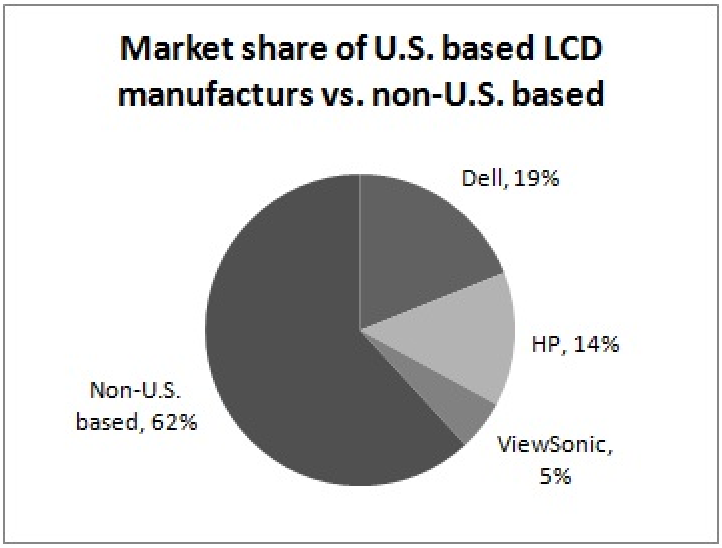


Figure 14.5: Market share of U.S. based LCD monitor manufacturers versus non-U.S. based manufacturers [DisplaySearch, 2008]

80% of all households in the United States buys at least one consumer electronic per year. In table 14.1 the change of the possession and utilization of consumer electronic devices between 1990 and 2007 is shown. From this table we can notice that consumers have become easier in the adaptation of new and innovating techniques [PricewaterhouseCoopers, 2008].

Take the VCR and DVD players as an example. After its first commercial launch in 1977 [Genova, 2001], it took the VCR 30 years to increase its presence in U.S. households to 90% by 2007. In 1997 the first DVD players were available in the United States [DidYouKnow, 2010] and in 2007, 82% of U.S. households owned a DVD player. It took the DVD player 10 years to increase its presence in U.S. households to 82%, whereas the VCR needed 30 years to increase its presence to 90%. This example shows that U.S. households see the need for such new developments, or at least are willing to keep up with new and improved technologies.

Not only the DVD, but also internet access and mobile phone figures from table 14.1 indicate that by the late 90's and ever since, the United States consumer electronics market is more accessible for consumers, and that consumers are more eager to adapt new technologies. In figure 14.6 we can clearly see that the average amount U.S. households spend on consumer electronics per year has almost never declined. Only in 1993 an 1997 there was a small decrease. In 1990 households spent an average of approximately 1,600 U.S. 2006-dollars on consumer electronics whereas in 2006 this amount has increased to $2,000. If we measure with nominal dollars, the amount of money spent on consumer electronics has doubled from approximately $1,000 in 1990 to $2,000 in 2006 [PricewaterhouseCoopers, 2008]. Both of these measurements indicate that U.S. households spend a greater percentage of their income on consumer electronics. Comparing these data to the spending of Dutch households as can be seen in figure 14.7, we see a more fluctuating but similar line. The average Euro versus U.S. Dollar exchange rate in 2006 was €0.8/$ [X-rates, 2010] and if we would convert the average Dutch household spending in 2006, which was €1,081 [CBS, 2010], to U.S. dollars we know that the average Dutch household spent $1,356 on consumer electronics in 2006. This is about $645 less than the approximate $2,000 average a U.S. household spent on consumer electronics in 2006. The reason for this could be that the U.S. houses more companies involved in the production of consumer electronics than the Netherlands.

Consumer electronics manufacturing companies in the United States of course do not only supply to the domestic market. Also on an international level these companies are active. The consumer electronics manufacturing sector delivers to several markets: consumers, enterprises and exports. The majority of the sector's output is generated from selling to the enterprise market, which is responsible for 64% of the total sector output. Next is the consumer market which generates about 26% of total, followed by the export market that is responsible for the final 10% [PricewaterhouseCoopers, 2008].

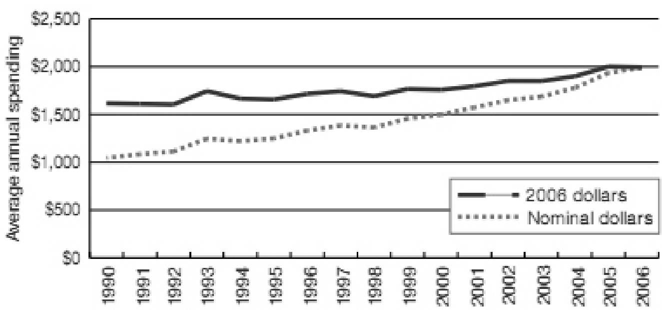


Figure 14.6: Average U.S. household spending on consumer electronics [PricewaterhouseCoopers, 2008]

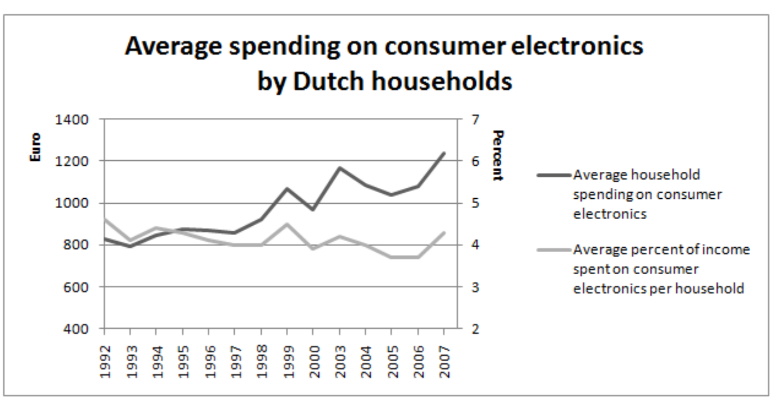


Figure 14.7: Average Dutch household spending on consumer electronics [CBS, 2010]

| | 1990 | 2007 |
|---|---|---|
| Television | 96% | 98% |
| average number of sets per home | 2 | 2.6 |
| connected to cable television | 56% | 62% |
| connected to video cassette recorders (VCRs) | 69% | 90% |
| DVD player | - | 82% |
| Computer | 22% | 74% |
| Internet access at home | - | 68% |
| broadband | - | 51% |
| Mobile phone | 5% | 73% |

Table 14.1: Comparison between 1990 and 2007 consumer electronics possession and use of U.S. households [PricewaterhouseCoopers, 2008]

**Structures and rivalry**

Within the sector of the manufacturing of consumer electronics, a lot of firms are active. However, many of these companies (i.e. companies that sell LCD displays, video cards and mother boards) are not the original manufacturing of the core components such as the LCD panel itself, the graphical processing unit on a video card, or the chipset on a mother board. In this chapter we will take the production of video card as an example and show how the designers of graphical processing units sell their designs to partners that actually manufacture the video card.

ATI and NVIDIA are the two best known designers of graphical processing units. NVIDIA has several product lines for specific purposes such as hardware video rendering, gaming and video performance, or to use the graphical processing units as a powerful units to process very difficult mathematical algorithms. We will restrict ourselves to the GeForce product line, which are video cards meant for consumers. For the production of video card boards based on technology by NVIDIA, there are a few companies that are authorized board partners [NVIDIA, 2010]: ASUS, BFG Technologies Inc., EVGA Corporation, GALAXY, MSI Computer Corp., Palit, PNY Technologies Inc. and XFX. These companies signed a deal with NVIDIA so that they can use the latest technology developed by NVIDIA, and vice versa so that NVIDIA can make sure they deliver high quality products. A specific GeForce video card produced by all of these partners are based on the exact same technology by NVIDIA, but the differences are primarily the clock speed of the GPU and memory, as well as some non-technical matters such as the warranty and service.

Intel and Advanced Micro Devices (AMD) are both best known for the developments of central processing units and this is a large part of their organization. Intel's products however include not only CPUs, but also motherboards, chipsets and embedded processors. AMD also produces graphical processing units (since it acquired ATI in 2006 [AMD, 2010a]) and chipsets, as well as embedded processors, chipsets and graphical processing units [Intel, 2010] [AMD, 2010b]. In 2009, a joint venture between AMD and the Advanced Technology Investment Company (ATIC) created a new semiconductors manufacturing company called GlobalFoundries [AMD, 2010a]. GlobalFoundries is headquartered in Sunnyvale, California and has seven semiconductor fabrication plants, 'fabs', that are currently in use. Fab 1 through 7 are located in Germany and Singapore. Fab 8 is located in the United States. More specifically in Saratoga County, New York and the fab is expected to be operational in 2012 [GlobalFoundries, 2010a]. GlobalFoundries manufactures semiconductor products for over 150 customers, including AMD, ARM, NVIDIA, Qualcomm, STMicroelectronics and Texas Instruments [GlobalFoundries, 2010b].

As explained in the industry of electronic components for consumer electronics there is a lot of collaboration between multiple companies. GPU designers such as ATI and NVIDIA sell their design to other companies that will actually build the video card based on that design. The same goes for chipsets on motherboards for example, there are only a few chipset designers including Intel and AMD, but a lot of motherboard manufacturers base their products on these chipsets from other companies. By doing this, designing companies do not have to occupy themselves with designing the video card as well; they can focus on their core business and have other companies build their designs.

**Economic factors**

The economic crisis that we are currently in has its effect on many companies in different sectors, as well as the consumer electronics sector of course. In figure 14.8 the annual total value of shipments for the computer and electrical product manufacturing industry, of which the manufacturing of consumer electronics is a sub-sector, from the United States is shown. As from 2003 we can clearly see an increase of shipments, or at least the total value of these shipments, until 2007. The sector obviously also experiences the effects of the financial crisis which we can see in a decrease of total shipments in figure 14.8 between 2007 and 2008.

Companies in the sector of consumer electronics manufacturing outsource their more simple hardware-building work to other countries such as China. The majority of the United States' import from China are products that need to be created physically, such as computers and accessories, toys, bicycles, television receivers, VCR's, cotton households, footwear, et cetera [U.S. Bureau of Census, 2010]. The most important categories in the context of this report are shown in figure 14.9. This graph clearly displays that although almost every category shows a decline in import from 2008 to 2009, computers seem to keep growing and the amount of television receivers seems to be quite stable.

As can be seen in figure 14.10 the Chinese Yuan was pegged to the dollar until July 2005 at CNY 8.27/$. From that date, the Chinese monetary policies changed and the government allowed the exchange rate to decline [Marsh, S. and Diaz, E., 2008]. After July 2005 the Yuan has been falling for three years straight, after which it maintains a fairly steady rate of CNY 6.82/$. This decrease of course made it more expensive for foreign countries, including the United States, to offshore production to China. As mentioned earlier in this chapter, the U.S. government would like to see more manufacturing in their own country instead of offshoring it to countries like China especially because of the losses of jobs in that sector. With the appreciation of the Chinese Yuan, China faces serious competition between other low-wage countries to attract foreign manufacturers now that their currency is worth more [Marsh, S. and Diaz, E., 2008].

Combining figures 14.8 and 14.9 we can clearly see that the sector of consumer electronics as well as the manufacturing of computer related hardware is declining.

As of 2007 the total value of shipments is declining and as of 2008, imports from China are also showing a decrease meaning that there are less manufactured electronics coming into the country. And because the total value of shipments is also going down, this decrease in import from China does not seem to be compensated by an increase of U.S. based manufacturers.

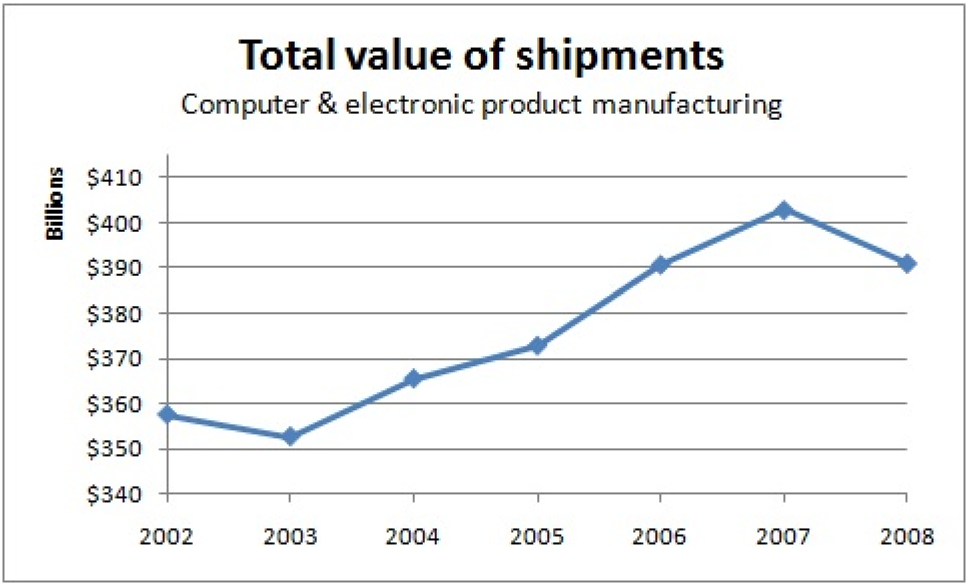


Figure 14.8: Total value of shipments of the computer and electronic product manufacturing sector [U.S. Bureau of Census, 2008]

### Commercial sector influence on games and simulation

The commercial manufacturing sector is of great importance for games and simulation, since products that enable us to play games and perform simulations must be build before anything can be done. We have seen that the consumer electronics sector in the United States accounts for a great percentage of the nation its economic stimuli and that the U.S. market is getting used to adapt new products and technologies, which is important to introduce new sorts of games and simulation systems.

The United States houses some manufacturing companies, but quite a lot of hardware manufacturers are Asian based companies, although leading gaming video card designs do come from American soil. The economy is of influence in the development of new games and forms of simulation; if there is more money available, there probably are more developments. With the current economic crisis it could very well be that companies choose to hold off those new developments.

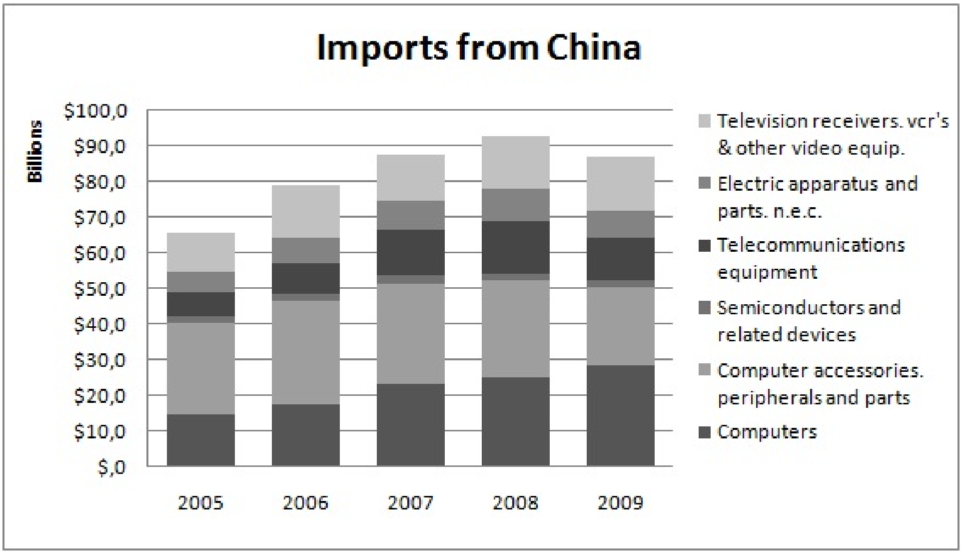


Figure 14.9: Total and distribution of imports from China in manufacturing industries [U.S. Bureau of Census, 2010]

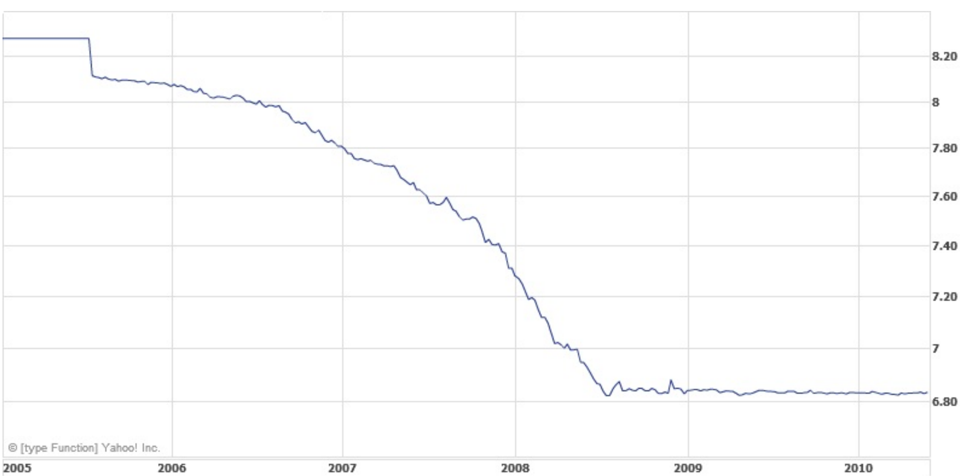


Figure 14.10: U.S. Dollar and Chinese Yuan exchange rate as from January 3, 2005 through June 7, 2010 [Yahoo! Finance, 2010]

## 14.3.2 Noncommerical and academic organizations

### Public and government organizations

There are a large number of organizations in the United States aimed at providing services and information to manufacturers. These organizations differ hugely in size and geographical focus, but a clear distinction can be made between federal or government initiated organizations and organizations that have their origin from within the manufacturing sector itself.

**Federal**

- Manufacturing Extension Partnership - The Manufacturing Extension Partnership (MEP) is a network of federal, academic and industry groups aimed at helping small and mid-sized manufacturing companies. The MEP centers serve as advisors to these manufacturers to improve their performance and competitiveness. The MEP was set up by the National Institute of Standards and Technology (NIST) as a handful of manufacturing technology centers in 1989, but has grown to a network of almost 400 centers nation wide.[Shapira, 2001; NIST, 2010]
- Manufacturing Engineering Laboratory - The Manufacturing Engineering Laboratory is a part of the NIST that "... promotes innovation and the competitiveness of U.S. manufacturing through measurement science, measurement services, and critical technical contributions to standards." One of its divisions is the Intelligent Systems Division; while its main focus is manufacturing robotics and automation, big part of the division's research is concerned with simulation and perception.[NIST, 2010]
- American Competitiveness Initiative - The American Competitiveness Initiative (ACI) was initiated by former US president Bush in 2006. The initiative created an extra six billion dollars in funding for R&D and education. Especially the areas with which manufacturing is concerned such as math and science were given a boost in resources. Also, the initiative aimed at dubbling the MEP funding in the next ten years.
- Manufacturing and Services - As part of the International Trade Administration, the Manufacturing and Services (MAS) unit concerns itself with the regulatory and legislative issues concerning the manufacturing industry.
- Manufacturing Council - The Manufacturing Council advises the Secretary of Commerce on government policies and programs that affect U.S. manufacturing. It consists of 15 executives of manufacturing companies who try to enhance the government's focus on the US' manufacturing competitiveness.

**Manufacturing and Trade Associations**

- Manufacturers Alliance/MAPI - The Machinery and Allied Products Institute (MAPI) was formed as a result of the National Industrial Recovery Act to help stabilize the industry during the Depression.The initial initiative failed, but the industry leaders acknowledged its value of peer-to-peer learning and co-operative innovation. Over 500 companies are currently connected to MAPI.
- The National Association of Manufacturers - The National Association of Manufacturers (NAM) was founded in 1895 at a time of depression to advocate the role of manufacturing in the U.S. The NAM helped in the establishment of the U.S. Department and Chamber of Commerce. In 1903, in order to decrease the power and influence of the national labor unions the NAM

launched several anti-union, pro-employers organizations called Citizen's Alliance. The enactment of the 1962 Trade Expansion Act was aided by the NAM. In an effort to change the view on manufacturing the NAM established the Manufacturing Institute around 1995.

- National Council for Advanced Manufacturing - The National Council for Advanced Manufacturing (NACFAM) was established in 1989. It's main goal is to improve innovation and global manufacturing competition of U.S. manufacturing companies, by advocating collaboration among all manufacturing stakeholders to influence policy and decision making.
- North American Free Trade Agreement - The North American Free Trade Agreement (NAFTA) was put into action on January 1 1994, in order to eliminate the duties and quantitative restrictions between the U.S., Canada, and Mexico. The remaining restrictions were lifted on January 1 2008 [U.S. Trade Representative, 2010]. While opponents claim the agreement caused a big increase in trade deficit and heavy job loss in U.S. border states, NAFTA claims an increase of 24% in jobs, a tripling in trade amongst the NAFTA nations and an increase in manufacturing output of 58% compared to 42% before the agreement [U.S. Trade Representative, 2008].

**Academic institutions**

Due to the large number of academic institutions in the United States, there are a lot universities that offer academic manufacturing programs. In the table below, an overview is given of the five biggest academic institutions that have manufacturing engineering programs. From this list, only Boston University will be visited by the Pixel2010 tour. Since manufacturing has an interdisciplinary nature, is it closely related to other crafts such as materials and mechanical engineering. While the number of institutions who offer these related programs is much larger, only universities which offer dedicated manufacturing programs are listed. [UnivSource, 2008]

| University | City(State) | University Type |
|---|---|---|
| Boston University | Boston (MA) | Private |
| California State University - Chico | Chico (CA) | Public |
| Florida State University | Tallahassee (FL) | Public |
| Miami University | Oxford (OH) | Public |
| Pennsylvania State University | University Park (PA) | Public |
| Washington State University | Pullman (WA) | Public |

**Comparison with the Netherlands** Compared to the Netherlands, there is a lot more focus on academic manufacturing research in the U.S.. This is explainable on the one hand by the size difference of both countries, but also by the fact that manufacturing in the Netherlands has a much smaller size of the GDP than in the U.S.; Dutch companies have shifted to services over the years. For consumer electronics the best known exceptions are the Dutch companies Philips and ASML (which was actually founded partly as a joint venture of Philips), which are major manufacturers of consumer electronics respectively and semiconductors. With the Technische Universiteit Eindhoven, Philips set up a lot of joint ventures and research projects, as well as offering numerous internships to students from the university.

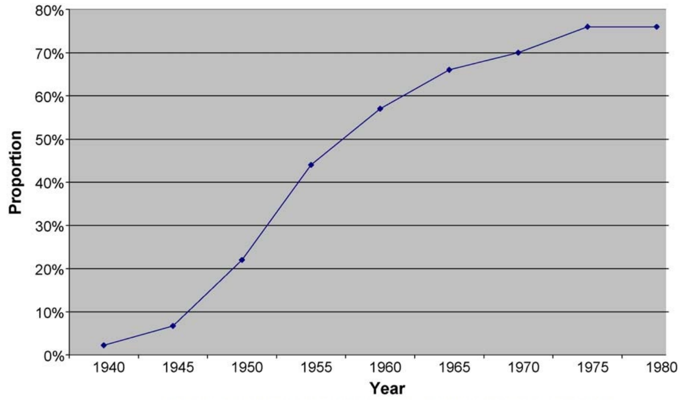


Figure 14.11: Proportion of Carnegie research universities with IAAs with Research Corporation: 1940-1980 [Sampat, 2006]

### U.S. patent system and academic institutions

Although manufacturing companies and companies in other related industries spend a major amount of resources on R&D , academic institutions also have a big part in the development of new technologies. [Mansfield, 1995] As with most inventions, these technological innovations must be patented for the researchers to be able to bear the fruits of their work. While it is common nowadays for academic institutions to license patents on their work, this has not always been so. Before the Bayh-Dole Act of 1980, academic institutions were hesitant to become involved in patenting and licensing. Most universities feared this could be considered compromising their commitment to open science and their task to spread knowledge.

In 1912 the Research Corporation was founded by Frederick Cottrell, a chemist researching at the University of California. He felt the need to protect his work from misuse, as well as the danger of it going to waste if it would become public property. He envisioned an organization that could act as a technology transfer agent to manage patenting and licensing, not only for him and his university but for other institutions as well. In 1937 MIT signed the first agreement with the Research Corporation and others followed as is shown in Figure 14.11

A comparable approach was taken by Harry Steenbok from the University of Wisconsin. Similar to Cottrell, Steenbok feared his invention would be discredited if not used properly, but he received such criticism from his colleagues that the university would not aid him in his efforts to patent his work. He initiated the founding of the Wisconsin Alumni Research Foundation, which would manage the patenting and licensing.

In the following years more academic institutions would follow, especially during World War II when technological advances paid for by public funds peaked. Another important development was the formation of spin-off companies, which aided universities to further commercialize their efforts. In 1968 the Department of Health, Education and Welfare began issuing Institutional Patent Agreements (IPA) to provide universities with a way to transfer technologies from publicly funded research. The Department of Defense had began allowing universities during the 1960s to re-

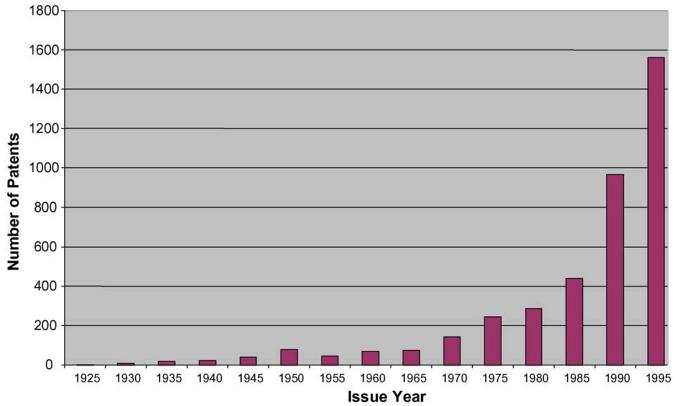


Figure 14.12: Patents issued to research universities, by year [Sampat, 2006]

tain patents on federally funded research already and the Nation Science Foundation started an IPA program in 1973.

In 1980 the Bayh-Dole Act was passed. This act gave academic institutions more incentive to patent and license their work and eased the process by removing the need for IPAs. The Bayh-Dole Act started a period of significant growth in university patenting and licensing. While the net effects on the transfer of technology from academic to commercial institutions is still unclear, the Bayh-Dole Act has certainly increased the amount of patenting by universities, as shown in Figure 14.12.

**Comparison with the Netherlands** The history of patent law in the Netherlands differs greatly from the U.S.'. Dating back from 1589 it was possible to have "patents for inventions" granted and recorded in the deed books of the "Staten-Generaal". These patents required a practical application, which had to be displayed within a year. There was a certain arbitrariness in the duration of the patents , which could be two years, but also fifteen or fifty years.

The first patent law in the Netherlands was ratified in 1817. Patents could be granted for five, ten or fifteen years. Due to the considerable costs and the requirements of a full description of the invention to be submitted, only few Dutch companies actually used the new law. In 1869 the law was abolished and because the Netherlands became the only European country without a patent law, it got the image of a nation of freeloaders.

The late 19th century was marked by international cooperation. In 1883, over 140 countries met in Paris to try to compare national laws on industrial property (patents, trademarks designs) and unify them. During the Paris Convention the nations agreed that all member countries would recognize the right of priority. Three years later, at the Berne Convention of 1886, international agreements on the protection of Intellectual Property, literary and art were made. The Netherlands was part of both the Paris and Berne Convention, but it took until 1910 before a new patent law was signed. Beginning in 1912, the number of patents granted grew steadily and in the '60s and '70s, there were between 14.000 and 18.000 applications.

The signing of the 1973 European Patent Convention by fifteen countries marked another new beginning. Two years later, it became possible for an inventor or manufacturer to obtain a patent for 17 countries. The European Patent Office in Munich granted patents and soon established offices in Rijswijk, Berlin and Vienna. The numbers of Dutch initial applications decreased dramatically.

In 1995, this decline led to a new law, the 'Rijksoctrooiwet 1995 '. This law made it cheaper and faster to patent it, without going years without substantial examination. The law created the possibility for new six-year patents, without the need to research on the state of the art. The 1995 law is still in effect today.

## 14.4 Porters Diamond

In this section we will map the manufacturing of consumer electronics sector in the U.S. using the Porter's diamond method and compare it with the Netherlands wherever possible. This chapter will start with a small introduction on the Porter's diamond, followed by the elaboration on each of the aspects in the Porter's diamond model. The chapter concludes with some trends and conclusions that can be drawn from this model.

### 14.4.1 Introduction

The sector analysis of manufacturing can be done with the Porters diamond. This analysis will enable us to analyze an industry or sector per nation, and gives insight into the dynamic workings of it. This model has been developed by Michael Porter [Havard University, 2008] which has been a leading authority on competitive and economic development of nations, but also on strategy and the application of competitive principles on social problems. The model works very well on developed nation which also have a history in each sector that is analyzed, the drawback is that its less effective on third world countries; in our case we compare the U.S. and the Netherlands which are both well developed and industrialized nations.

Porter's Diamond models consists of four determinants and two variables [Porter, 1998], these are depicted in Figure 14.13. The four determinants are [Porter, 1990]:

- Factor conditions: "The nation's position in factors of production, such as skilled labor or infrastructure, necessary to complete in a given industry"
- Demand conditions: "The nature of home-market demand for the industry's product or service"
- Related and supported industries: "The presence or absence in the nation of supplier industries and other related industries that are internationally competitive"
- Firm strategy, structure and rivalry: "The conditions in the nation governing how companies are created, organized and managed, as well as the nature of domestic rivalry"

These determinants are constantly influencing each other but are also influenced by two major variables which are defined as:

- Government: Each sector has regulations and laws that are applied upon by the government, but also sets the political climate in which the sector is operating in.

- Chance: Circumstances or opportunities that cannot be influenced by the sector itself (like war or economic crisis).

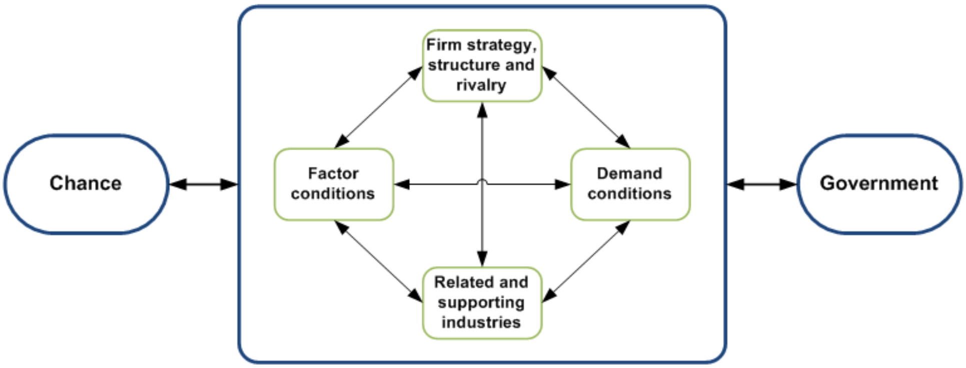


Figure 14.13: Porters Diamond

### 14.4.2 Factor conditions

There are two kinds of factor conditions, basic and advanced factors. The basic factors are limiting conditions on the manufacturing sector and cannot really be influenced by the sector itself. The advanced factors on the other hand can be influenced and contribute to the development of a competitive position.

#### Basic Factors

- Materials: The U.S. has huge amounts of natural resources like iron and oil, which are critical resources for any consumer electronics product[CIA, 2010a]. As metals, plastics and silicon are the main components used for the (consumer) electronic devices and derived from mining and oil activities.The Netherlands main natural resource is gas [CIA, 2010b], which is not a core component to the manufacturing of consumer electronics. In the U.S. it should be possible to produce semiconductors and circuit-boards as well as other components used in consumer electronics. The Netherlands is dependent on the import of these resources and components.
- Geographic position: There are three states that dominate the consumer electronics market in the U.S.: California, Texas and New York [Pricewaterhouse-Coopers, 2008]. The most famous technology center is of course Silicon Valley (California) and the other big centers are: Silicon Alley (New York) and Silicon Hills (Texas).
  In the Netherlands there is one technological center, which is Eindhoven because Philips is based there. Philips is the biggest native producer of consumer electronics in the Netherlands.
- Foreign Direct Investment (FDI): This tells about the longterm participation between countries and can be used to measure growing economic globalization. These investments are driven by the big corporations and financial organizations. The FDI flows for the U.S. was 271 billion dollars inward and 378

billion dollars outwards. The FDI flows for the Netherlands was 118 billion dollars inward and 28 billion dollars outward.[United Nations, 2010b] [Bureau of Economic Analysis, 2010]
More information about the FDI can be found in table 14.2, where the GFCF stands for gross fixed capital formation (that is an official macro economic concept). Although these numbers are for the whole nations it can show how the in and outward flow of investments are going. For both the U.S and the Netherlands the inwards FDI flow is going up where as the outward flow are fluctuating. As some big corporations are listed per nation, we can see that for the U.S. the biggest electrical components corporations are: IBM, HP and General Electric. For the Netherlands the only electrical equipment manufacturer is Philips. Also another fact is that the Netherlands has much higher FDI flowing in and outward then the U.S. when seeing it as a percentage of the GFCF.

| FDI flow | 1990-2000 | 2005 | 2007 | 1990-2000 % of GFCF |
|---|---|---|---|---|
| U.S. inwards | 109,513 | 104,773 | 271,176 | 8.0% |
| U.S. outwards | 92,010 | 15,369 | 378,362 | 6.6% |
| NL inwards | 19,833 | 47,791 | 118,376 | 24.6% |
| NL outwards | 28,484 | 131,816 | 28,544 | 35.3% |

Table 14.2: FDI flows for U.S. and the Netherlands, numbers are in millions of dollars [United Nations, 2010b]

- Labor Market: The unemployment ratio is rising since the financial crisis with an estimated ratio of 9.3% in 2009 in the U.S., where the Netherlands has an estimated ratio of 5% unemployment. A trend here is that there is more value added per worker in the manufacturing sector, as described in the section of development.

**Advanced Factors**

- Highly qualified labor: The last decades there has been a shift in the consumer electronics manufacturing sector towards a more skilled labor force and more focus on the research and development. This shift was accompanied by an increase in offshoring by the domestic manufacturing sector. In 2006, the U.S. has a shortage of skilled manufacturing personnel, especially in more specialized fields [Blass, 2006].
- Inflation: The inflation is fairly stable the last 10 years, between two and four percent per year, for a more detailed info see figure 14.14. The U.S. had a stable inflation between the one and four percent, untill the financial crisis started, which made the inflation going towards deflations. This has effects on the exchange rates and import + exports, although the U.S. has a fairly stable inflation[Inflation Data, 2010]. The Netherlands has a stable inflation between the one and four percent where the financial crisis has less effect on the inflation [Centraal Bureau voor de statistiek, 2010].
- Rate of exchange: The rate of exchange is a major factor in the international competitiveness of the U.S.. A strong U.S. dollar leads to cheaper imports of goods, services and more offshoring, but it limits the foreign investments into

the U.S. and insourcing. As of June 8th 2010, the dollar commands a fairly strong position compared to the Euro and is at a stable rate of exchange to the Japanese Yen and the Chinese Yuan, though external factors may very well change this.

- Research institutes: The research institutes can roughly be divided into federal and academic institutes, but the federal institutes will be categorized in the government section of the Porter's diamond as they are initiated (and/or funded) by the government. In the U.S. there are many universities that offer academic manufacturing programs, which educate people towards the high skilled workers. It is not uncommon for universities to link themselves with commercial organizations, to aid them in research. The five biggest universities for manufacturing are: California State University, Florida State University, Miami University, Pennsylvania State University and Washington State University.
  In the Netherlands the number of research institutes is much smaller, due to the fact that the focus of the Netherlands lies in services instead of manufacturing. The best example is the cooperation between Philips and Universiteit Eindhoven, which demonstrates how the academic and commercial manufacturing businesses can be combined.
- R&D: It is a trend in consumer electronics to be the first to launch new products, this is one of the main drives to increase the focus on research and development. The life cycle of electronic products is getting shorter[LaPlante, 2009] and the technological advances are rapidly increasing. Where smaller devices, smaller and energy-efficient components are key elements for new consumer electronic products; in this R&D plays a major role to support these advancements and development towards new implementation of the products.

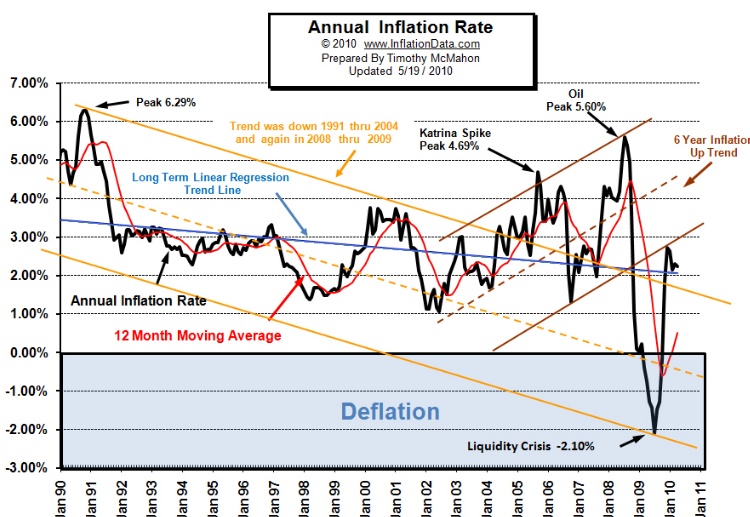


Figure 14.14: Annual inflation for the U.S. including trends and financial crisis [Inflation Data, 2010]

### 14.4.3 Demand conditions

This determinant is focused on the demand on the domestic market, and also in lesser extend towards to external demand.

#### Composition

The U.S. consumer electronics market consists of different forms of customers. Mainly there are the consumer and enterprise markets. The U.S. enterprise market claims 64% of the sector its gross output, whilst the consumer market is responsible for the other 36% of the consumer electronics sector its gross output. [PricewaterhouseCoopers, 2008]

#### Shape and growth

Consumers in the United States are becoming more eager to adapt new technologies and products as we have seen earlier in this report. The amount of money the average U.S. household spends on consumer electronics has almost always increased since 1900 through 2006 and the same goes for Dutch households. The total value of shipments within the sector of manufacturing, which includes the manufacturing of consumer electronics, has however decreased between 2007 and 2008.

#### Domestic market vs international market

As mentioned earlier in the sector analysis the domestic market of the U.S. is responsible for almost 90% of the economic stimuli of the American consumer electronics. Roughly 10% of the money generated by the U.S. consumer electronics market comes from exporting goods. What is not included in those numbers is foreign imports from American transnational companies that also operate in other countries. Large companies often have multiple sub-companies in different countries. Products imported from a certain country could come from a transnational company. Certain imports to the Netherlands from China may very well be really generated by U.S. based companies because there is a lot of offshoring taking place in the sector of manufacturing.

### 14.4.4 Firm strategy, structure and rivalry

#### Market structure

In the sector of manufacturing of electronics in the United States there are a few big players as we have seen in the commercial sector analysis of this report. First of all there is Apple who is becoming a bigger and bigger player on the global telephone market and is dominant amongst the U.S. based manufacturing companies. Furthermore there is GlobalFoundries, a joint venture between AMD and ATIC is one of the largest manufacturers of semiconductors. Although seven of their total eight manufacturing plants are not in the United States, their headquarters is. In the industry of LCD panels there are three United States based companies that posses 38% of the global LCD monitor market. There are also quite some firms that design electronics and have other companies, that are not necessarily U.S. based, manufacture their ideas. Examples of this are ATI and NVIDIA who design GPU's and other companies that build the actual video cards. The same goes for chipsets designed by Intel and AMD that are used on computer motherboards from different companies.

#### National competitiveness

As mentioned, there are quite some firms in the United States that only design chips or processors and have other companies build their ideas. Although the actual manufacturers are usually not based in the United States, the competitiveness between the design companies is more important than the manufacturing since it's about the core component. In the sector of manufacturing electronics related to consumer electronics and computers, we know the regular big players such as ATI and NVIDIA, but also Intel and AMD. Also Qualcomm is a popular manufacturer of CPU's for handhelds such as smartphones. In the U.S. the competitiveness is more between the designer companies and not so much between the actual manufacturing.

#### Trends

There are several technological trends that can be observed in the manufacturing sector of consumer electronics; these are all applicable for both the U.S. and the Netherlands.

- Outsourcing: Outsourcing and offshoring of manufacturing of components (or complete products) is mostly done to decrease costs, as labor costs in the U.S. and the Netherlands are very high compared to for example China.
- Environment: The environment is playing a bigger role in the production of consumer electronics. Where the government will apply stricter rules on products and manufacturing.
- Miniaturization: The consumer product are getting smaller, due to smaller chips and technological advances. This also leads towards innovation and integration of various services into one product, like a mobile phone has a camera, GPS, texting options and much more.
- R&D: Shorter life-cycles and quicker development of consumer electronics mean that research and development department are getting more focus.

### 14.4.5 Related and supporting industries

This determinant is focused on other interaction with other clusters. Another important aspect is how the supply and service chain are routed. The growth and success of the manufacturing in the U.S. has close relations to other clusters like:

- Suppliers of material: Manufacturers are dependent on the suppliers that ship them the necessary materials and/or raw materials that can be transformed into product that go up the chain until they are used in consumer electronics.
- Material engineering: Research and development is essential for manufacturers, one of those reasons is for material engineering. This is the scientific field where materials are analyzed.
- Enterprise electronics: Consumer electronics is just 36% of the market share in consumer electronics, where as the enterprise market has 64%.
- Software: Software is an industry that relies on the hardware build by manufacturers.

### 14.4.6 Chance

What is the influence of chance on the manufacturing industry of consumer electronics? In the following section we will look at factors that doesn't have much to do with the U.S. and are largely outside of the control of the firms.

**Disasters** Disasters can influence the manufacturing sector on several ways. Factories can be destroyed or supply of materials and parts can be hampered. For instance in 1999, an earthquake in Taiwan forced factories to close for weeks because their machines where out of calibration. The prices of memory these days almost doubled[Advocate, 1999].

**Economic fluctuations** The economic health of a country compared to the rest of the world is important for the manufacturing sector. The sector is strong dependend on import and export of goods. Therefor exchange rates are an important factor. The financial crisis leads to less purchasing power of the consumer. Manufacturers have to handle this situation.

**War** The influence of war on the manufacturing sector can be both positive and negative. A lot of money goes into R&D during war time which leads to a development sprint. A lot of techniques developed for war are used today in consumer products. But war can be negative too. The manufacturing sector depends on other countries for goods and services. When those countries become at war, prices can raise.

### 14.4.7 Government

**NIST** National institute for standards and technology. This is a federal institute founded in 1901. We will discuss the role of this institute on manufacturing of consumer electronics.

**ANSI** American National Standards Institute is a private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States. Although this institute is privately held, the government can ask for standardization. This institute is a big player on the standardization field.

**NAM** National Association of Manufacturers. This association is for all manufacturing. We will find out if this association is worth looking at for this study.

**Subsidies** We will discuss several kinds of subsidies. To name a few: Export subsidies, R&D subsidies.

**Tariffs** NAFTA created a free trade zone between Mexico, Canada and the US. Goods and people can cross the border easily and no tariffs have to be paid.

**Environmental rules** All product must be more environment friendly. The used materials should be recyclable, the production process should be clean etc. This is mainly due to government rules. What kind of regulations and rules are there and how do they influence the manufacturing process.

## 14.5 Conclusion

In this section we will conclude this meso research paper. We will summarize the previous sections and point out the most important conclusions from the respective sections.

### Technology

**Current developments** There are some important point in the developments chapter of this paper. First of all, there is a change in the workforce; while the number of employees working in the manufacturing sector has decreased by 19% from 1998 to 2006, there is a 22% increase in value added per worker in the same period. Furthermore there is an increased focus on research and development. Another important conclusion is that outsourcing, and especially offshoring, plays a big part in the manufacturing sector. While the low skilled jobs are lost to cheaper producing countries, there are some notable benefits of offshoring, such as an increase in high skilled labor and cheaper consumer prices. Compared to the Netherlands, the developments in the U.S. seem to be the same.

**Challenges** As for technical challenges, we looked at the environmental challenges concerning manufacturing. The focus on this issue has affected the manufacturing sector significantly and is likely to remain a factor. The social challenge the manufacturing sector faces is the increasing shortage of high skilled labor; as the U.S.' workforce is reaching its retirement age, there will be an even stronger need for these kind of employees in the future. Another important challenge is the effect of the current global financial crisis, although there are no conclusive reports on the effects yet.

### Sector Analysis

In 2008 the U.S. consumer electronics sector employed over 15.3 million Americans, generating a direct output of $1,352 billion dollar. For the strategy and future vision we looked at the manufacturing of mobile phones and LCD monitors. In the mobile phone sector only Apple has a significant market share since the introduction of the iPhone 3G. For LCD monitors, there are no significant U.S. based manufacturers. When we look at demand conditions, there are two main conclusions: the amount of spending on consumer electronics has doubled from 1990 to 2006. This might be contributed to by the significant increase in speed by which new technologies are accepted by and diffused to consumers. When comparing to the Netherlands, we see that while the amount of spending on consumer electronics is doubled, the percentage of income spent is more or less the same; this appears to be the opposite of the U.S.. We conclude the sector with an analysis of the economic factors: while the import and export of consumer electronics increased until 2007, there is a clear decline in the last few years in the U.S..

Another part of this section is concerned with the noncommercial and academic organizations related to manufacturing. The most important conclusion is that the U.S. government and the manufacturing sector itself are very active in encouraging the development and strength of the sector. When comparing the academic institutions in the U.S. and the Netherlands, there is a major difference; in the Netherlands only Philips and Technische Universiteit Eindhove have a major joint venture when it comes to the manufacturing and development of consumer electronics. We also looked at the Dutch and U.S. patent system, but there are no conclusive facts to be noted there.

### Porter's diamond

In the last section of our meso research we use the Porter's diamond to analyze multiple factors influencing the manufacturing sector. As this section treats most facets of the manufacturing sector summarily it can be considered as a conclusion in it own and will not be treated any further.

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# Part III

# Indepth research

# Chapter 15

# Introduction

The third and last part of this preliminary report consists of an in-depth research. This in-depth research is used to get a better insight into technologies and business models used within the Games and Simulations industries. All technologies investigated are often used or state-of-the-art technologies.

To get a rich and well defined research, six research tracks are selected:

**Artificial Intelligence** Everything that has to do with Artificial Intelligence. From smart agents within a simulation to computer strategies within games.

**Augmented Reality Business** Augmented Reality is a new technology, made famous by the iPhone. Within this tracks new business plans that can be employed for Augmented Reality technology are investigated.

**Augmented Reality IT** IT technologies that are used or can be used within Augmented Reality are investigated.

**Engines and Hardware** Graphics engines, rendering techniques and graphic cards are important behind the scenes of Games and Simulations. These technologies are investigated within this track.

**New Media Input Devices** Beside the keyboard and the mouse many inputs for computer systems exist. Within this track new developed input devices are investigated.

**Serious Games** Games that do not have entertainment as their main objective are investigated within this track.

The following chapters contain all individual research conducted by participants of the study tour. Research is ordered on research track as listed above.

# Chapter 16

# Artificial Intelligence techniques used in Go

*Section by Marije de Heus*

## Abstract

This paper surveys the most used artificial intelligence techniques used in Computer Go. Even though Computer Chess reached grandmaster level over a decade ago, Computer Go is still nowhere near the level of professional Go players. This article explains what it means for an AI technique to be successful and what AI techniques are used by the several Computer Go programs available.

## 16.1 Introduction

Board games like chess, checkers, reversi and go have been the subject of many studies during the last 40 years [Millington and Funge, 2009]. Especially for chess many AI techniques have been developed, and chess computers reached grandmaster level in 1994, when Kasparov, the highest rated chess player in the world, was beaten by a computer chess program in a timed tournament [Burmeister and Wiles, 1995]. The game Go, played by two players using black and white stones that can be placed on the 19x19 grid, has a much more complex strategy even though the rules are very simple. It has been estimated that the number of different game states is larger than the number of atoms in the universe. This makes it impossible to investigate every situation so smart AI techniques have to be used. This paper will give an overview of the techniques that are currently used for Go.

## 16.2 Research question

This paper investigates the successful AI techniques most used in Go, with the following research question:

*What successful AI techniques are most used in computer Go?*

To answer this research question, the following subquestion needs to be answered:

- What AI techniques are most used in computer Go?
- What defines the success of a Go program?

### 16.2.1 Structure of this paper

In order to answer the research question we will first take a closer look at the game Go. Section 3 will be all about the game itself; readers who are already familiar with the game may skip this section. Section 4 describes the successfulness of Computer Go so far; there are many tournaments and prizes and games of professional players vs. computers that give a good view on Computer Go's current position. Section 5 is all about the AI techniques used in Go. This paper ends with a conclusion in section 6 where the research question will be answered.

## 16.3 The game of Go

Go is an ancient oriental board game for two players with very simple rules, yet strategies for it can be very complex. This section first explains the rules of the game, then addresses the different ways of counting score, and finishes with some very basic techniques that are often used by beginning amateurs. The rules that are described here are the official rules used by Go associations [AGA, 2010] [BGA, 2010].

### 16.3.1 Basic rules

The game is played on a grid. The size of the grid may differ: usually it is 19x19 lines but sometimes smaller grids are used, especially for children or players who are new to the game. In this paper we will assume a grid is 19x19 unless it is stated otherwise. In the beginning, the grid is empty. The two players alternately place white and black stones the intersections of the grid. Stones can no longer move once they are placed on the board, unless they are captured by the opponent's stones. The goal of the game is to control an area larger than your opponent's. The scoring rules will be explained in subsection 3.2, but we will first mention some terms commonly used in Go.

**Group** Vertically and horizontally adjacent stones of the same color are called a group (or sometimes a chain or String).

**Liberty** A liberty is a free position horizontally or vertically adjacent to one of the stones in a group. It is a property of the stone as well as of the group.

**Capturing** If a player places a stone on the last libery of the group of the opposite player, the group is said to be captured and all stones are removed.

**Suicide** It is usually not allowed to place a stone in such a way that it leaves your own group without liberties. Doing so is called suicide. This is not true when you can capture your opponent's group by doing so, since their group will first be removed, leaving your group with a liberty after placing the stone. Whether suicide is allowed or not does not matter a lot for artificial intelligence techniques, since suicide is rarely benefinicial.

**Ko rule** Sometimes it is possible that certain moves keep repeating, making the game go on indefinitely. The Ko rule prevents this: it prohobits a player to make a move that makes the games return to the state before the opponent's last move. This is a very important rule for AI techniques, because it ensures all games have a finite number of moves and therefore prevents infinte loops.

**Passing** A player may pass instead of placing a stone. This usually occurs when they believe they cannot increase their score anymore. When both players have passed consecutively the game ends and the score is counted.

**Living, dead or unsettled** A group is said to be living, dead or unsettled. A living group cannot be captured even if it is the opponent's turn. In practice this means the group must have at least two liberties. A dead group cannot avoid to be captured, even if the owner can move first. An unsettled group is one that can be captured if the opponent moves first but can avoid being captured if its owner moves first.

**Handicap** It is possible to give an advantage to one of the players by allowing him or her to place a number of stones on the grid before the game is actually started. This is called a handicap for the opponent. For example, if one player gets to place five stones before the game starts, the other player has a handicap of five stones.

### 16.3.2 Scoring

Even though there are some minor differences between rules from different countries (especially China and Japan/Korea), these do usually not affect the game play. However, we still explain both Chinese and Japanese scoring rules since they are the most common and differ significantly.

**Area scoring** The score is the number of stones on the board plus the number of empty stones surrounded by their stones. This is the Chinese rule for scores.

**Territory scoring** Japan and Korea use a different way of counting score. They count all the stones that each player captures during the game as well as the empty points surrounded by a player's stone. Sometimes there can be disagreement on if a group is dead or not. In that case the players usually continue the game until both players pass consecutively again. Under area scoring, the score will then be based on the position of the game after the second time they passed. Under territory scoring they will return to the position after the first passes and remove the dead groups.

## 16.4 Successfulness of Go programs so far

Most AI techniques that are suggested for Go are implemented in some Go program in order to test them. Those Go programs are then ranked by letting them play to human Go players, since human Go players are ranked according to their skill. The rank system consists of kyus and dans, starting with 30 kyu going up to 1 kyu and then 1 dan going up to 9 dan, shown in the table below. Usually only the first game a computer plays against a human is considered, since the human may learn from the program's mistakes but the program is often not able to learn from the human's mistakes (see also the section on machine learning). The following subsections describe the current Go programs and their success so far.

| Rank Type | Range | Stage |
|---|---|---|
| Double-digit kyu | 30-20k | Beginner |
| Double-digit kyu | 19-10k | Casual player |
| Amateur dan | 1-7d | Advanced amateur |
| Professional dan | 1-9p | Professional Player |

### 16.4.1 Go programs

Go programming started in the late 1960s and got a big boost in the mid 1980s, when PCs were more readily available and Go computer program tournaments were organized [Mueller, 1995]. Harrison named the most recent and most successful Go programs in his 2010 thesis [Harrison, 2010], which will be discussed here. We will also mention the techniques the programs use; these techniques are discussed in section 5.

**GNU Go** GNU Go is a free, open source program, allowing many people to contribute to it. Its first version came out in 1999 and right now it is about six to seven stones weaker than the top commercial programs [GNU, 2010].

**Many Faces of Go** The Many Faces of Go is one of the older Go programs available. It first came out in 1981 and was developed by David Fotland [David Fotland, 2010]. It has booked some successes in the late 80s and early 90s when it won the United States Computer Go competitions [David Fotland, 2010]. In 2008 it was the World computer go 19x19 and 9x9 champion [David Fotland, 2010]

**Go++** Go++ is one of the most successful Go programs currently available. Since 1996 it was placed in the top 3 of every tournament it entered [Michael Reiss, 2010].

**Crazy Stones** Crazy Stones was developed by Rémi Coulom. The development of this program was carried out as an initiative from the French Ministry of Research. It has won quite a few prizes since it started (about five years ago) [Remi Coulom, 2010]. It uses Monte-Carlo evaluation and has apparantly been very successful doing so. In 2007 the Monte-Carlo search was improved with patterns learned by a Bayesian technique[Remi Coulom, 2007]. The Bayesian technique will not be discussed in this paper.

**MoGo** MoGo is the result of Yizao's internship, where Rémi Coulom participated. He shared his experience from programming CrazyStone, resulting in another Monte Carlo based program using a tree search algorithm based on the UCT algorithm and patterns. There are high-performance clusters for main events[Wang and Gelly, 2007] [INRIA, 2010].

### 16.4.2 The success of Go Programs so far

The success of Go programs is usually defined by how well they do against professional Go players. There are many tournaments organized for this purpose, we will first mention the most popular ones. There have also been prizes for excellent computer Go programs, they will be described next. We conclude this section with some of the results of computer versus human games.

**Tournaments** The Computer-Go website has a very useful and updated calender with all the upcoming Computer Go tournaments in it [Nick Wedd, 2010a].

**KGS Computer Go Tournament** This website organizes many online tournaments where computer Go developers can test their programs at all times [KGS Computer Go Tournament, 2010].

**European Go Congres** The European Go Congress is organized annually and usually involves computer Go events too [European Go Congress, 2010].

**US Go Congres** The US Go Congress is held annually as well, and sometimes involves a computer Go tournament as well [US Go Congress, 2010].

**Computer Go Forum** This tournament is hold anually as well and alwasy includes computer go games (hence the name) [Computer Go Forum, 2010].

**Prizes**

**Ing Prize** This prize was offered by the Taiwanese banker Ing Chang-ki and was the driver for many Go programmers to improve their programs. It was offered at the Ing Cup (a world computer Go congress). The winner of the tournament could challenge a young professional Go player with a handicap. If the computer won the match the prize would be rewarded and a new prize was announced: a larger one for winning a game with less handicap. The Ing prizes expired in 2000 when Chang-ki died. In 1997 Handtalk was the last program that claimed a prize of 250,000 NT dollars for winning a match with an 11-stone handicap against three 8 or 9 year old professionals [Nick Wedd, 2010b].

**Selection of computer vs. human games** At the tournaments mentioned earlier in this chapter, Computer Go programs play against humans. This is a good way to test the program, since all humans are ranked. Therefore it is easy to see if the program has improved, even if they play against different humans. The Computer-Go website keeps a table with information about all the interesting human vs computer Go games [Nick Wedd, 2010b].

**Februari 2010** Zen won the game against Nam Chi-hyueong (1p) on a 9x9 grid with no handicap.

**August 2009** Fuego and MoGo won the game against Shen-Su Chang (6d) with 4 stones handicap on a 19x19 grid.

**February 2009** MoGo won the game against Shi-Jim Yen 6d with no handicap on a 9x9 grid.

**August 7 2008** MoGo won the game against Myungwan Kim (8p) with a handicap of 9 stones. The game was played on a 19x19 grid.

## 16.5 Artificial Intelligence techniques used in Go

This section describes the AI techniques that are most used in Computer Go programs. We start with the basic AI techniques needed to solve a game, then describe some possible ways to search the game tree, discuss machine learning and see how programs can divide the game into different stages to improve their performance. The section ends with some information about the difference between local and global factors in Go.

### 16.5.1 Basic AI techniques

All programs that play games have some basic requirements. They need a way to represent the different game states, a way to generate moves, define some goal states, and develop an evaluation function. Here we will describe this fundamental properties of Go programs. A lot of this information came from a paper called "AI Techniques Used in Computer Go" [Burmeister and Wiles, 1997], which describes just these techniques and how they were implemented in the programs available at the time.

**State Representation** Go is a perfect information game, meaning that all the information about the state of the game is available at any time. Each intersection point of the grid is either empty or occupied by a black or white stone. The size of the state-space is therefore $3^{361}$ or $10^{172}$, compared to a state-space for chess of approximately $10^{50}$ and othello of $10^{30}$ [Allis, 1994]. However, describing the game state like that is not very useful for a computer. It will need information about the groups (adjacent stones), but this is very difficult in practice, because it is hard to determine which groups will be useful. The appropriate level of representation may vary on the sub-task being performed, e.g. tactical analysis, life-and-death analysis, or assessing territory [Burmeister and Wiles, 1997].

**Move Generation** The average branching factor (number of possible moves at a certain moment in time) is very large (200) compared to that of chess (35) [Burmeister and Wiles, 1995]. This branching factor does involve all possible moves, even though some moves could be eliminated by a human at first sight. Goal-directed search is used to read out ladders of about 60 ply deep. These ladders usually have only one or two possible moves [Burmeister and Wiles, 1997].

**Goal States** The goal of Go is to acquire more territory than your opponent, either by surrounding empty points or by capturing their stones. The goal state of Go is more complicated than that of chess (check mate), since it largely depends on the opponent"s stones, while check mate does not. The ending of a game in Go is not very clear. The game ends in principal when both players pass, and then the score is counted. However, if there is discussion about the score, the players will continue the game until they do agree on the score. It is difficult for a computer to determine when to pass [Burmeister and Wiles, 1997].

**Evaluation Function** The life-and-death status of groups have to be considered to evaluate a certain Go position. It consumes a lot of time and is done by tactical search (see also the next section). Determining the winner from any position is P-space hard

### 16.5.2 Searching the Game tree

Some small games like Tic-Tac-Toe can be solved by searching the complete game tree. All possible moves and game states can be searched and the best move can easily be decided. However, Go is too complex for such a game tree search, with a game tree size of $10^{360}$ compared to $10^{123}$ for chess, and there are less than $10^{100}$ atoms in the universe. Searching parts of the game tree is possible. Here we describe some of the common ways to do this.

**Goal Search** Goal search is used to look for nodes in the game tree that accomplish specific tasks, like establishing life or death, creating eyes, connections, cuts, safety or territory, and capture. These sub-goals may all help to reach the final goal: win the game by acquiring the most territory [Harrison, 2010].

**Heuristic Evaluation Functions** Creating a good heuristic evaluation function is difficult, but they are used in most programs. Some useful heuristics are: moves that capture the opponent's stones and moves that protect your own stones. These heuristic evaluation functions are usually quite complex. They largely decrease the branching factor, enabling the program to look further down in the game tree[Harrison, 2010].

**Tactical search** Tactical search is used for purposes like determining whether strings are dead or alive, whether eyes are formed and determine the life-and-death status of groups. Tactical search is a heuristic device that has two move generators: one for attacking moves, and one for defensive moves. The moves suggested by them are sorted according to criteria like liberties of liberties and simple eye shapes. Next, an alpha-beta depth-first search. The search is limited to a maximum number of nodes. Tactical search is a type of goal-oriented search [Burmeister and Wiles, 1997].

**Life-and-Death Search** Some programs use perform life-and-death analysis to determine the status of a group. Others just use a form of tactical search for this purpose. Life-and-death search is another goal directed type of search. There is a static life-and-death evaluator that determines the status of a group. The search is done to save or kill a group. If the goal is not yet achieved, more moves are generated and the search is continued. The life-and-death evaluator is called at each node during the search to determine if the goal has been achieven [Burmeister and Wiles, 1997].

**Monte-Carlo** Monte-Carlo search strategies are used a lot in computer Go programs and results have been quite good. The Monte-Carlo evaluation functions lead to precise evaluations by playing a number of random games from the current game state and infer the value of each of the possible next moves from these evaluations [Chaslot et al., 2006]. The move that does best on average is then chosen [Brugmann, 1993].

### 16.5.3 Machine learning

A lot of recent research has been done on the use of machine learning in Go, especially using neural networks [Donnelly et al., 1994] [Richards et al., 1998] [Lubberts and Miikkulainen, 2001] [de Groote, E., 2005]. In this subsection we will discuss some of the most used types of machine learning [de Groote, E., 2005]: supervised learning, reinforcement learning and we conclude the subsection with some information about neural networks.

**Supervised learning** With supervised learning, learning is done using examples. An example consists of two things: the input signal, and the desired output. This output could for example be decided by a human being. It is the task for the program to learn a function that produces the desired output given the input [de Groote, E., 2005].

**Reinforcement learning** In the past decades a lot of research on reinforment learning has been done by animal psychologgists. In reinforcement learning, winning a game leads to a reward whereas losing the game causes a punishment. The difficulty here is that it is unclear which moves contributed to the loss or win. Two popular types of supervised learning are Temporal-Difference learning (used to learn evaluation functions) and Q-learning (moves are evaluated instead of positions) [de Groote, E., 2005].

**Neural Networks** Neural networks are often used to map the features of a game state to a desired output, since it uses an implicit representation of the game states. The state space of Go is simply too big for an explicit representation. The neural network learns by updating the weights of mappings between features of game states and outputs [de Groote, E., 2005]. A lot of reseearch has been done on these so called evolutionary techniques in neural networks [Donnelly et al., 1994] [Richards et al., 1998] [Lubberts and Miikkulainen, 2001].

### 16.5.4 Different approaches for different stages of the game

Go can be divided into three phases of the game: the opening, midgame and endgame. Each of these phases requires different techniques to be used. The phases will be discussed here

**Opening** The opening stage of the game, also called fuseki, can be compared to the book openings in chess. It is usually wise to start by placing stones in the corners. Specific sequences in the corners are called fuseki. Most good Go programs have databases with fuseki moves, usually between 5,000 and 50,000 [Donnelly et al., 1994]. Usually Go programs play most of their opening based on the openings stored in their look-up table. The look-up table is created by storing many successful openings of games played before.

**Midgame** The midgame is much more complex than the opening. The branching factor is usually between 200 and 300, making it impossible to look ahead more than a few moves when considering all posibilities. This is where AI techniques are needed most to select good moves and eliminate the others. There are some problems with midgame techniques: they are usually difficult to apply and error-prone [Donnelly et al., 1994]. Midgame is where the AI techniques mentioned in this chapter (searching the game tree, machine learning) are most useful, since smart techniques have to be used as there are too many possibilities to search the entire game tree.

**Endgame** The endgame, like the opening, is much easier than the midgame. The branching factor is reduced and local patterns can be very useful. However, the score does not usually change in the endgame so playing a good endgame does not contribute a lot to the score [Donnelly et al., 1994]. The endgame can usually be played by searching the entire game tree, so the program knows which move will have the best outcome.

Having considered the three phases, we can conclude that the endgame is usually not much of a problem, just like the opening. However, the midgame is very difficult as the branching factor may be very large and much of the research focuses on this phase of the game.

## 16.6 Conclusion

To answer the research question, we will first answer the second subquestion about what defines the success of a Go program.

### 16.6.1 Successfulness of Go programs

The success of Go programs can be measured by looking at how well they do against humans. There are many tournaments that allow the program developers to test their programs. However, since most programs use a combination of techniques, it is hard to tell how successful a single technique is. Computer Go is not yet anywhere near master level, but it will probably turn out to be that a good Go program will need a combination of techniques. In 2010, there are Go programs that have beaten 1p human players without a handicap. The 1p rank is the lowest level of professional human players (there are 10 levels in total), so there are Go programs that are at a professional level. However, they are still nowhere near grandmaster level yet. In this paper we described some of the most used AI techniques in Computer Go. We discussed several ways of searching the game tree and machine learning and looked at what the effect is of splitting the game in different phases.

### 16.6.2 Successfulness of AI techniques

The success of Go programs can be measured by looking at how well they do against humans. There are many tournaments that allow the program developers to test their programs. However, since most programs use a combination of techniques, it is hard to tell how successful a single technique is. Computer Go is not yet anywhere near master level, but it will probably turn out to be that a good Go program will need the combination of techniques. Even though we cannot contribute the success of the programs to a single technique, we can say something about what techniques have been tried in past programs but are not used anymore (they are not successful) and the ones that are commonly used (they are).

In conclusion, the most successful AI techniques that are currently used in Go programs are Monte Carlo and goal directed search. A lot of research has been done on machine learning, but this is not yet used a lot in Go programs. Results of early studies are promising though.

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# Chapter 17

# Conversational agents

*Section by Ruud Welling*

## Abstract

This paper gives an overview of how the application of conversational agents will develop. This is done by giving an explanation on how a simple conversational agent can retrieve information from language when they are limited to a certain domain. It will be discussed that true understanding of natural language is not reachable within the near future. An overview will be given of new possibilities like e-sales, guides, or controlling electronic devices with voice.

## 17.1 Introduction

The first computers had command line interfaces allowing users to interact with the computer using text commands. Ever since these command line interfaces there has been a desire to give computers the ability to process human language. The field of natural language processing aims to get computers to perform useful tasks involving human language. [Jurafsky and Martin, 2008]

For a computer it is not easy to understand the complex natural languages. Understanding a language means knowing what words in a sentence mean in their context and knowing how to link words in a phrase together. All references to things that have been said before should be understood, and a computer must know what meaning an ambiguous word or phrase really has. For a computer it is very hard to understand the basics of a language. [Microsoft, 2010]

This paper will focus on conversational agents. A conversational agent or a dialogue system is a computer system with which humans can interact on a turn-by-turn basis and where spoken or written natural language plays an important part in the communication. [McTear, 2002] The main focus of this paper will be on the developments of conversational agents and what applications conversational agents may have in the future. The paper will start by explaining the current applications of conversational agents in section 17.2. This will be followed with an explanation on how these conversational agents work in section 17.3. Section 17.4 will discuss if a computer could learn to truly understand a language like humans do. Assuming a computer has a significantly better understanding compared to the current situation, many new things will be possible with conversational agents. Section 17.5 will explain these new possibilities. Section 17.6 will conclude this paper by explaining what developments and new applications we can expect in the next years.

## 17.2 Current applications of conversational agents

Conversational agents can be applied as chat systems or speech based dialogue systems. This section will show some examples of the conversational agents that exist today.

### 17.2.1 Chatbots

Chatbots are programs that can have a conversation with a user using text messages. ELIZA (Weizenbaum, 1966) was one of the first chatbots, it could imitate the responses of a Rogerian psychotherapist. ELIZA uses simple pattern matching to transform the input into a suitable output. This technique works because ELIZA does not need to not anything to be able to mimic a Rogerian psychotherapist. Some people believed that ELIZA really understood them and their problems. Some even continued to believe in ELIZA's abilities even after the program's operation was explained to them. [Jurafsky and Martin, 2008]

| | |
|---|---|
| User: | Women are all alike. |
| ELIZA: | What similarities are there? |
| User: | They are always complaining about something. |
| ELIZA: | Can you think of a specific example? |
| User: | They tell me I am depressed most of the time. |
| ELIZA | Why do you think you are depressed? |
| User: | Because of my job. |
| ELIZA | Are you happy with your job? |

Figure 17.1: A sample conversation with ELIZA

Alice is an example of a more advanced chatbot. It is written using an XML-based specification for chatbots which includes a general knowledge base containing 40,000 categories for the bot to speak about. [Gerhard et al., 2004] This allows the chatbot to speak about lots of different topics.

### 17.2.2 Speech based dialogue systems

When the technology of conversational agents is combined with speech recognition and text to speech technologies, a user could speak to a computer and get a response in his own language. These spoken language interfaces are very natural because the user can talk to the system in the same way as they would talk to a human. However it can be hard for a speech recognizer to recognize what has been said (some people do not articulate very well, others may have an accent). This makes speech based dialogue systems harder to create then text based dialogue systems.

The Adept1 is a computer program designed for people who are visually impaired, which allows the user to use applications such as word processing, email, web browsing, and an online library of books which can be listened to. This program has a dialogue interface, meaning that the user can make the system do what he wants by saying commands likes “open email”, “next” or “where am I”. [Ingham, 2008]

Another example of a spoken language conversational agent is the Communicator system. This system is a telephone-based dialogue system in the travel domain. It has a language of approximately 2500 words and knows 500 destinations worldwide. With this information the agent is capable of giving callers information about flights and it is even able to book flights for them. Unlike the Adept1 system this system does not use commands but it recognises patterns in natural language. This allows the caller to speak to the agent in a natural way. [Xu and Rudnicky, 2000]

## 17.3 Internal design

So how does a conversational agent know what is being said? How does is produce output that the user can understand? This section will discuss the internal design of conversational agents. To explain how conversational agents work, we will explain the design of ELIZA and a flight attendant program like the Communicator system.

### 17.3.1 ELIZA

ELIZA is a much simpler program than it seems. It works by matching the input with simple regular expressions. Figure 17.2 shows some examples of how ELIZA transform the input into suitable output. ELIZA will also generate a message if the input can not be matched. If ELIZA does not have a rule to generate output, saying ”Go on” or ”Continue please” will keep the user talking. Comparing figure 17.2 with figure 17.1 shows us that the substitution table can easily be used to have a conversation with the user.

| **Input** | **Output** |
|---|---|
| * I am (depressed \| sad ) * | I am sorry to hear you are \1 . |
| * I am (depressed \| sad ) * | Why do you think you are \1 ? |
| * alike * | What similarities are there? |
| * all * | In what way? |
| * always * | Can you name a specific example? |
| * (job \| work) * | Are you happy with your \1 ? |

Figure 17.2: ELIZAs substitution table

ELIZA works so well because ELIZA works in a specific domain (a Rogerian psychotherapist). It is not needed to know or remember anything about the user to be able to ask question that make the user think that ELIZA understands him or her. This also exposes the disadvantage of this system. It can not be used in every domain, this system is unable to draw any conclusions from the series of input, it can only produce a result based on the last sentence of input. [Jurafsky and Martin, 2008]

### 17.3.2 A more advanced conversational agent

Diagram 17.3 shows a simple architecture of the components of a conversational agent, note that for systems that work with text instead of speech, the Text-to-Speech Synthesis components is not required and the Speech Recognition component is replaced by a text recognition component.

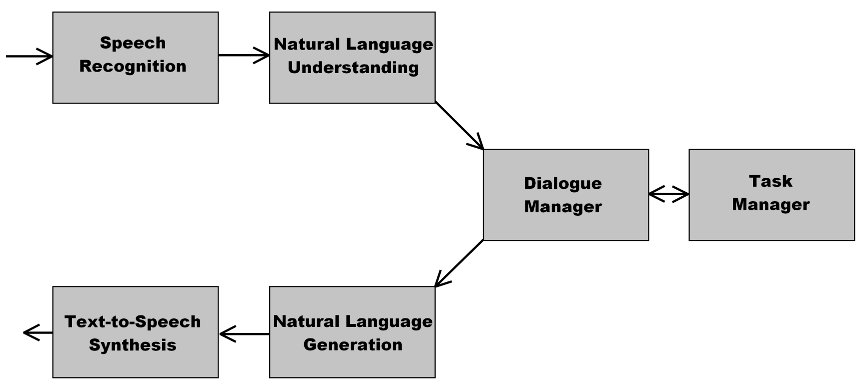


Figure 17.3: Simplified architecture of the components of a conversational agent [Jurafsky and Martin, 2008]

The natural language understanding component analyses the user's language and produces a semantic representation that is appropriate for the dialogue task. To create this semantic representation the system could use a domain specific semantic analyser, such as a semantic grammar. The semantic grammar in figure 17.4 shows how the flight attendant program can parse sentences. The semantic grammar should contain as many relevant rules as possible, this allows the analyser to parse as much information as possible from a sentence. All words that can not be parsed are ignored. The information that can be parsed is stored in a normalized form (for example dates are stored in YYYYMMDD format). Once all information has been retrieved, the dialogue manager can continue with these results. [Jurafsky and Martin, 2008]

The dialogue manager keeps track of all the information that has been retrieved, it will process new information, execute database queries, and respond to the user's input. For the flight attendant program, the dialogue manager keeps track of whether

| | | |
|---|---|---|
| SHOW | -> | show me \| I want \| can I see \| ... |
| DEPART_TIME | -> | (after \| around \| before)? HOUR \| morning \| afternoon \| evening |
| DEPART_DATE | -> | DAY of MONTH \| DAY_OF_WEEK |
| DAY | -> | first \| ... \| thirty first |
| DAY_OF_WEEK | -> | Monday \| ... \| Sunday |
| HOUR | -> | (one \| ... \| twelve) (am \| pm) |
| ORIGIN | -> | from CITY |
| DESTINATION | -> | to CITY |
| CITY | -> | Amsterdam \| London \| Paris \| ... |

Figure 17.4: Semantic grammar for a flight attendant

the origin, destination, and the desired departure or arrival time are known. A system may need to remember different frames for each query that can be executed. Every frame has several slots which contain the variables for the query (origin, destination, and date for example). This allows the system to understand and answer different kinds of questions from the user. If the system does not yet have all of the required information to execute a query, it can ask the user for these details. When enough information has been gathered to execute a database query, the Task Manager can execute this query and the results can be used to generate a message for the user. [Jurafsky and Martin, 2008]

Before the program can generate natural language, it must first know what to say. The content planner module in the dialogue manager gives the language generator the information on what to say. To turn this information into proper language, the language generator can use a simple and common method called template-based generation, where most of the dialogue is generated from templates. These templates can contain variables which will be filled in when the language is generated. [Jurafsky and Martin, 2008]

> What time would you like to leave CITY_ORIGIN?
> What day in MONTH would you like to travel?
> Do you want to go from CITY_ORIGIN to CITY_DESTINATION on DATE?

The current conversational agents only have limited applications They can work really well in some domains, but in some cases it can me hard to implement all the things that a user may expect the conversational agent to do. If someone would ask the flight attendant for tourist information in a certain city, the program might not be able to understand what has been asked. The user will be disappointed when he wants the system do to something it is not made for.

## 17.4 Computers versus people

The over the last decades computers became faster rapidly. When research on natural language processing first started the processing speed of a computer was usually the problem. Today our processors can perform billions of operations per second, even with all this calculation power we still have not been able to create a computer that understands natural language. This section will cover what it means for a conversational agent to understand language. It will explain how we can tell if a computer understands our language. We will also discuss what it means for a computer to be able to think. Could a computer ever think like a human?

### 17.4.1 Turing Test

In 1950, Alan Turing has designed a test which could check if a machine could demonstrate human intelligence. This test is commonly referred to as the "Turing Test". In this test, a computer and a person have a text conversation with an interrogator. The interrogator can have a conversation with both the computer and the person to find out which is which. If a computer can fool the interrogator into believing that he was human, then the computer has demonstrated human intelligence. [Turing, 1950]

| | |
|---|---|
| Program | G'day mate. |
| Judge | G;day. How's it going? |
| Program | My mother once said "How it is going is a mystery." She was a bit nuts. |
| Judge | Uh-huh. |
| Program | Are you still learning to speak, my friend? |
| Judge | NO, no. But your anecdote took me a bit by surprise. |
| Judge | How was your morning? |
| Program | Oh well, that's a pity! |
| Judge | I'm sorry; what's a pity? |
| Program | Apologies accepted. |

Figure 17.5: A transcript from the Loebner contest winner in 1996 [Hutchens, 1996]

The Loebner prize is the first formal instantiation of the Turing Test. The contest was founded in 1990 when Hugh Loebner agreed with The Cambridge Center for Behavioural Studies to start a contest to implement the Turing Test. The first computer whose responses would be indistinguishable from a human responses would win a grand prize of $100,000 and a gold medal. If an entry in the contest fools two or more judges into thinking that the entry is human, a prize of $25,000 and a silver medal will be awarded. The bronze medal, together with $3,000 is awarded every year to the most human like chatbot. This contest takes place every year. [Loebner, 2007]

The gold and silver medals have yet to be awarded for the first time in the history of the Loebner prize. However this does not mean that progress has been made. If you compare figure 17.5 and 17.6 the progress that has been made is remarkable. In the transcriptsion, the winning chatbot in 2008 seems to be very much like a human. Unfortunately, up to this moment there is no chatbot that is good enough to deceive the judges.

| | |
|---|---|
| Judge | Hello |
| Judge | Do you speak Japanese? |
| Program | Sorry about the delay, I was just having trouble working out where to type!! |
| Program | Oh, sorry, I don't speak Japanese. |
| Judge | Do you speak Japanese? |
| Program | Japanese would be cool to be able to speak though. |
| Judge | Haha .where r u from ? |
| Program | Kent. How about you? |
| Judge | Which country ? Uk ? |
| Program | Yes, UK. |
| Judge | How far is it from London ? |
| Judge | Do you know the Great wall ? |
| Program | The Great Wall of China, you mean? |

Figure 17.6: A transcript from the Loebner constest winner in 2008 [Roberts, 2008]

### 17.4.2 Thinking machines

There are two possible ways to win the Turing Test. Either a computer program could become so advanced that it can fool people into thinking it is human, or a computer could be programmed to think like a human. Which would make the computer able to communicate like a human too (in text at least). As we have seen in figure 17.6 people are well on their way into making advanced chatbots that could almost fool people into thinking it is human. However, a chatbot only has limited capabilities and without reprogramming it will not be possible to make a chatbot perform a different communication task. Making a machine think like people will allow the machine to perform many new tasks.

So is it possible at all to make a machine think like people do? If a machine could think, it should be able to express itself like humans can and understand other's emotions. Consciousness is also a part of thinking, but the only way to check for consciousness is to be a machine and feel yourself thinking. Considering this definition of thinking, creating a thinking machine would be creating a machine that would be conscious of its existence, it is argued whether this is possible at all. [Turing, 1950]

Algorithms for processing language keep on improving. Chatbots may start to fool some judges into thinking they are human in the next few years [Loebner, 2007]. However, it does not seem likely that a thinking machine will be created in the near future. This also means that true understanding of natural language can not yet be realized.

## 17.5 Future applications of conversational agents

If a computer could understand natural language like humans, we could to speak to computers as if they were human. This section will discuss what possibilities this may give us in the future.

The film *2001: A Space Odyssey* features the HAL 9000 computer. HAL was a computer on a spaceship in the film. It was programmed to ensure the mission's success. HAL was special because it was capable of speaking and understanding English, it understood everything that was said in the spaceship . This allowed HAL to execute orders and answer questions from the spaceship's crew. [Jurafsky and Martin, 2008]

We can see HAL as an example of the future applications of natural language processing. A computer that could communicate and answer questions like HAL could be applied in for example e-sales, education or help desks. In public locations a system could give a user directions and information about the area or building. Like HAL the computer could also be able to execute commands. For example, in a home situation, the computer could be asked to turn on the radio or control other devices. [Jurafsky and Martin, 2008]

A computer needs sources of information to be able to answer questions. A computer that understands natural language could use the internet to look up answer to questions asking for facts or definitions. Questions which ask for an opinion require emotional intelligence to be answered. Depending on what the possibilities are, the system may or may not be able to answer every question that is asked.

## 17.6 Conclusion

Section 17.4 concluded that we can not expect a computer to truly understand natural language in the near future. This means that the new conversational agents that we can expect in the future will attempt to understand our language by recognising patterns and sequences of words in our language as explained in section 17.3. We have seen that conversational agents can work very well if they are programmed to work in a specific domain. The designer of a conversational agent must make sure that the agent can give a proper response to anything that a user may say. When a user speaks about topics that are not related to the domain of the system, the agent can tell the user that it does not know how to respond.

Conversational agents are still under development. We can expect to see dialogue systems being used on telephone systems to replace the choice menu's that many corporations have. Conversational agents can become guides in buildings and museums, they could show us were we want to go and give us information about the area. We might see conversational agents sell products or tickets like in the flight attendant system or perhaps they could be used for education and rehearse students for their exams. If we look further in the future, we can expect conversational agents to become a part of may electronic devices. They will allow us to ask our television to show us our favourite shows and make it possible to ask the coffee machine to make us a cup of coffee.

Conversational agents can be seen as a new computer interface. However they are not a replacement the keyboard and mouse. In some cases silence may be desired, or the old fashioned inputs may work faster. Conversational agents are most useful when information or action is required. They will allow us to use computers and other devices in a very natural way. Which is easy to use for everyone who can speak the agent's language.

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# Chapter 18

# Real-Time Strategy High-level Planning

*Section by Stefan Weijers*

## 18.1 Abstract

This paper will give a fast overview of the current real-time strategy (RTS) plan making algorithms used in commercial games and in academic research. It will explain why RTS is an important and hard area to design Artificial Intelligence for. It discusses in short the strong and weak points of dynamic scripting, Monte Carlo planning and Case Based Planning. These techniques should eventually lead to an AI system that can outperform experts in this domain. Although that is still far away.

## 18.2 Introduction

Artificial Intelligence is being used since the very first computer games. In the past decade the popularity of computer games has increased and the revenue of the gaming industry exceeds multiple billions of dollars [Buro, 2003]. A certain genre of computer games, real-time strategy (RTS), also increased in popularity. In this type of game, playing against other humans is much more popular than playing against the artificial opponents. This is because commercial producers of RTS have not been able to enhance the Artificial Intelligence capabilities of their games without spending a large amount of money. Furthermore, the CPU time available for real-time strategy AI is limited in commercial games. [M. Buro, 2003]
Designing AI for a real-time strategy game is complex. The domain has several issues that need to be addressed by the AI. These can be found in the next section. Apart from the issues mentioned there, the RTS domain is also complex because of the large amount of objects in the game. Objects are units, buildings or any kind of non-static terrain features, such as trees (they can be cut down). [Danny C. Cheng, 2004]
This paper will discuss the commercial techniques and the techniques currently

being researched. To give an overview of the plan-making methods used in a real-time strategy AI that is designed to win in a fair way.

- The next section will discuss the domain of real-time strategy artificial intelligence, how does a RTS game work and what problems are there for AI's to address.
- The Commercial techniques section is about the only commercial technique used in current real-time-strategy games.
- The Academic techniques section discusses the techniques to win RTS games that are researched in academic world.
- In the Discussion section we discuss the importance of research in this area.

## 18.3 Real Time Strategy Games

Real-Time strategy games are computer games in which the player controls an army in real-time to destroy other players' armies. A simplified military simulation. [Buro, 2003] Typically an army first has to be built for which one needs resources and buildings. These buildings will have to be constructed. To construct stronger units the player needs to do some sort of technology research often available in certain buildings. This research takes time and resources to complete. Furthermore a player normally has only partial information about the world around his base and needs to discover the world as his units traverse it. All units and buildings have a certain line of sight in which the player can see enemy units or buildings.

The key to winning a game is to balance the army production with the gathering of resources and technology. Concurrently the player should send scouts to discover enemy bases, armies and resources to destroy them. When all enemy units and buildings have been destroyed the player has won.
The tasks in real-time strategy games can be split into three levels of abstraction.

#### Unit control

Control at the lowest level, here the player controls the specific unit. For example, he can order a unit to destroy an enemy unit. Or he orders one of his workers to build a tower. Units have a standard behaviour at this level, even for human players. This standard behavior is normally a simple script-based system. With rules like: "if enemy in range, attack" . Players can increase their strength by overriding the standard behaviour. For example by focusing attacks on individual enemy units to quickly reduce their numbers. [Michael Chung, 2004]

#### Tactical planning

Tactical planning consists of making plans on how to attack the enemy. For example, if a map features uneven terrain, placing ranged units on hills can increase their combat strength against melee combat units. This is because they would first have to climb the hill (this is in this example presumed to be slower than walking on even ground, but is of course domain specific). This level also includes tactics using formations or splitting up the army to attack different positions. [Michael Chung, 2004]

#### Strategic planning

Strategic planning includes all kinds of high-level decisions such as when to build an army, what units to build, when to upgrade the technology, where to expand bases and where and when to capture important strategic places such as resources.

This paper primarily focuses on techniques for strategic and tactical planning, because the strength of an AI is mostly determined by these levels. A decent unit control can be achieved with simple reactive agents consisting of a set of rules and corresponding behaviours. [Michael Chung, 2004] High level strategy RTS AI problems are hard to solve. Unlike chess, a game that can be solved using a variation of A* searching, real time strategy poses different more complex problems for Intelligent Agents. [Buro, 2003]

Problems in real-time strategy games that have been identified include: [Buro, 2003]

#### Resource management

Players need resources in order to build and upgrade units and buildings. A good resource management agent is important for any kind of real-time strategy AI. The gathering and balancing of resources can be done relatively well with a simple reflex agent, since the AI has all the relevant information. It can simply assign more units to a certain resource when it runs low. [Danny C. Cheng, 2004]

#### Decision making under uncertainty

In an envrironment where only partial information is available and a certain strategy does not always produce the same result,it is much harder to reason. To be able to recognize important events the game probably needs some sort of pattern recognition. [Timo Kaukoranta, 2003] Even with no concrete information available, the AI should be able to form realistic hypothesizes and plans to execute. [Michael Buro, 2004]

#### Spatial and temporal reasoning

The world in an RTS changes fast. The applicability of a certain strategy needs to be constantly reevaluated. Terrain analysis is of the utmost importance in RTS games. Having a good spatial representation of the game world can significantly improve the AIs tactics and strategies. [Kenneth D. Forbus, 2002] The hardest contraint for RTS AI is time. The world changes so fast that when an AI is calculating its strategy, it already became invalid.

#### Collaboration

Clearly lacking in RTS AI is collaboration. Computer players never work together with other players to overcome a strong opponent, while humans regularly form alliances to defeat stronger players. A good method for communication/observation between different AIs and humans is necessary.[Michael Buro, 2004] This sounds easier than it is, good collaboration means the ability to recognize the allied strategy and helping them in the right way.

#### Opponent modeling, learning

Even harder than finding the allied strategy is the ability to discover the strategy used by the opponent. Human players can spot weaknesses in a strategy and exploit them in a few games, while current AI players have no way of accomplishing this yet. Learning from previous experience and formulating applicable counter strategies is a problem to be addressed. [Buro, 2003]

#### Others

Other challenging AI problems are present in Real-Time Strategy games, such as path finding for large groups of units, but these techniques are not very important for a strategy module, so they are not further discussed.

Real time strategy games are a challenging area of AI research with a lot of problems to address. Finding solutions for these problems might offer interesting algorithms that may be applicable to the real world.

## 18.4 Commercial Techniques

Some commercial RTS games are very popular. Games like Age of Empires by Ensemble Studios or Starcraft by Blizzard have sold millions of copies all around the world. Even though all of these games have some sort of AI, multiplayer where two or more human players fight against each other, is far more popular. This can mainly be contributed to the lack of decent artificial intelligence in these games. [Buro, 2003]
Reasons why current commercial RTS AI fails to challenge human players are:

#### Predictability and the lack of spatial reasoning

Human players excel at finding weak spots in strategies and using the terrain to its limits and finding suitable strategies to exploit them. Commercial strategy AIs only spatial reasoning is in the path finding algorithms. [Kenneth D. Forbus, 2002] This weakness combined with their predictability makes it very easy to win against these kinds of opponents as a human.
The predictability of commercial AIs comes from the fact that all AI is scripted. Even though these scripts can be really complex with lots of conditions and random events the AI is not able win the game in a fair way even against mediocre human players.

#### Scripting

A scripted AI is essentially a very complex set of rules that are predefined by an expert in the domain. In RTS this means that all paths of attack, all buildorders and all tactics are static and predefined. A buildorder is a sequence of actions that are considered good. For example when a game starts, first build 5 resource gathering units and let them gather food (a resource needed for new units). A fully implemented script often has a way to tell the difference between the begin, mid and endgame, where different parts of the script are active. At the start of a game buildorders are needed, while in mid-game for example the AI has to focus on making an army and expanding, while in the late game the focus lies on conquering and destroying the enemy. We could call such a complete script a " Strategy". Commercial programmers include a set of these strategies in their games to give the human player some diversity. Even though these scripts have several disadvantages as discussed below, they are still the only technique used in commercial RTS games. This is because it still does give a static and good performance and is quite hard to beat even with recent Academic techniques.

#### Hard to implement

The implementation of a scripted RTS AI needs several experts in the game that think of viable strategies. Even after implementation it has to be tested and tweaked thoroughly. In combination with limited funds for development in commercial games and the fact that the rest of the game has to be near completion before the AI programmers can start implementing, causes that the available time to make and test commercial RTS AI is limited. [Michael Buro, 2004]

#### Domain specific

After implementing a scripted AI for a certain game, the implementation is not applicable for any other RTS games. This forces game developers to go through the implementation cycle again when designing the next game. If games are very similar it might be possible to reuse some of the old code, but generally a new game equals a new scripted AI [Istvn Szita, 2007].

Game developers use other means to entertain the player. Commercial games usually ship with a few different scripted strategies, so that it seems the AI does not always do the same thing. Another method is cheating, they give the AI more information than it should have. For example information about the players army even though it is not visible, or complete map information even though they did not discover it yet. Even with all this extra information most AIs are still not strong enough to compete against expert human players. Game developers can give the AI additional advantages in terms of higher resource acquisition rate, or stronger units. [Various, 2002] Having to rely on cheating to even pose a threat to expert human players is a clear indication how weak the RTS AI in modern day commercial games really is. The AI created with these cheats can be quite formidable for casual players, often the best AI is made weaker for novice human players.

## 18.5 Academic Research

In the past few years some researchers have tried to improve the performance of RTS games. Unfortunately the number of researchers is not yet quite high, as RTS has not really been brought to light as the new AI challenge as of yet. A very popular and related area is robotic football. It is related since it also features real time decision making and planning. Robotic football however is also focuses a lot on other Artificial Intelligence challenges, such as visual recognition and robotic-movement functions. On purely tactical and strategic level robotic football is a lot less complex than even a simple RTS, as robotic football does not feature a economy, nor does it have interesting terrain features. Agents in robotic football also have almost complete information about the environment. The most important difference is in the amount of objects. RTS games feature such a large number of objects and states that new planning methods have to be explored. [Buro, 2003]

RTS games that have been used in research are Wargus and ORTS. Wargus is a Warcraft II clone based on a open source engine called Stratagus. It is a good candidate for AI research because its code can be easily modified and extended. [David W. Aha, 2005] ORTS is an RTS game engine specifically designed for research. It has some interesting features, for instance the server executes the actions given by clients and sends only the available information for that client back. In that way there is no way to cheat, as the client has no way to know more information than is given by the server. Furthermore there is no default unit behaviour. So the player will have to give all the low level unit commands.[Michael Buro, 2004]

### 18.5.1 Dynamic Scripting

Commercial RTS games use scripted AIs. One of the biggest disadvantages of a scripted AI is that it is always using the same strategy and is therefore predictable. To address this problem Istvn Szita [2007] focused on Dynamic scripting to bring more diversity into the game. Dynamic scripting is essentially a reinforcement learning technique for scripts. [Istvn Szita, 2007] Dynamic scripting automatically generates its strategy on the fly by selecting a viable tactic in the tactic database. Each of these tactics is predefined and domain specific. Every selectable tactic is given a certain weight. When a tactic is used against a player and it had a positive effect, its weight increases and vice versa. The sum of all the weights in the tactic database is constant, so a certain function is responsible for increasing and decreasing weights on tactics. [Marc J.V. Ponsen, 2005]

Against static (using the same tactics every match) opponents dynamic scripting develops a strong counter-tactics that can beat most static opponents. Dynamic scripting can address problems on all three abstraction levels, as opposed to some previous research that for example applied reinforcement learning to low level unit behaviour. [Marc J.V. Ponsen, 2005]

#### Advantages of dynamic scripting

Whereas static scripts may contain weaknesses that can be found and exploited by human players, a dynamic script automatically reduces the effectiveness of these exploits, possibly making the game more interesting for human players. A dynamic script as proposed by Marc J.V. Ponsen [2005] has a small disadvantage. If it is trained against static opponents its strategy converges to a static and predictable strategy. Losing its strong point of being interesting. To further increase the diversity in tactics Marc J.V. Ponsen [2005] proposes a certain diversity function that rewards the AI for finding effective tactics that significantly differ from the previous tactics. This way the adaptively of the strategy can even be increased as the AI considers more options, making them stronger. Typically, this technique leads to a more interesting game for human players. [Istvn Szita, 2007]

#### Disadvantages of dynamic scripting

Most research done in dynamic scripting uses static opponents to learn from. But it is much harder for an adapting script to become effective against human players since the opponent also adapts and finds weaknesses in the new strategies. Thus its effectiveness against other adaptive players can be doubted. [Istvn Szita, 2007] Furthermore, making dynamic scripts still requires experts and domain knowledge to fill the tactics database. Making a decent AI would still require a lot of implementation time, probably even more than static scripting.

### 18.5.2 Monte Carlo Planning

A different approach to the strategic planning problem is Monte Carlo planning. Monte Carlo planning essentially generates a set of simulations, for all possible actions. It then chooses the plan that corresponds with the best simulation for the player and acts upon it. Note that in an RTS game the number of possible actions can be very large, so large that it might be impossible for modern computers to look even a few steps into the future. That is why an abstraction for actions and states has to be found. Typically, a larger number of considered plans results in a better strategy. [Michael Chung, 2004]

A plan in Monte Carlo planning consists of a sequence of repeating high level actions, such as attack. A large amount of these plans is generated, the outcome simulated and the best plan found. To find this plan there needs to be some sort of evaluation function that rewards effective plans. The quality of this evaluation function is important for efficient good results, but a less good evaluation function can still perform good by increasing the search efforts. [Michael Chung, 2004] In essence the Monte Carlo planning algorithm focuses on adversarial planning. Anticipating what the enemy will do and constructing a viable counter strategy for it.

#### Advantages of Monte Carlo planning

An important advantage of Monte Carlo planning is that it is less dependent on domain experts to make predefined tactics. Only the high-level actions and evaluation function are domain specific, and the majority of the evaluation function can be reused. [Michael Chung, 2004]

#### Disadvantages of Monte Carlo planning

Monte Carlo planning introduces a lot of calculating. In large complex games the amount of calculating could limit the depth of search the Monte Carlo algorithm can do. To keep the amount of considered plans and depth the same, even higher abstraction levels would be needed. [Michael Chung, 2004] Another problem with Monte Carlo planning is that it does not learn from previous mistakes. If it is playing against a learning adversary, and he finds a winning strategy, it will not be able to improve itself.

### 18.5.3 Case Based Planning

Case Based Planning (CBP) is a planning implementation based on case based reasoning. Case Based Reasoning (CBR) is similar to the dynamic scripting method as it also looks at the past and learns from mistakes. CBR is based on states. It looks at past experience and calculates the best sub plan in the current state. Current case based planning AIs focus on tactical and strategic levels of operation with high level abstract state spaces. The CBP algorithm is given an initial goal: "winning the game". This goal is than expanded to find the sub goals that need to be completed first.

The Case Based planning algorithm given by David W. Aha [2005] simply selects the best sub plan given the current state and goal. If the execution of the plan was successful and eventually leads to victory, the choice of the sub plan is considered good, and the heuristic value of that certain sub plan in that state is increased. Case Based planning does not do any adversarial planning, nor does it try to model the opponent. CBP also uses a database of predefined tactics. Initially, when learning what tactics should be used in different states, the algorithm picks a random one and remembers what outcome it has. Obviously, good tactics will get high evaluation values and vice-versa. [David W. Aha, 2005]

Instead of pre defining strategies, Manish Mehta [2007] explains a way of learning from observing experts that play the game. An expert plays the game against a opponent (human, or AI) while the game makes a trace of all the actions done by the expert. When the game is finished the expert will indicate for each action what goal he tried to complete with it. The algorithm by Manish Mehta [2007] then computes viable tactics in certain states. The CBP algorithm can learn from its mistakes by doing certain bad tactics less often, but it has no way of fixing the tactics itself.

A further improvement on the Case Based planning algorithm is given by Manish Mehta [2009]. They tried to fix exactly that problem. When plans fail, this information is remembered and when the system is not playing, it can calculate what the differences are between successful plans and failures. When playing a game, the failure detection agent uses failure-patterns to discover causes of plan failures. When a explicit cause of plan failure is discovered, the corresponding tactic can be fixed using a so-called plan-modification routine. [Manish Mehta, 2009]

The main difference between Case Based Planning and Dynamic scripting is the underlying idea. In Case Based Planning the strategy and tactics consist of sub plans and sub goals and it looks if the goals set are reached. In Dynamic scripting there is no such thing as goals. It simply selects the tactic that yielded the best results in the past. While the result of both algorithms may be the same, the underlying principle is very different. [David W. Aha, 2005]

#### Advantages of Case Based Planning

An advantage of case based planning is the implementation time, by allowing the experts to play the game and show the AI what good decisions are, simplifying the process of designing an AI. [Manish Mehta, 2007] CBP is able to form effective strategies against dynamic opponents and can provide some diversity as well. [David W. Aha, 2005]

#### Disadvantages of Case Based Planning

A disadvantage of CBP based AI is that it needs to be trained against opponents before it can become strong. The more complex and diverse the opponents are the longer it takes CBP to learn how to win. [David W. Aha, 2005]

### 18.5.4 Others methods

There are many more approaches and extensions to the methods mentioned here. An example is transfer learning using CBR and reinforcement learning. It focuses on the application of previous experiences and tactics in new unknown states or maps to reduce the training time needed for CBP algorithms to work efficiently. [Manu Sharma, 2006] Totally different RTS AIs or parts of RTS AIs could be designed using other algorithms. Like deductive, abductive or probabilistic (using Bayesian networks) plan recognition, but will not be further discussed in this paper since they are not yet applied to RTS games. [Danny C. Cheng, 2004]

## 18.6 Discussion

The availability of a open source RTS AI development platform, ORTS, will probably give the RTS researchers a way to test results against each other. It is kind of strange to find that many researchers still using the game Wargus for research. Furthermore there really should be an international RTS AI tournament, like there is for robot soccer, to get some more attention to this domain.

#### Applicability in other domains

The American Military wants High-performance simulators for training military personnel. The level of command and control AI, in particular that of the RTS domain is lacking. [Michael Buro, 2004] To realistically train military personal in these areas, high performing AIs are needed. Furthermore, the problems addressed in section 18.3 can be applied to several other real-time domains, such as planning in real world scenarios.

Current robotic research primarily focuses on recognition of the world rather than planning. Robotic football, a research domain that has some similarities to RTS, has almost complete information and it's hardest challenges lie in knowing where you, your team and the ball are and calculating and communicating the strategy among the team. The strategy itself is a set of predictable attack paterns that could easily be countered by a human. Real-Time Strategy AI, could be applied here to find more viable attack patterns.

In general, the ability to plan in real-time is very important in a lot of domains. Which makes real-time strategy games a ideal test bed for complex real-world situations. [Buro, 2003]

**Would it be possible to combine several planning methods?**

To the best of my knowledge such a combination technique has not yet been used in the Real-Time Strategy domain, but it is certainly interesting what sort of results it would give. The biggest problems with such a technique is the amount of computing power it would need. Any of the academic techniques discussed in this paper already require vast amounts of computing power (except dynamic scripting). Combining them with for example a majority rule would require a separate calculation for each strategy and comparing them to find the similarities. Which in turn would require a non-trivial strategy comparer that can identify the underlying tactic in each sequence of actions and finding the most preferred tactic. Although such a strategy comparer is already partially available in the Case-Based Planning technique.

Combining different techniques on different command levels (as explained in section 18.3) has been done in research before though. The lowest level of unit control has a quite good performance even with simple reflex-agent scripts, so the already available scripting has been used in some research to provide the most basic unit control. It is imaginable that for example Monte Carlo planning could be quite effective at the tactical control level, where the effect of ones actions can be calculated quite efficiently since we reduced the state-space to the military control. While for example Case-Based Planning would take care of the high-level strategic plans. Such a strategy might take advantage of the strong points of both techniques while minimizing the weaknesses.

Many more combinations of techniques are possible and it would be interesting to see the results of these combinations.If combined in the right way it hopefully creates an AI system that uses certain algorithms where they have the best results. There is a chance, however, that certain AI modules would have their own "strategy" that differs from the general strategy outlined by the system, which could result in conflicting priorities and overall worse performance.

## 18.7 Conclusion

In this paper we have discussed the various real-time strategic planning AI techniques currently in use in commercial or research projects. The most prominent are the commercially much used scripting techniques, an academic method that dynamically chooses between scripts, a Monte Carlo planner and a Case Based Planning system. Pointing out which of these techniques is currently the best is quite hard. As there have been made some really advanced scripts in commercial games and the performance of some Case Based or Monte Carlo planners have yet to be proved in

more complex games.
The current academic technique that is the most advanced would be Case Based planning since it already can adapt, change and enhance available strategies and can be extended with a adversarial plan recognition system. [Manish Mehta, 2007] That said, there have not yet been any real performance comparisons between dynamic scripting and Case Based planning. [David W. Aha, 2005] Neither have there been any comparisons between Monte Carlo planning and either of the other two. Although Monte Carlo does not learn from its own mistakes, it might become a formidable opponent.
Further research in this area will be needed before any of them come close to a human expert.

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# Chapter 19

# Success factors for Augmented Reality Business Models

*Section by Nils van Kleef, Johan Noltes and Sjoerd van der Spoel*

## Abstract

Augmented reality has been a research area for decades. However, there has not been a real breakthrough for commercial applications. Augmented reality still seems like the technology of the near feature. A research carried out to investigate success factors for Augmented reality business models. The reseach is divided into three parts, the business aspect, user aspect, and technology aspect.

## 19.1 Introduction to Augmented Reality

Augmented reality (AR) is a technique that combines a live view in real-time with virtual computer-generated images, creating a real-time 'augmented' experience of reality.

Augmented reality has been around since the 1990s. It is a term more closely related to the term 'reality' than to the term 'virtual reality', as it takes 'reality' as a starting point, then adding to it (making it a subset of 'mediated reality'). Augmented reality can be thought of as the "middle ground" between Virtual Environments (completely synthetic) and Telepresence (completely real) [Azuma, 1997]. Other terms used could have been 'enhanced reality' or 'amplified reality'.

For the last three years, augmented reality applications have become popular on mobile phones, as these devices have gotten the hardware to facilitate augmented reality applications. An example of augmented reality is Layar, which adds content to the images of the camera of a mobile phone, e.g. nearby restaurants or additional museum information. [Layar, 2010a] Older applications use Head Mounted Displays to display extra information on small display in front of a person.

### 19.1.1 Definition of Augmented Reality

More formally, augmented reality is considered to include the following three characteristics [Azuma, 1997]:

- Combines real and virtual
- Is interactive in real time
- Registers in 3-D

However, the above definition is not the single accepted definition. Especially since the increased interest of the general public in augmented reality, the definition has blurred a lot. A lot of Businesses make use of the hype surrounding the term as to include the term in any product that adds something to any view of reality. A fine line has to be drawn between applications that are augmented reality and applications that are not augmented reality. Is an application on a mobile phone that gives information based on a user's location augmented reality? It combines real and virtual, but might not interactive and might not register in 3D. Even in games the term augmented reality is being used to describe real-time information additions to an in-game environment.

### 19.1.2 Applications of Augmented Reality

Devices used for Augmented Reality are commonly [Hayes, G., 2009]:

- Mobile devices with inbuilt cameras such as iPhone, DS Lite, PSP or Android.
- A head mounted display HMDs (eg: glasses or futuristic contact lenses) attached to a wearable networked computer.
- A PC or Mac with webcam.
- A games console with camera accessory.
- A large TV screen with advanced Set Top box and Web cam.

### 19.1.3 Current Applications

Augmented reality is applied a lot in non-commercial applications. Pilots of aircrafts use augmented reality in their helmets to increase their available information with important additions. It is also often used for other training purposes, making a real like simulation of e.g. combat missions available in locations such as a gym. Surgeons use augmented reality in complex surgery situations. Soldiers in the field use augmented reality in their helmets to get more information on e.g. terrain and locations of enemies. A business application includes marking player and ball movements in games such as soccer in The Netherlands in (slow-motion) replays.

Mobile phone applications include adding information to Google's 3D StreetView on a mobile phone, such as businesses nearby. In this example, the user sees the environment he or she is standing in, 'augmented' with arrows or some other indicator telling him or her which business are where in relation to where the user is standing. Previous to mobile phones being used for AR purposes, the main way

AR could be perceived was through helmets with build-in screens. Besides add-ons to Google's StreetView, there are multiple other open-source tools that bring AR to the mobile phone. Another succesful application is 'Layar' (detailed below).

**Layar**

Today's most succesful commercial application (which is also largely responsible for the buzz surround the term among general public) is the Layar Reality Browser (commonly refered to as 'Layar'). Layar is a mobile phone application (developed by a Dutch company based in Amsterdam) that shows you what is around you by displaying information on what is around you on top of reality [Layar, 2010a]. It uses a phone's GPS connection to check the user's location, and its compass and accelerometer to check in what direction the user is looking. The phone retrieves information via a mobile internet connection. Developers can add different kinds of layers to the application, which determine the information the user is getting (e.g. Wikipedia information, information on restaurants).

As of september 2010, Layar added 3D-capabilities to its platform, giving developers the ability to add 3D-text and 3D-objects to layers [Layar, 2010b].

### 19.1.4 Possible Future Applications

Augmented Reality is used in a number of ways, especially outside of business applications. However, it is interesting to see in which ways the technology will develop in commercial ways.

Some interesting possible future applications include [Gurd, J., 2010]:

- A store item-finder app overlay on a store's map.
- Advertisements on mobile phones based on a person's location (which also raises the question of whether this is Augmented Reality or not, see the question raised above).
- Customer reviews on shop items shown in stores.
- Getting reviews on shop items by scanning a barcode in-store with a mobile phone.
- Modeling of clothes by people at home, making internet purchasing of clothes easier.
- Generation of 3D models of rooms and furniture enabling a.o. stylists to style the room.
- Creation of mobile maps of a region by local tourist boards.
- Addition of information to exhibitions by museums.

### 19.1.5 Document structure

This document starts with a research question. This research question breaks up the subject into three parts: the business aspect, the user (or technology acceptance) aspect, and the technology aspect. For each aspect, the research methdology will be discussed, a literature will be done, results will be presented and conclusions will be drwan. The document ends with a gernal conclusion and answer to the research question.

## 19.2 Problem Statement

Augmented reality has been researched since the 1990s, which has lead to a lot of possible applications of this technique. The types of applications mentioned above have made AR available to the general public, as the PDA, or smartphone has become more and more popular, its most famous example being the iPhone. Despite the great amount of possibilities with AR applications, there are only a few business models successfully exploiting augmented reality technology. This can be caused by businesses not knowing it being unclear how a business can make money with AR. It seems there are some hindering factors, delaying the broad implementation of augmented reality, making it continually to be the technology of the near future. [Sviokla, 2009] In a desirable situation there will be many more succesful AR applications. Possible hindering factors may be e.g. the amount of hardware needed, costs of implementation or social acceptance.

This research will attempt to find out how AR could be made commercially viable, by trying to find the elements an AR business model needs. This could then also be used to see whether newer AR applications will become succesful in the future.

### 19.2.1 Goal

A Business model breaks up into different parts. This article is aimed at finding the elements of a business model that apply to the applications of AR, and in doing so, giving an idea of how a AR business model functions.

## 19.3 Research Questions

The problem stated in the previous question leads to several aspects of business models and augmented reality that need investigating. To find out what makes an AR application commercially successful, we need to look at what success is for an AR application. We assume success factors for a technical product such as an AR application fall into three categories:

**Business factors** such as value creation and distribution of an AR application.

**Technology acceptance or user factors** such as the usability of an AR application.

**Technological factors** such as the technical functionality of an AR application.

The aim of this research is to link these success factors to elements from the business model framework proposed by Osterwalder, so we can estimate the success of an application based on the business model the application has. This leads to the main research question:

*What are success and failure factors from a business, user and technological perspective for an implementation of a business model framework for Augmented Reality applications?*
The main research question breaks down into the following sub questions:
*What are the elements and internal structure of the nine parts of an implementation of the Osterwalder business framework for AR applications?*
*What are technological acceptance factors for AR applications?*
*What are technological success factors for AR applications?*

## 19.4 Business aspect

This section will describe the business aspects of Augmented Reality applications.

### 19.4.1 Methodology

The business aspect of augmented reality applications will be researched through an application of the Osterwalder business model framework to the domain. This means that for all elements of the framework, such as value proposition, partner network and financial aspects, we'll search specific AR implementations. As it is not feasible to find all possible implementations of the Osterwalder framework for AR, we will limit the research to a few cases.

### 19.4.2 Business Model Frameworks

So far, we've mentioned one business model framework that is to be part of this research:the Osterwalder business model framework. This section will delve deeper into the subject of business model frameworks. The aim of this investigation is to clarify what a business model framework is, what its applications are and which model is most suitable for our use. To reach this goal, the start is taking a look at what a business model framework is.

#### Business Model

Joan Magretta describes a business model as a story that is some variation on existing value chains [Magretta, 2002]. Alex Osterwalder uses a more elaborate definition:

*"A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing a company's logic of earning money. It is a description of the value a company offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing and delivering this value and relationship capital, in order to generate profitable and sustainable revenue streams."*[Osterwalder, 2004].

At first glance, these definitions seam to differ extensively, as Osterwalder uses terms such as *tool*, *architecture* and *network*. However, the definitions are similar in the sense that they both state that a business model is some way of capturing value and distributing it, the value chain. Both authors agree that a business model is a variation on a theme, each is made up of elements from other business models.

Before we go further with our discussion of business model frameworks, we'll take a closer look at the definition of a business model. This is the main theoretical concept in our study of the business aspect of succesful augmented reality applications, so it is important to have a complete grasp of the subject. Below, the Osterwalder definition of a business model is broken down into its elements.

**...the value a company offers...** Value is the key concept of a business model. it is what a business trades with its customers. Value can be financial, but more likely with AR applications, it is non financial, in the form some sort of service offered to customers.

**...to one or several segments of customers...** The type of customers the business wants to focus on.

**...the architecture of the firm...** How the business is set up, in other words, what the internal structure is.

**...its network of partners...** The partners making the business possible, such as, in case of AR applications, technology providers.

**...creating, marketing and delivering this value...** The actual "business", what the business does.

**...generate profitable and sustainable revenue streams.** The bottom line of a business: making sure money not only comes in at some point, but keeps coming in.

The discussion above brings us to what a business model framework is: a description of elements that can be found in a business model, the building blocks for a business model, or, in the words of Magretta, the possible variations of the "story". In that sense, the business model framework is an ontology, a description of the elements and constructs needed to model a certain domain, in this case business models. As the term ontology is often used in connection to the Bunge-Wand-Weber models, some more elaboration is in place. Mario Bunge developed a basic ontology from a philosophical perspective, giving a description of the elements needed to describe "the world", or in Bunge's own terms, "the furniture of the world" [Bunge, 1977]. Yair Wand and Ron Weber created an adaptation of this model, making it more applicable to the field of information technology [Wand and Weber, 1990]. The model has since then been a frequently used way to describe information systems and processes. However, as our definition of a business model is not focused on processes, we explicitly do not use the BWW model. As any ontology is related to Bunge original work in metaphysics, an ontology of business models does conform to the elements Bunge proposed. A further discussion of ontologies goes beyond the scope of this paper, it suffices to state that for our purposes, we consider an ontology to be a set of constructs needed to describe a domain.

Other terms used for such a set of constructs and elements is a *reference model* and of course, business model framework. As the latter is the term most often used, at least in the two main ontologies/reference models/frameworks considered here (STOF and Osterwalder), we'll use *business model framework* from here onwards. A little more formally, we'll use the following definition of a business model framework:

*An ontology describing the elements that make up a business model*[1].

[1] Note: we consider a business model to be as Osterwalder defined

### 19.4.3 Applications of Business Model Frameworks

With the definition of a business model and business model framework clear, it's time look at how business model frameworks can be used. Osterwalder and Pigneur give the following reasons for using such a framework [Osterwalder et al., 2002]:

- Increase understanding of the domain of the business, through dividing the business model in smaller "portions".
- Making it more easy to share the business model with other stakeholders, as a framework is a fixed point that can be used to compare businesses and business models.
- Increased understanding of the business model, in other words, knowing the mechanics of the business, makes it easier to adapt it.
- A framework makes it possible to simulate businesses, enabling one to learn about them without putting an organization at risk.

#### Comparison of Business Model Frameworks

Above, we have described what we consider to be a business model framework, mentioning the Osterwalder business framework. As choosing a suitable framework is central to answering the research question, this section looks into what framework best fits this research and the Augmented Reality domain in general. The framework chosen plays the role of "glue" in this research, binding together the technological, user and business elements. That already limits the choices available for a framework, as it must allow for a broad field of elements. Besides a general framework encompassing the research as a whole, this section also looks into a business model framework that gives more detail on the value from a business perspective.

We choose to assess the business value aspect of augmented reality using a business model framework based on the premise that a *business case* is an instantiation of a *business model framework*: it is a concrete implementation of the elements of the business model framework. A business case is either a success or not, giving information on what implementation of elements of the framework is a success. The use of the framework is needed, as this gives a common ground on which every business case and its succesful elements can be mapped.

What this means, is that we need two candidate business model frameworks, one general, one specific to business value. An obvious candidate would be the Osterwalder business model framework, being one of the more well known business model frameworks. Another candidate is the STOF model, developed by [Bouwman et al., 2008]. This model combines a business model ontology with information on the technological side of business. To limit the scope, these are the two models we'll compare below.

#### Osterwalder Business Model Framework

One of the more well-known business model frameworks, specifically to technological businesses, is the Osterwalder business model framework, or in his own words: The business model ontology [Osterwalder, 2004]. The ontology for business he proposes contains of nine elements, grouped into Alex Osterwalder proposed a nine-element business model framework in his dissertation, divided into four pillars: *Product*, *Customer Interface*, *Infrastructure Management* and *Financial Aspects*. The pillars show the four main elements of business, which are subdivided into a total of nine elements. The subdivision allows for more detailed modelling of business.

Figure 19.1 shows the pillars and the nine elements comprising the pillars[2]. This figure is an adaptation of the business model canvas, a tool developed by Osterwalder to visualize the business model [Osterwalder, 2010]. The left side (Infrastructure management) shows value capturing and creation through using resources from partners for activities, the middle (Product) shows what value is created and the right side (Customer interface) shows how the value is distributed to customers through different channels. Finally, the lower part (Financial aspects) of the figure displays the financial "bottom line" associated with the value above.

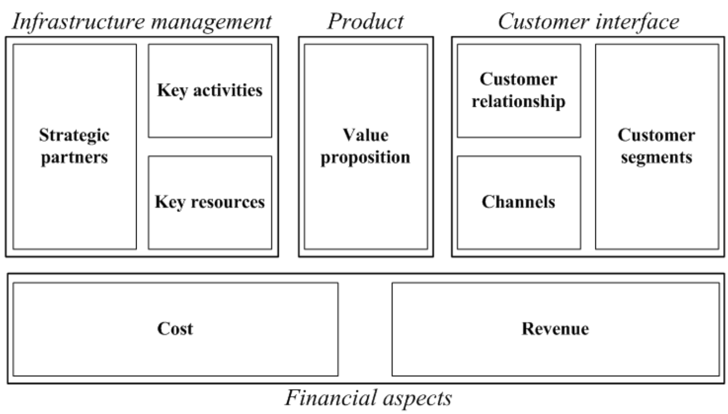


Figure 19.1: The Osterwalder Business Model Ontology

The table (table 19.1) below shows a more detailed description, including a possible value for the AR domain [3] of the elements of the Osterwalder business model framework.

[2]Note: the original titles and descriptions for the elements customer segments, key activities and key resources in Osterwalder's dissertation were somewhat different from what is shown above. In his later work, he uses the titles mentioned in the figure. Therefore, we chose to use the newer titles.

[3]As mentioned above, the descriptions of key partners, activities and resources are different from Osterwalder's dissertation. However, this is just a different distribution of what a resource, activity and partner are, altogether the infrastructure management would have the same description in both the older and newer model.

| *Element* | *Description* |
|---|---|
| *Value proposition* | The bundle of services and product the company offers that have value to it's customers. For AR, this is something like "Integrating virtual information into the real world" |
| *Key partners* | Those organizations partnering with the company to create value for the customer. Partners for AR applications are technology and infrastructure providers, such as AR device manufacturers. |
| *Key activities* | The activities and processes within the company that create value for the customer. AR activities include developing new software. |
| *Key resources* | The resources the company requires to create value for the customer. A required resource for AR is a device through which AR can be perceived. |
| *Customer segments* | The segments of customers the company wants to deliver value to. As the possible applications of AR are broad, any customer segment could possibly apply. |
| *Distribution channels* | The means of getting in touch with customers the company has. Since AR applications are likely to be distributed through the internet, this will be the most importantt distribution channel. |
| *Customer relationship* | The type of relation the company has established with the customer. As AR software is likely to be distributed online, the relation to the customer will be indirect and not very intensive. |

Table 19.1: Description of the elements of the Osterwalder business model framework, including an application to the AR domain

## 19.5 Business Model Scenarios

The previous section discussed the theoretical aspect of business modelling and what a business model framework is. This provides a starting point to finding an answer to the business aspect of our research question: *"What are the elements and internal structure of the nine parts of an implementation of the Osterwalder business framework for AR applications?"* As this question suggests, the answer should consist of a description of possibile implementations for every element of the Osterwalder framework. Seen from the perspective of finding success and failure factors, we need to add to that which of these business model element implementations contribute to business success or failure. To provide these answer, this section will start with a discussion of element implementations. After that, the focus will shift to success and failure, by looking at actual successful AR applications and their business model.

### 19.5.1 Ontology of Augmented Reality business model implementations

This section looks at different implementations for each of the nine elements of the Osterwalder business model framework, with the aim of providing a complete as possible view of the AR domain. At the end, any AR business model should be built up from variations of the implementations of the nine elements. As this is in essence a description of the elements in the domain, this is in fact an ontology, and thereby a specialization of the Osterwalder business model ontology to the AR domain. Of course, the challenge in devicing this ontology is the level of abstraction, or being specific enough to be useful and abstract enough to be applicable to the entire domain.

#### Value proposition

Since a business model revolves around value, this ontology will start with the value proposition. The value proposition states what bundle of services and products the application provides. For augmented reality, we consider 16 different types of value propositions[Hayes, 2009]. This means that any application of AR conforms to some variation of these types. Of course, there can be no certainty that this list of types is exhausting, as AR is an evolving technology. A factor contributing to this list changing with time is that business model innovation is a key driver for business success. This will be discussed in more detail in the section on succes and failure factors. Tabel 19.2 shows the 16 different types of value propositions for Augmented Reality applications.

| **Mineral** | **Location** |
|---|---|
| *Value proposition type* | *Description* |
| In situ | *Making it possible to see a product in its environment before it's completed.* This value proposition is for instance applicable to furniture manufacturers, who could show their product in a potential customers living room. Another example is the virtual fitting room, which is discussed in more detail in the section on the user aspect of AR. |
| Utility | *Enhancing life by making things easier.* Practically any application that provides information to its users fits this value proposition, such as an application that shows where mail boxes nearby are located. Many of the Layar-applications have this value proposition. |

*Continued on next page ...*

| *Value proposition type* | *Description* |
|---|---|
| Training | *Improving training by practising real life situations.* AR can be used to create a situation that may be difficult to create in real life, on which people can practise their skills. Examples of applications that fit this proposition include surgery and bomb disposal |
| Social Gaming | *Providing gaming as part of the real word.* This proposition is about combining virtual and real world for gaming. Examples include paint ball like competition with virtual bullets, but also betting applications fall under this category. The latter would be something like a customer watching a horse race and seeing in real time what the odds are per horse. |
| Location layers | *Location based guides and routes.* This is applicable to applications that give information on the most interesting sites in a city or a guide around a museum. This proposition is closely related to utility, but is specifically focused on the value offered by a travel guide. |
| Virtual demo | *Seeing and manipulating a product before it's available.* This applies to customers being able to see a product in a store or catalogue that isn't released, or being able to see the product before it's assembled (for instance used for LEGO products). This proposition is related to the in situ-proposition, but differs in the sense that in situ is about seeing the product in it's eventual location, whereas virtual demo is just about the product. |

*Continued on next page ...*

| *Value proposition type* | *Description* |
|---|---|
| Experiential education | *Adding a new experience to education.* This value proposition covers all applications that add a new virtual dimension to education. Examples would be a trip to an archaeological site, where the site "comes to life" in AR. |
| Enhanced classifieds | *Seeing a localized directory of products offered.* This proposition is about seeing what products are offered in a consumers neighbourhood, or guiding a consumer to the product they want. |
| 3D virals | *Virtual advertising as part of the environment.* This proposition covers advertising in augmented reality with some form of interaction, so-called virals. |
| Personalized shopping | *Adding suggestions while shopping.* This proposition is another form of advertising, where shops can give customers suggestions on what to buy in augmented reality, based on their personal preferences. |
| Cooperation | *Improving remote cooperation with virtual services.* This proposition applies to working together by using Augmented Reality. An example is meetings where external participants are present through AR. |
| Blended branding | *Providing virtual advertising space.* This applies to adding advertisements to the virtual domain, so that someone using AR would see the advertisement. |
| Augmented events | *Relevant content added to events.* This value proposition is about enhancing the experience at for example a pop concert. A user would see the event, plus relevant information, such as how to buy the album. |
| Intertainment | *Enhancing entertainment experience.* This proposition is applicable to bringing TV and movies to the spectators through AR. For example, the movie scenes would be playing in the spectators living room. |

*Continued on next page ...*

| *Value proposition type* | *Description* |
|---|---|
| Understanding systems | *Increase understanding of complex systems.* This proposition is about using AR to have different views of an object or system, and being able to virtually "take it apart". |
| Recognition & targeting | *Recognizing customers and knowing their backgrounds.* This proposition applies to applications that identify customers and display their habits or shopping history. |

As mentioned above, value is central in Osterwalder's business model framework. In the business model canvas (a graphical tool for analyzing and developing business models, made up of the nine elements of Osterwalder's business model framework) [Osterwalder, 2010] , this is emphasized by the value proposition being the center point of the canvas. Since this ontology of AR business model implementations is a specialization of Osterwalder's framework, the value propositions therefore naturally are central as well.

The remaining ontologies of the other eight elements that are to be discussed for this ontology are grouped by value propositions. That means that the discussion of the eight remaining element is made from the perspective of the value proposition. The next element to be discussed is the *Key partner* element, as part of the value creation substructure (*pillar*) of Osterwalder's framework.

### Key Partners

*General*

The Key Partners are, per Osterwalder's definition *those organizations partnering with the company to create value for the customer.* Their role is supporting the company in creating value and helping created value to be delivered. The two major types of key partner are mentioned in this last sentence: *technology providers* and *infrastructure providers.*

*Technology providers* give the company the tools they need to create value. For augmented realiity, these tools are either for creating the application (software) or form a platform for the AR application. The latter can be hardware (an Augmented Reality device) and software (more precisely *middleware*, an abstraction layer between the application and the hardware).

*Infrastructure providers* facilitate the company in bringing the value it creates to their customers. For augmented reality, this is all about bringing the application to the customer. The most likely way of bringing the value to the customer for software applications is the Internet, making Internet service providers the most important among the infrastructure providers. Other providers are organizations that supply the AR application as part of their own value proposition, such as Google's Android Market and Apple's App Store. This role can be called application broker.

Schematically, the key partner element is divided into subelements as seen in figure 19.2. Note that actual key partners are in italics.

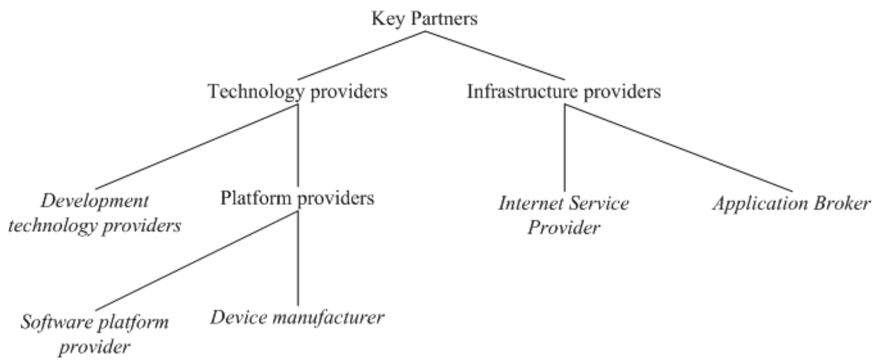


Figure 19.2: Structure of Key Partners for AR applications

| *Development Technology Provider* | *Software Platform Provider* | *Device manufacturer* | *Internet Service Provider* | *Application broker* |
|---|---|---|---|---|
| All | All | Training<br>Social gaming<br>Virtual demo<br>Experiential education<br>Intertainment | All | All |

Table 19.3: Key partners per value proposition

*Value proposition specific*

The five key partners mentioned above do not necessarily apply to every value proposition. Specifically the device manufacturer does not apply to every proposition, as not every proposition needs specific hardware. Table 19.3 below shows the five key partner types, and to which value propositions they could apply.

**Key Activities**

*General*

Key activities are the processes a company performs on its resources in order to create value. As companies that create AR applications are software developers, the most important processes involve the creation of software. Software development is broken down into two types of processes, that create value for customers. The first is *Creating new software*, which creates value by offering completely new functionality to customers. The second type is *Resolving software problems*, which is about adding value through removing bugs and problems with existing software. Figure 19.3 shows the sub elements of the Key Activities element.

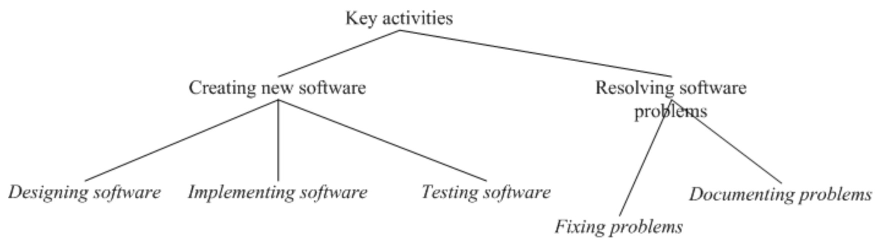


Figure 19.3: Structure of Key Activities for AR applications

*Value proposition specific*

As both key activities type apply to any software development company, there are no differences in key activity types for the different value propositions.

### Key Resources

*General*

Key resources are the resources the company needs to create value for its customers. Resources are used by the company's processes and activities. AR applications are essentially software, and technology is needed to create software. Since AR needs a device for it to be perceived, devices are also needed in the process of AR application development. Technology is defined as the practical application of knowledge in a specific area, which means that knowledge is also a resource for AR. This knowledge can either be in the form of patents filed, or expertise of the company's staff. This brings us to the structure of key resources as shown in figure 19.10.

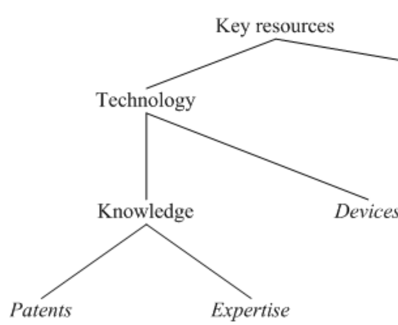


Figure 19.4: Structure of Key Resources for AR applications

*Value proposition specific*

Every value proposition potentially needs devices, staff, expertise and patents to create the value they deliver to customers. There are therefore no differences in resource types for the sixteen value propositions.

### Customer Relationships

The customer relationship element represents the type of relationship the company has with it's customers. The relation can either be focused on customer acquisition (getting more customers), customer retention or increasing sales per customer (add-on relationship). The relationship differs per type of value proposition and can take an abundance of forms. What can be said in general is that a customer relationship for an AR application is not likely to be direct, as the company would have no direct contact with its customers.

### Distribution Channels

*General*

Distribution channels are the ways the company gets in touch with their customers and distributes its value. For software, the most prominent distribution channel is directly through the Internet, allowing customers to download the application from the company's website. An alternative is to distribute the application to some application publisher or broker, which in turn transfers the application to it's customers. The latter is mostly applicable to AR applications for mobile devices, specifically to Google's Android Market and Apples App Store. The final alternative would be to distribute through (electronics) stores. This structure is shown in figure 19.5.

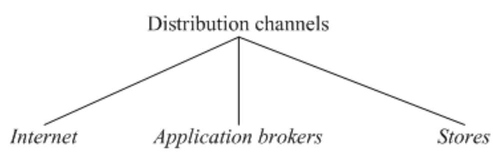


Figure 19.5: Structure of Distribution Channels for AR applications

*Value proposition specific*

As mentioned above, the application broker channel is most applicable to AR for mobile, as seen in the two brokers we mentioned. The value propositions that are likely to be used through mobile devices are in situ, utility, location layers, enhanced classifieds, 3D virals, personalized shopping, blended branding and augmented events.

### Customer Segments

*General*

Customer segments are the types of customers the company wants to deliver value to. Since this is different depending on what value the company wants to delivered, no general remarks can be made on this subject.

*Value proposition specific*

Table 19.4 is an incomplete list of potential customer segments per value proposition.

| *Value propostion* | *Customer segments* |
|---|---|
| In situ | Manufacturers, architects |
| Utility | "Smartphone" users |
| Training | Students, teachers |
| Social gaming | Gamers |
| Location layers | "Smartphone" users |
| Virtual demo | Shop customers, shopkeepers |
| Experiential education | Museums, zoos, educational institutions |
| Enhanced classifieds | "Smartphone" users |
| 3D Virals | "Smartphone" users |
| Personalized shopping | "Smartphone" users, shopkeepers |
| Cooperation | Business professionals |
| Blended branding | "Smartphone users" |
| Augmented events | "Smartphone users" |
| Intertainment | Home entertainment users |
| Understanding systems | Students, teachers, mechanics |
| Recognition & targeting | Marketers |

Table 19.4: Potential customer segments per value proposition

**Value & Cost Structure**

The value and cost structure describe the financial aspect that is associated with the value captured and delivered by the application, specifying both cost and revenues. The main costs for an AR application are staff, for developing the application itself, and possibly Internet hosting, for delivering the application to the company's customers. The revenues can either be advertisements or fees customers pay for the application.

**Overview of the AR Business Model Framework**

Appendix B shows an overview of the AR Business Model Framework described above. The appendix shows a specialization of the Osterwalder Business Model Canvas, that can be used for augmented reality applications.

### 19.5.2 Success and Failure Scenarios

The previous section has discussed an ontology of AR applications. This section looks at what impact specific business model implementations have on the success of an AR application. To start, we look briefly at what success is.

**What is *success*?**

A well known definition of business success is profit. If a business is profitable, it is deemed successful, and vice versa. As profit is essential to a business' survival, this seems like a valid definition. However, it can be refined. As the business model framework discussed is all about value, value should also be considered in the definition of success. Therefore, we assume a business to be successful if it adds value for its customers. With that *should* also come profit.

**Successful AR ventures**

An application that implements the framework discussed above is likely to be profitable, as it means it conforms to the standards of the industry. If other companies can be successful with business model that matches the framework, then so can a new venture implementing the framework. Since there are still very few paid AR applications, the field is still open for new entrants. It is however outside the scope of this research to exactly determine what combination and implementation of the nine elements is really successful.

## 19.6 User aspect

One factor that influences the success of a new technology is the acceptance by users. Various studies have been done to be able to predict the intention of users to actually use a new technology. In this section, a research is carried out to be able to predict factors that influence the acceptance of Augmented Reality. First a literature study will be done to find a relevant method to analyze user behavior. A method will be chosen to be adjusted for the Augmented Reality domain. The results of the research will be discussed, and end with a sub conclusion on the user aspect of this research.

### 19.6.1 Literature

A technology acceptance model examines how users come to accept and use a technology. According to Venkatesh et al., information systems research has long studied how and why individuals adopt new information technologies, and the explanation of user acceptance of new technology is often described as one of the most mature research areas in the contemporary information systems literature. Within this broad area, there have been several streams of research, and each of these streams makes important contributions to the literature on user acceptance of information technology. One stream of research focuses on individual acceptance of technology by using intention or usage as a dependent variable. Other streams have focused on implementation success at the organizational level and task-technology fit among others. In this section, a number of these users acceptance models will be discussed.

**Technology Acceptance Model (TAM)**

The Technology Acceptance Model (TAM) [Davis, 1989] is a theory that models how users come to accept and use a technology. The model suggests that when users are presented with a new technology, a number of factors influence their decision about how and when they will use it, summarized as:

- Perceived usefulness (PU) - This was defined by Davis as "the degree to which a person believes that using a particular system would enhance his or her job performance".
- Perceived ease-of-use (PEOU) - Davis defined this as "the degree to which a person believes that using a particular system would be free from effort".

Validation of TAM found it to account for 40% of the variance in usage intention.

**Unified Theory of Acceptance and Use of Technology (UTAUT)**

Unified Theory of Acceptance and Use of Technology (UTAUT) is a technology acceptance model that aims to explain user intentions to use an information system and usage behavior. The theory holds that four key constructs (performance expectancy, effort expectancy, social influence, and facilitating conditions) are direct determinants of usage intention and behavior. Validation of UTAUT in a longitudinal study found it to account for 70% of the variance in usage intention. [Venkatesh et al., 2003]

UTAUT was developed through a review and consolidation of the constructs of eight models that earlier research had employed to explain information systems usage behavior:

- Theory of Reasoned Action (TRA)
- Technology Acceptance Model (TAM)
- Motivational model (MM)
- Theory of Planned Behavior (TPB)
- Combined TAM and TPB (C-TAM-TPB)
- Model of PC Utilization (MPCU)
- Innovation Diffusion Theory (IDT)
- Social Cognitive Theory (SCT)

The unified theory of acceptance and use of technology comprises four core determinants of intention and usage, and up to four moderates of key relations. Four constructs play a significant role as direct determinants of user acceptance and usage behavior: performance expectancy, effort expectancy, social influence, and facilitating conditions. The four key moderators in UTAUT are gender, age, experience, and voluntariness of use.

The authors of UTAUT argue that in terms of explained variance the unified model is a substantial improvement over any of the original eight models and their extensions. They posed that ATAUT provides a useful tool to asses the likelihood of success for new technology introductions and helps to understand the drivers of acceptance in order to proactively design interventions targeted at populations of users that may be less inclined to adopt and use new systems.

### 19.6.2 Methodology

To identify the success and failing factors for Augmented Reality technology, a survey will be held. The result of this survey should be an overview of factor that support or inhibit the success of Augmented Reality.

As mentioned in the previous section, there are a number of models are available to determine the user acceptance of technology. Because of the high predictable value of UTAUT, the questionnaire of UTAUT will be used. UTAUT contains a user questionnaire with selectable building blocks to determine the extend of acceptance of technology. The relevant building blocks are selected, based on the relevancy to Augmented Reality. A survey is carried out with possible users of Augmented Reality applications. The estimated number of responses is 50. The survey will result in factors that support or inhibit the success of augmented reality applications.

**Research model** The basis for the research model will be the results of the UTAUT model. For reference, Figure 19.6 shows the initial research model of UTAUT. However, the results of UTAUT show that seven constructs that have direct impact on user intention. They will be included in the initial research model for a theoretical reference. These constructs are performance expectancy, effort expectancy, attitude toward using technology, facilitating conditions, self-efficacy, social influence, and anxiety.

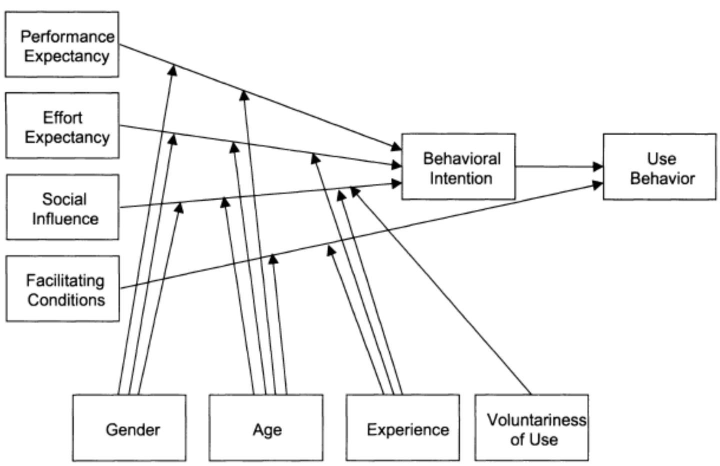


Figure 19.6: UTAUT Research model

**Target group** The target group of this questionnaire will be consumers that might use augmented reality for private use. This includes entertainment, gaming, personal assistance etc. The questionnaire explicitly will not be used for a professional user target group, i.e. supporting of professional tasks in working conditions.

**Setup** In the questionnaire, an introduction to augmented reality technology is be given. There are a lot of technologies and applications that could be used. Due to the limited time, the scope will be narrowed to Handheld Displays (i.e. mobile phone) and applications for a consumer target group. This explicitly excludes Head Mounted Displays and Spatial Displays as technology, as well as use in a professional environment.

Two applications will be presented in the questionnaire, using a short text and video. The first is Layar[4], which provides a framework to add information to live images captured by the camera of a mobile phone. In particular, an example of an real estate application is given. The second application is a virtual dressing room[56], developed by the on-line shop Tobi. Users can view an image om theirself which is captured via a webcam, and try different clothes which are shown on top of this image. The questionnaire ends with some general questions.

**Questions** The building blocks of the UTAUT model are changed to comply to the augmented reality context as described before. The main questions can be found in Appendix A. The phrase 'augmented reality' can be replaced by either 'Layar' or 'the virtual dressing room'. Answers could be given on a seven-point scale ranging from 1 (completely disagree) to 7 (completely agree). The Behavioral Intention questions had a seven-point scale ranging from 1 (extremely unlikely) to 7 (extremely likely). Due to the nature of the applications (for consumer usage), it is assumed that the applications would be used voluntary, so no questions about voluntariness of usage were asked. The UTAUT questionnaire was extended with general questions about the gender, age and experience level with new technology of the respondent.

### 19.6.3 Results

The questionnaire has been put online during using Thesistools.com during one week in July 2010, and has been promoted via social media (Twitter, Facebook, LinkedIN etc.) and direct mails. In this section, the results of the questionnaire will be presented and discussed.

**Respondents** In total, 59 respondents have filled in the questionnaire. Of these 59 results, 49 were complete and had answers to all questions (the other 10 had at least three missing answers). For a better quality of conclusions, only the 49 fully completed results will be used during the analysis. Table 19.5, 19.6 and 19.7 show some statistics about the respondents. Due to the network that was queried, we expect most of the respondents to be students with higher education.

**Reliability** The questionnaire consisted of seven groups of questions. To check the internal consistency of answers within a group, a Chronbach Alpha consistency analysis were executed. In statistics, a group is considered internally consistent when the $\alpha$ value is above 0.60.

The results are shown in Table 19.8 for Layar and Table 19.9 for the Virtual Dressing Room. For Layar, the $\alpha$ value of Facilitating Conditions was below zero,

[4]Layar video available via: `http://www.youtube.com/watch?v=b64_16K2e08`

[5]Virtual Dressing Room video available via: `http://www.youtube.com/watch?v=NxQZuo6pFUw`

[6]Virtual Dressing Room demo available via: `http://www.tobi.com/editorial/tobi-blog/1039-try-it-on-in-our-virtual-dressing-room?p111609`

| Age group | Frequency | Percent |
|---|---|---|
| 0 - 10 | 0 | 0% |
| 11 - 20 | 7 | 14.3% |
| 21 - 30 | 30 | 61.2% |
| 31 - 40 | 2 | 4.1% |
| 41 - 50 | 6 | 12.2% |
| 51 - 60 | 3 | 6.1% |
| 60+ | 1 | 2.0% |

Table 19.5: Participant ages (n=49)

| Gender | Frequency | Percent |
|---|---|---|
| Male | 39 | 79.6% |
| Female | 10 | 20.4% |

Table 19.6: Participant gender (n=49)

| Answer | Frequency | Percent |
|---|---|---|
| None | 2 | 4,1 |
| Very little | 2 | 4,1 |
| Little | 3 | 6,1 |
| Not a little, not much | 2 | 4,1 |
| A bit | 6 | 12,2 |
| Much | 17 | 34,7 |
| Very much | 16 | 32,7 |

Table 19.7: Experience with new technology (n=49)

indicating an measurement error within one of the questions. We assume the the measurement error existed due to the different interpretation of human and technical resources. After removing question FC3, the $\alpha$ value reached its highest value, although it is just above zero.

The Chronbach Alpha analyses show that for both Layar and the Virtual Dressing Room, the $\alpha$ value is far below 0.60. The results of this construct do not have enough internal consistency, and will not be used for further analyses. The Social Influence of Layar also has a $\alpha$ value below 0.60. Removing question SI3 raises the $\alpha$ value to 0.928. This shows that respondents feel a difference between support from the environment and encouraging to use from their environment.

**Correlations** A correlation analysis is carried out to check whether there is a signification relation between the different constructs. A correlation between -1.0 and -0.5, or between 0.5 and 1.0 can be considered as correlated. A 95% confidence interval will be used to determine significance.

Table 19.10 shows the correlation matrix for Layar, Table 19.11 shows the correlation matrix for the Virtual Dressing Room. Italic values are significant ($p$ <0.05). For both Layar and the Virtual Dressing Room, a strong correlation between PE - AT can be seen. Both also have significant correlation between PE - BI, AT - BI can be seen. Layar also has a (negative) signifficant correlation between SI - EE and ANX - EE. The Virtual Dressing Room has a signification correlation between ANX - BI. Overall, it has to be mentioned that the correlations for the Virtual Dressing Room are lower than the correlations for Layar.

A high correlation does not directly imply a casual relationship. A regression analysis is needed to conform such a relationship.

| Question | M | SD |
|---|---|---|
| Performance expectancy ($\alpha = 0.705$) | | |
| PE1 | 4.22 | 1.462 |
| PE2 | 4.27 | 1.287 |
| PE3 | 5.12 | 1.252 |
| Attitude toward using technology ($\alpha = 0.686$) | | |
| AT1 | 5.29 | 1.041 |
| AT2 | 3.61 | 1.592 |
| AT3 | 4.71 | 1.500 |
| AT4 | 4.08 | 0.932 |
| Social Influence ($\alpha = 0.401$) | | |
| SI1 | 2.63 | 1.439 |
| SI2 | 2.73 | 1.538 |
| SI3 | 4.76 | 1.164 |
| Facilitating conditions ($\alpha = 0.02$) | | |
| FC1 | 3.61 | 2.379 |
| FC2 | 5.47 | 1.815 |
| FC3 (removed) | 3.80 | 1.915 |
| FC4 | 4.88 | 1.867 |
| Anxiety ($\alpha = 0.951$) | | |
| ANX1 | 2.24 | 1.562 |
| ANX2 | 2.20 | 1.541 |
| ANX3 | 2.06 | 1.573 |
| ANX4 | 1.96 | 1.471 |
| Behavioral intention to use the system ($\alpha = 0.894$) | | |
| BI1 | 2.96 | 2.111 |
| BI2 | 2.90 | 2.064 |
| BI3 | 2.22 | 1.723 |
| Effort expectancy ($\alpha = 0.712$) | | |
| EE1 | 5.04 | 1.190 |
| EE2 | 5.37 | 1.349 |
| EE3 | 4.63 | 1.167 |
| Other | | |
| KNOWL. | 1.84 | 0.773 |
| GENDER | 1.20 | 0.407 |
| AGE | 3.41 | 1.189 |
| EXPER. | 5.45 | 1.826 |

Table 19.8: Descriptive Statistics, Factor Loadings, Squared Multiple Correlations, and Cronbachs Alpha of the Observed Indicators to explain acceptance of Layar

| Question | M | SD |
|---|---|---|
| Performance expectancy ($\alpha = 0.871$) | | |
| PE1 | 3.43 | 1.882 |
| PE2 | 3.22 | 1.598 |
| PE3 | 4.49 | 1.502 |
| Attitude toward using technology ($\alpha = 0.865$) | | |
| AT1 | 4.73 | 1.800 |
| AT2 | 2.73 | 1.693 |
| AT3 | 3.90 | 1.874 |
| AT4 | 3.24 | 1.677 |
| Social Influence ($\alpha = 0.712$) | | |
| SI1 | 2.24 | 1.407 |
| SI2 | 2.27 | 1.440 |
| SI3 | 4.04 | 1.732 |
| Facilitating conditions ($\alpha = 0.035$) | | |
| FC1 | 4.63 | 2.233 |
| FC2 | 5.69 | 1.698 |
| FC3 | 2.57 | 1.720 |
| FC4 | 4.24 | 2.006 |
| Anxiety ($\alpha = 0.911$) | | |
| ANX1 | 2.22 | 1.558 |
| ANX2 | 1.71 | 1.155 |
| ANX3 | 1.65 | 1.182 |
| ANX4 | 1.80 | 1.384 |
| Behavioral intention to use the system ($\alpha = 0.958$) | | |
| BI1 | 1.59 | 1.189 |
| BI2 | 1.73 | 1.319 |
| BI3 | 1.53 | 1.101 |
| Effort expectancy ($\alpha = 0.827$) | | |
| EE1 | 5.06 | 1.478 |
| EE2 | 5.43 | 1.414 |
| EE3 | 4.53 | 1.445 |
| Other | | |
| KNOWL. | 1.16 | .373 |
| GENDER | 1.20 | .407 |
| AGE | 3.41 | 1.189 |
| EXPERIENCE | 5.45 | 1.826 |

Table 19.9: Descriptive Statistics, Factor Loadings, Squared Multiple Correlations, and Cronbachs Alpha of the Observed Indicators to explain acceptance of the Virutal Dressing Room

| Q | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 KN | 1 | .11 | .00 | .19 | *.29* | .27 | *.28* | *.39* | -.22 | -.19 | *.42* | *.49* | *.56* | -.21 | .01 | *-.33* | *-.34* | *-.30* | -.26 | *.66* | *.68* | *.42* | .23 | .08 | *.37* |
| 1 PE1 | | 1 | *.48* | *.50* | *.41* | *.32* | *.46* | *.34* | -.16 | -.07 | *.39* | -.07 | .01 | -.04 | -.08 | -.18 | -.06 | -.11 | -.21 | *.31* | *.38* | *.32* | -.09 | -.17 | -.07 |
| 2 PE2 | | | 1 | *.35* | *.38* | *.31* | .21 | .26 | .28 | *.33* | .10 | .10 | -.19 | -.02 | .15 | -.15 | -.01 | .04 | -.07 | .25 | *.38* | *.46* | -.17 | -.25 | -.11 |
| 3 PE3 | | | | 1 | *.60* | *.30* | .20 | *.29* | .00 | .16 | *.35* | -.05 | .19 | -.02 | -.04 | -.24 | -.24 | -.27 | -.28 | .19 | *.34* | *.34* | .09 | -.14 | -.01 |
| 4 AT1 | | | | | 1 | *.28* | *.32* | .25 | -.08 | .05 | *.42* | .05 | .28 | .04 | .07 | *-.42* | *-.28* | -.27 | *-.37* | *.36* | *.41* | *.43* | .24 | .00 | .14 |
| 5 AT2 | | | | | | 1 | *.28* | *.50* | .13 | .16 | .00 | .06 | .24 | .20 | -.23 | -.10 | -.04 | -.03 | -.22 | *.31* | *.35* | *.43* | -.04 | -.06 | .08 |
| 6 AT3 | | | | | | | 1 | *.67* | *-.30* | -.16 | .20 | .08 | *.36* | .02 | .12 | -.23 | -.18 | -.18 | *-.30* | *.33* | *.31* | .21 | .23 | .11 | .26 |
| 7 AT4 | | | | | | | | 1 | -.02 | .06 | .08 | .04 | *.32* | .16 | .03 | -.07 | -.10 | -.07 | -.10 | *.34* | *.38* | *.34* | .05 | -.06 | .16 |
| 8 SI1 | | | | | | | | | 1 | *.87* | *-.30* | .05 | *-.34* | .18 | .02 | .18 | .15 | .27 | .23 | -.25 | -.21 | .12 | *-.40* | -.27 | *-.31* |
| 9 SI2 | | | | | | | | | | 1 | -.20 | .06 | -.19 | .11 | .03 | .14 | .12 | .23 | .21 | -.11 | -.07 | *.29* | *-.32* | -.21 | -.25 |
| 10 SI3 | | | | | | | | | | | 1 | *.33* | .21 | *-.39* | .15 | *-.37* | *-.35* | *-.31* | *-.30* | *.34* | *.41* | .26 | .01 | -.13 | .01 |
| 11 FC1 | | | | | | | | | | | | 1 | .20 | *-.45* | .00 | -.11 | -.09 | -.14 | -.11 | *.32* | *.39* | .22 | .03 | -.09 | .14 |
| 12 FC2 | | | | | | | | | | | | | 1 | -.04 | -.25 | *-.53* | *-.47* | *-.49* | *-.50* | *.34* | *.35* | .13 | *.51* | *.52* | *.35* |
| 13 FC3 | | | | | | | | | | | | | | 1 | -.25 | .06 | .12 | .18 | .08 | -.18 | *-.33* | -.21 | -.12 | -.20 | -.12 |
| 14 FC4 | | | | | | | | | | | | | | | 1 | -.06 | -.11 | -.10 | .00 | .09 | .06 | .25 | .01 | .05 | .12 |
| 15 ANX1 | | | | | | | | | | | | | | | | 1 | *.77* | *.77* | *.87* | -.26 | *-.33* | -.11 | *-.50* | *-.33* | *-.42* |
| 16 ANX2 | | | | | | | | | | | | | | | | | 1 | *.85* | *.84* | -.18 | -.23 | -.07 | *-.30* | -.23 | *-.35* |
| 17 ANX3 | | | | | | | | | | | | | | | | | | 1 | *.87* | -.19 | *-.29* | -.08 | *-.39* | *-.37* | *-.37* |
| 18 ANX4 | | | | | | | | | | | | | | | | | | | 1 | -.19 | -.26 | -.08 | *-.37* | *-.34* | *-.35* |
| 19 BI1 | | | | | | | | | | | | | | | | | | | | 1 | *.86* | *.64* | .17 | -.09 | *.34* |
| 20 BI2 | | | | | | | | | | | | | | | | | | | | | 1 | *.71* | .21 | -.02 | .24 |
| 21 BI3 | | | | | | | | | | | | | | | | | | | | | | 1 | -.12 | -.10 | -.01 |
| 22 EE1 | | | | | | | | | | | | | | | | | | | | | | | 1 | *.43* | *.73* |
| 23 EE2 | | | | | | | | | | | | | | | | | | | | | | | | 1 | .23 |
| 24 EE3 | | | | | | | | | | | | | | | | | | | | | | | | | 1 |

Table 19.10: Correlations Matrix of the Observed Variables of Layar. *Note:* correlations significant at $p < .05$, significant correlations are in Italic.

| Q | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 KN | 1 | -.07 | .11 | -.07 | -.12 | .00 | -.09 | .07 | .20 | .11 | -.11 | -.08 | .01 | .18 | .14 | .22 | .21 | *.37* | .11 | .20 | .22 | .24 | -.21 | .06 | -.09 |
| 1 PE1 | | 1 | *.79* | *.70* | *.59* | *.44* | *.70* | *.61* | .03 | .06 | *.33* | .05 | .02 | -.06 | .16 | -.01 | -.01 | -.15 | .07 | *.41* | *.48* | *.37* | .25 | .09 | .23 |
| 2 PE2 | | | 1 | *.60* | *.48* | *.35* | *.45* | *.55* | .03 | .04 | .23 | .09 | .06 | -.12 | .05 | -.02 | -.01 | -.08 | .06 | .25 | .27 | .22 | *.29* | .08 | *.35* |
| 3 PE3 | | | | 1 | *.73* | .21 | *.52* | *.44* | .00 | .04 | *.45* | .07 | .14 | -.02 | .01 | .11 | .00 | -.13 | .07 | .23 | *.31* | .19 | .10 | .22 | .19 |
| 4 AT1 | | | | | 1 | *.35* | *.66* | *.55* | -.05 | .00 | *.33* | -.10 | .01 | .01 | .17 | -.02 | -.11 | -.19 | .00 | .12 | .20 | .06 | .10 | .02 | .09 |
| 5 AT2 | | | | | | 1 | *.61* | *.72* | .19 | .17 | .17 | -.02 | -.14 | .03 | .06 | .07 | .18 | .05 | .22 | *.44* | *.45* | *.43* | .10 | .00 | .15 |
| 6 AT3 | | | | | | | 1 | *.81* | -.11 | -.07 | .23 | .05 | .03 | -.07 | .13 | .11 | .00 | -.12 | .07 | *.35* | *.40* | *.31* | .13 | .06 | .16 |
| 7 AT4 | | | | | | | | 1 | .00 | -.02 | *.29* | .01 | -.02 | -.01 | .03 | .11 | .07 | .02 | .11 | *.40* | *.41* | *.37* | .09 | .01 | .17 |
| 8 SI1 | | | | | | | | | 1 | *.90* | *.33* | -.14 | -.07 | .23 | *.33* | .20 | .11 | .15 | .26 | .12 | .13 | .14 | .08 | .03 | .05 |
| 9 SI2 | | | | | | | | | | 1 | .22 | -.03 | -.19 | *.32* | *.29* | *.34* | .23 | .28 | *.36* | .14 | .16 | .19 | .06 | .01 | .02 |
| 10 SI3 | | | | | | | | | | | 1 | -.04 | .14 | -.18 | .00 | .01 | -.09 | -.19 | .09 | .11 | .19 | .01 | .09 | .10 | .11 |
| 11 FC1 | | | | | | | | | | | | 1 | *.30* | *-.37* | -.04 | .01 | -.01 | -.09 | -.25 | .00 | -.01 | -.05 | .18 | .26 | .24 |
| 12 FC2 | | | | | | | | | | | | | 1 | -.15 | .18 | -.19 | *-.39* | *-.39* | *-.37* | -.21 | -.22 | *-.33* | *.42* | *.58* | *.49* |
| 13 FC3 | | | | | | | | | | | | | | 1 | .15 | .20 | .33 | *.40* | .15 | .06 | .02 | .13 | -.24 | -.09 | -.17 |
| 14 FC4 | | | | | | | | | | | | | | | 1 | -.11 | -.04 | -.15 | -.09 | .17 | .10 | .15 | *.38* | .21 | .26 |
| 15 ANX1 | | | | | | | | | | | | | | | | 1 | *.75* | *.68* | *.78* | .15 | .27 | .24 | -.21 | .01 | -.21 |
| 16 ANX2 | | | | | | | | | | | | | | | | | 1 | *.80* | *.77* | .22 | *.32* | *.37* | -.27 | .01 | -.26 |
| 17 ANX3 | | | | | | | | | | | | | | | | | | 1 | *.63* | .19 | .22 | *.34* | *-.29* | -.01 | -.29 |
| 18 ANX4 | | | | | | | | | | | | | | | | | | | 1 | .23 | *.37* | *.36* | -.10 | .00 | -.17 |
| 19 BI1 | | | | | | | | | | | | | | | | | | | | 1 | *.89* | *.92* | .12 | .04 | .13 |
| 20 BI2 | | | | | | | | | | | | | | | | | | | | | 1 | *.87* | .02 | .11 | .04 |
| 21 BI3 | | | | | | | | | | | | | | | | | | | | | | 1 | .03 | -.02 | .06 |
| 22 EE1 | | | | | | | | | | | | | | | | | | | | | | | 1 | *.54* | *.77* |
| 23 EE2 | | | | | | | | | | | | | | | | | | | | | | | | 1 | *.54* |
| 24 EE3 | | | | | | | | | | | | | | | | | | | | | | | | | 1 |

Table 19.11: Correlations Matrix of the Observed Variables of the Virtual Dressing Room. *Note:* correlations significant at $p < .05$, significant correlations are in Italic.

**Regression analysis** With a regression analysis, it is possible to show the predictive value of variables in a model. The regression is standardized so the values are between -1 and 1. A 95% confidence interval will be used to determine significance of the predictive value.

Table 19.12 shows the standardized regression for Layar. For the first step, it is interesting to look at the predictive value of variables to Behavioral Intention as dependent variable, as this construct shows the degree of acceptance. It can be seen that Performance Expectancy and Attitude to Technology are the two constructs that have a significant predictive value to Behavioral Intention. When these constructs two are taken as new dependent variables, no predictive values can be found within the 95% confidence interval. However, at a 90% confidence interval, the SI - PE and ANX - AT regressions are significant predictive values. Finally, EE has a predictive value to both SI and ANX. This shows that all constructs can be used to determine Behavioral Intention, however only PE and AT have a predictive value at the 95% confidence interval.

Table 19.13 shows the standardized regression for the Virtual Dressing Room. It can be seen that next to Performance Expectancy and Attitude to Technology, also Anxiety has a significant predictive value to Behavioral Intention. The two remaining constructs, EE and SI only have a predictive value at a low confidence interval. This shows that only PE, AT and ANX have a predictive value at the 95% confidence interval.

The tables also show the squared multiple correlation ($R^2$) explanatory power. The higher $R^2$, the stronger the explanatory power of the independent variables for the dependent variable. However, the value of the explanatory power depends on discipline where the questionnaire is used. For the IT domain, a value of 0.50 has a moderate explanatory power.

The combined $R^2$ of PE and AT to BI for Layer is 0.301, which is a fairly moderate explanatory power. The combined $R^2$ of PE, AT and ANX to BI for the Virtual Dressing Room is 0.248, which is also a fairly moderate explanatory power.

### 19.6.4 Conclusions

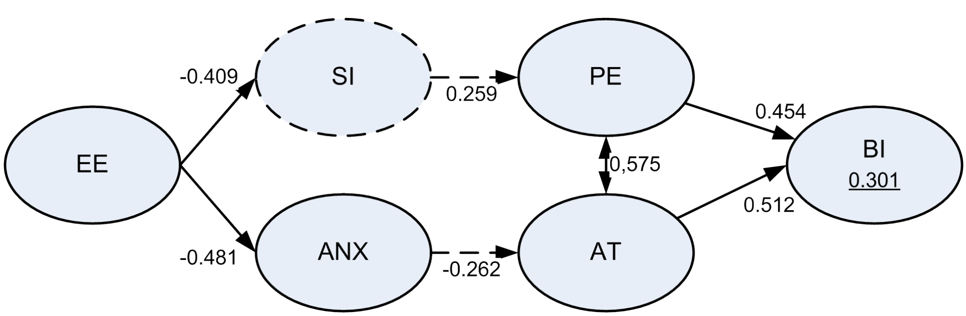


Figure 19.7: Standardized path coefficients of the adjusted UTAUT model for Layar. $p < .05$. Dotted lines are non-significant paths. Squared multiple correlations ($R^2$) are underlined.

| | Regression | $p$ | $R^2$ |
|---|---|---|---|
| PE - BI | *0.454* | 0.001 | 0.206 |
| AT - BI | *0.512* | 0.000 | 0.262 |
| SI - BI | 0.097 | 0.506 | 0.009 |
| ANX - BI | -0.23 | 0.112 | 0.053 |
| EE - BI | 0.097 | 0.509 | 0.009 |
| AT - PE | *0.572* | 0.000 | 0.327 |
| SI - PE | 0.259 | 0.072 | 0.067 |
| ANX - PE | -0.196 | 0.176 | 0.039 |
| EE - PE | -0.169 | 0.246 | 0.028 |
| SI - AT | 0.059 | 0.685 | 0.004 |
| ANX - AT | -0.262 | 0.069 | 0.069 |
| EE - AT | 0.152 | 0.296 | 0.023 |
| ANX - SI | 0.067 | 0.646 | 0.005 |
| EE - SI | *-0.409* | 0.004 | 0.167 |
| EE - ANX | *-0.481* | 0.000 | 0.231 |

Table 19.12: Regression analysis of Layar. *Note:* regressions significant at $p$ <.05 are in Italic.

| | Regression | $p$ | $R^2$ |
|---|---|---|---|
| PE - BI | *0.363* | 0.010 | 0.131 |
| AT - BI | *0.403* | 0.004 | 0.163 |
| SI - BI | 0.170 | 0.243 | 0.028 |
| ANX - BI | *0.314* | 0.028 | 0.099 |
| EE - BI | 0.072 | 0.621 | 0.005 |
| AT - PE | *0.678* | 0.000 | 0.460 |
| SI - PE | 0.207 | 0.154 | 0.043 |
| ANX - PE | -0.006 | 0.969 | 0.000 |
| EE - PE | 0.261 | 0.070 | 0.068 |
| SI - AT | 0.153 | 0.292 | 0.024 |
| ANX - AT | 0.051 | 0.729 | 0.003 |
| EE - AT | 0.125 | 0.392 | 0.016 |
| ANX - SI | 0.198 | 0.173 | 0.039 |
| - SI | 0.093 | 0.523 | 0.009 |
| EE - ANX | -0.189 | 0.193 | 0.036 |

Table 19.13: Regression analysis of the Virtual Dressing Room. *Note:* regressions significant at $p$ <.05 are in Italic.

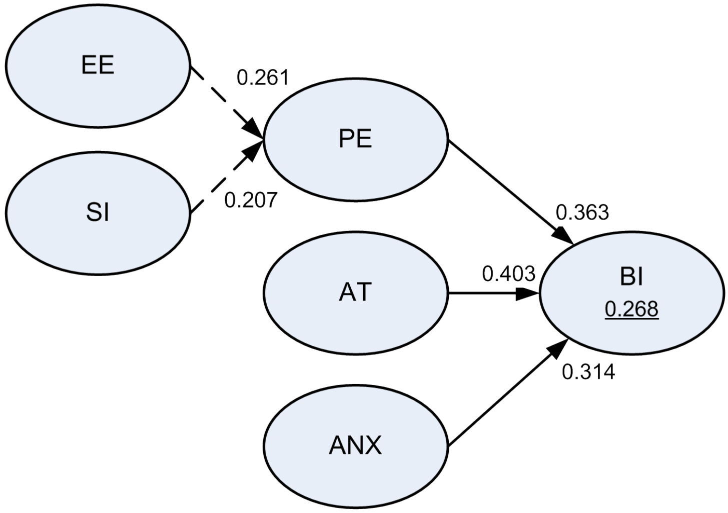


Figure 19.8: Standardized path coefficients of the adjusted UTAUT model for the Virtual Dressing Room. $p$ <.05. Dotted lines are non-significant paths. Squared multiple correlations ($R^2$) are underlined.

Combining all results gathered from the questionnaire data analysis, a new model can be made for the applications. Figure 19.7 shows the standardized path model for Layar, with Performance Expectency and Attitude to Technology having high predictive values for Behavioral Intention. Figure 19.8 shows the standardized path model for the Virtual Dressing Room, with Performance Expectancy, Attitude to Technology and Anxiety having high predictive values for Behavioral Intention. It is remarkable that the model for the Virtual Dressing Room has less valuable predictors and explanatory values than the Layar model. This could be coherent with the lower intention to use the Virtual Dressing Room.

Both Layar and the Virtual Dressing Room have Performance Expectancy and Attitude to Technology as strong predictive and explanatory constructs for Behavioral Intention. Factors that play a role within these groups are usability, usefulness, fun and productivity. It can be prudently concluded that technology acceptance factors for Augmented Reality in this application domain are related to usability, usefulness, fun and productivity. Applications might be accepted and successful when attentions is paid to these factors.

## 19.7 Technology aspect

Introduction, structure etc.

The technology aspect of augmented reality applications are important to look at. This research describes applications of augmented reality from a technological point of view and tries to look for how it could be developing in the coming years. It tries to find out which augmented reality applications are already currently available, with a focus on describing trends in augmented reality applications over the last two years. The important thing is finding out which technologies are necessary and successful for improving the application of augmented reality technology. Several issues with current technologies will be discussed, as well as several already successful applications.

### 19.7.1 Methodology

The methodology used in the technology study is described in this section. The literature research approach as used in [Vermolen, 2010] is used here as a basis. This ensures that the literature study will be focused and select the most important papers for this research. After the literature study, the Augmented reality technologies described in the relevant papers are divided into different categories. Then, per category, an overview of some of the problems and success factors are given. A conclusion is given last.

The steps taken while doing the literature research are the following:

1. Finding relevant conferences and journals.
2. Selecting databases for locating relevant articles.
3. Writing down the search criteria with which to find the relevant articles in the databases.
4. Excluding papers that are false positives (that turn up among the relevant search results when using mild criteria, but turn out to be irrelevant when using harsher criteria that cost more time to implement). Exclusion is done in the order show below, by scanning the:
   (a) Title
   (b) Abstract
   (c) Entire text

### 19.7.2 Literature Research

This section describes the literature research done in order to make the categorization of augmented reality techniques. The methodology used is described in the section methodology above.

#### Relevant conferences and journals

There are some conferences that contain a paper on an application of augmented reality in a specific situation. These were ignored. Besides that, a number of conferences have been held with their main topic being augmented reality or something very closely related (e.g. virtual reality) in the years 2008-2010. These years were selected to make sure the literature research stays focused and because we can assume that these conferences discuss the latest advancements in augmented reality:

- Augmented Reality Conference: Advancing the Business of AR, San Francisco (CA, USA), April 21, 2010

- are2010, Augmented Reality Event (ARE), Santa Clara (CA, USA), June 2-3, 2010
- 1st European AR Business Conference, Berlin (Germany), April 23, 2010
- IEEE Virtual Reality 2008, Reno (NV, USA), March 8-12, 2008
- IEEE Virtual Reality 2009, Lafayette (LA, USA), March 14-18, 2009
- IEEE Virtual Reality 2010, Waltham (MA, USA), March 20-24, 2010
- 7th IEEE and ACM International Symposium on Mixed and Augmented Reality - ISMAR 2008, Cambridge (UK), September 15-18, 2008.
- 8th IEEE and ACM International Symposium on Mixed and Augmented Reality - ISMAR 2009, Orlando (FL, USA), October 19-22, 2009.

There were not a lot of journals with relevant information on augmented reality. The two journals found that were relevant are:

- The International Journal of Virtual Reality (IJVR).
- Presence. http://www.mitpressjournals.org/loi/pres

**Database selection**

The database generally used by scholars at the University of Twente is Scopus. Scopus is the world's largest database with publication data and summaries of articles from over 14.000 scientific journals. Furthermore, it has the required search options for this literature research. Scholar.google.com was used as a back-up for Scopus in case Scopus could not find a conference or journal.

**Search criteria**

Search criteria were used to find papers on Scopus. The search criteria used were:

1. The title of a conference or journal, as listed above. Often only a part of the title was taken as input for the search query, because of the chance of missing a conference or journal by inputting the entire name.
2. The year was selected to be 2008, 2009 or 2010, as to limit the number of papers found. These papers will most likely discuss the most advanced augmented reality techniques, and limiting the years in which to search helps in narrowing down the search domain.
3. The keyword used was "augmented reality". The search options were set to look for this keyword in the abstract title, abstract and keywords in Scopus. Google Scholar does not have this option, so when used, the search options were set to look for this keyword anywhere in the article.

After applying the above criteria, there were 285 papers left to narrow down. All four of the conferences listed above that took place in 2010 failed to provide any papers when looking on Scopus or scholar.google.com. However, searching for the other conferences and journals found more than enough results to continue with the next step in the literature research.

### Excluding papers

While making these selections, the criteria that each paper was tested against was: could the paper contain information likely to provide an answer to the research question? The papers with irrelevant titles were excluded first. These included papers focusing on the human-interaction side of augmented reality applications, or papers about other topics than augmented reality. This resulted in a selection of 191 possibly relevant papers.

Next, papers with irrelevant abstracts were excluded. After excluding irrelevant papers here, a selection of 79 papers was left. Each of these was still (possibly) relevant, but further narrowing down would take place as described below.

The exclusion process is shown in figure 19.9.

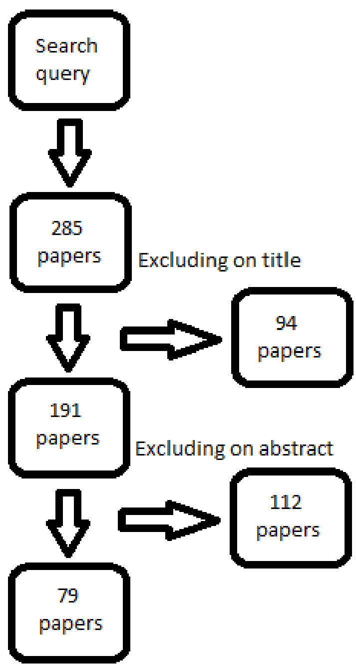


Figure 19.9: The selection of papers during the literature research

Not all of the papers that followed from the excluding based on the abstracts were finally used in this paper. Some did not give any relevant information after scanning through the entire paper. They were naturally left out.

Reading some of the important parts of the papers gave an insight in the different technological problems that augmented reality faces. Some of them can be solved, others worked around but both take time (i.e. developing the solutions). Others will not be solved, but might be less of concern.

### 19.7.3 Categorization

During the selection of the papers based on abstracts, a categorization was already partly made. This categorization was done based on use of the augmented reality technologies. This section describes the categorisation as well as the different categories. It gives a short overview of the problems and success factors and a short future outlook on the technology based on the literature research. The categorization is by no means exhaustive. A categorization based on different criteria could be made as well (e.g. one based on the kind of technologies involved instead of the application). Papers could also fall into multiple categories, then one was chosen that was deemed the most related. The augmented reality applications can be categorized as follows:

- Common technologies
- Art
- Engineering
- Medical
- Mobile phone
- Multimedia
- Navigation

This is quite a list and therefore each category will be described shortly below. In the end, 47 papers were used as a reference.

#### Common technologies

This section discusses a number of common technology within the field of augmented reality.

**Success factors** Some factors involved in most augmented reality technologies are latency [Lee et al., 2010], noise and orientation errors on tracking distant objects in augmented reality [Livingston and Ai, 2008]. Another one is spatial tracking [Huber et al., 2009]. This refers to the ability of an augmented reality system to keep track of certain objects that it picks up via its camera. Contrast sensitivity and color perception of the augmented reality displays also play a role, as when these are not good enough, a user's visual capabilities can be reduced in such capacity that using the system is not viable anymore [Livingston et al., 2009]. But the study found out that even by using only medium contrast, users would be able to use the augmented reality device well enough. A different problem for augmented reality objects is the recognition of the boundaries between physical world and the virtual world [Chen and MacIntyre, 2008].

Another problem is that a lot of environments need to be prepared for working with augmented reality. Markings are needed for the augmented reality system to pick up certain locations. [Lee and Hllerer, 2008] discusses a way of user interaction for augmented reality on unprepared tabletop environments. This could lead the way for greater applications of augmented reality applications on unprepared environments.

A lot of research is done to detect a physical object and create a virtual 3d object equivalent of it [Sherstyuk et al., 2008]. This virtual object can then be used for collision detection with other, virtual objects [Beaney and Mac Namee, 2009] or in other ways be manipulated.

**Future outlook** The papers show that the factors involved can be reduced a lot. Latency can already be reduced to a minimum. In reducing noise, a better camera helps a lot. While mobile phones often contain cameras that have quite a bit of noise, the cameras get better every year.

Some researchers are also focusing on hear-through augmented reality technologies instead of see-through augmented reality technologies [Lindeman et al., 2008]. This could lead to a greater amount of augmented reality sound applications or combinations of visual and audio applications in used in a museum or entertainment park.

### Art

This section discusses art and related endeavours such as art exhibitions.

**Success factors** In the arts, painting in a new way can be learned by using augmented reality techniques. If someone wants to learn Chinese painting, that person can use the latest advances in the field [Duh et al., 2009]. Other artists make use of augmented reality to create art by using the technology itself to create a collage of multiple photos [Papagiannis, 2009].

An interesting application of augmented reality in is the use in an art exhibition. By carrying a camera, head-mounted display and eye tracker, the user can look at a painting while the display shows the user information on the painting [Park et al., 2008]. Another application is as an augmented reality museum guide with a handheld device [Miyashita et al., 2008].

**Future outlook** In our opinion augmented reality systems will see an increased use in musea and exhibitions. It is a new and exciting technology that exhibitions often like to take advantage of because people will find it interesting. Such systems can also be reused from exhibition to exhibition, thereby giving it a reason for long term use too.

### Engineering

The term engineering here covers different applications of augmented reality, mainly collaboration, construction, engineering, industrial and space planning.

**Success factors** In teleconferences [Kantonen et al., 2010], multitouch interaction setups [Seichter et al., 2009], or collaboration efforts between people (possibly situated at different locations), augmented reality can help display things that another participants can see. These collaborations can be greatly supported by augmented reality [Nilsson et al., 2009].

Maintaining equipment, such as an armored personnel carrier turret, can benefit from augmented reality by enhancing the view of the engineer with labels and instructions for reparations [Henderson and Feiner, 2009].

Industrial building acceptance is the process of determining whether a product that has been built is actually the one that was commissioned before final approval and payments are done. Augmented reality can help here by displaying a video image of the product and then overlaying a 3D model on top of it [Schoenfelder and Schmalstieg, 2008]. Some research brings together the mobile phone with industrial design applications. In [Hakkarainen et al., 2008], a mobile phone is used to help with assembly in a production line. The display functions as a manual by displaying a step by step guide for an assembly task.

A spatial augmented reality user interface is described in [Marner et al., 2009]. It is meant for an industrial designer applying digital airbrush to augment a physical model.

Augmented reality sees its use in space planning by displaying an overlay of a room or (enclosed) space. Technology can then be used to sort the space [DiVerdi et al., 2008] or for interior or architecture design or for factory layout [Lee et al., 2008]. This can also be applied in the outside world for use in civil engineering [Schall et al., 2008].

**Future outlook** Businessess and industries can have a great benefit by using augmented reality techniques. Quality control becomes much easier, as well as assembly or maintenance steps. Spacial planning is another area where augmented reality applications can be very convenient. Also, collaboration efforts by participants at different locations can become a lot easier.

When you already have a physical model, or it is easier to get a physical model, it could be more practical to use augmented reality techniques, other than rebuilding these models in a computer program.

### Medical

This section describes some medical applications of augmented reality. Both surgeons and patients can benefit from augmented reality technology, as described below.

**Success factors** Except for virtual reality practice environments for surgeons, the medical environment also features some augmented reality applications. Dangerously close to virtual reality comes a visualization environment in absence of direct vision. This ensures that a surgeon can still see what he is doing while not being able to see with his own eyes. Another application is using a see-through head mounted display that displays augmented reality information [Bichlmeier et al., 2008].

An important, recurring benefit of augmented reality is its use in training. Surgeons can learn to use an ultrasound by using an augmented reality ultrasound simulator [Blum et al., 2009a]. Employees working in a clinic can undergo training by using a physical representation of a patient, connected with a virtual patient for feedback [Blum et al., 2009b]. This way the trainee gets to work with a physical body while still getting feedback and not having to train on a live patient.

Some applications leaning quite to virtual reality include rehabilitation applications. Patients can use an augmented bicycle to recover from certain injuries or disabilities by cycling [Ranky et al., 2010]. Other applications are the use of a headset as equipment, but this can be considered as virtual reality instead.

**Future outlook** The medical world can use a lot of augmented reality applications. For rehabilitation of patients and training of personnel. However, especially specialists such as specialized surgeons are known to be reluctant towards changing their work methods, even if this can lead to their work becoming more efficient. Also the costs of such techniques are taken into account and are a reason for the lack of applications in actual support of surgeries and operations.

### Mobile phone

Technologies built for mobile phone devices have a lot of limitations hardware-wise. Another limitation is that applications developed for mobile phones have to keep into account the different types of mobile phones used and the different hardware specifications present on these devices. A developer can assume certain minimum specifications, knowing that an application that runs on a mobile phone equipped with better hardware will run smoother, but the developer will have to make a choice for these minimum specifications anyhow. However, the fact that a great many people nowadays have a mobile smartphone with augmented reality capabilities and that the mobile phone is cheaper to buy than e.g. a tablet PC makes the mobile phone a target for augmented reality application developers.

A lot of the augmented reality mobile phone technologies presented here are also applicable to other situations. However, in this case in the research they were specific applications of augmented reality on mobile phones.

**Success factors** A technology used and researched in some mobile phone augmented reality applications is marker tracking [Wagner et al., 2008]. This technology made augmented reality a viable technology in the early 2000's. Nowadays, research focusses on how to make augmented reality technologies need less obtrusive markers or none at all. Shape recognition and pose estimation are other technologies that are being researched [Hagbi et al., 2009]. This happens mainly by analysis of contour structures.

Some problems that are still present are the effects of augmented reality on depth perception. Objects that are away appear even farther away and appear to the user to be smaller than they actually are or should be [Jones et al., 2008].

Blur and smearing effects can be caused by moving the camera around wildly [Klein and Murray, 2009]. This can cause an augmented reality application to lose track of objects. Also equipping mobile phones with better camera's can help in dealing with these issues.

Most mobile smartphone users nowadays have heard of Layar (which is also discussed earlier in the paper). A different prototype mobile augmented reality client has been rsearched, which contains the real world with geospatial media sharing and social connection [Murphy et al., 2010].

It can also be done the other way around. A virtual world can be augmented by things from the real world [Laaki et al., 2010]. Especially social environments and games like Second Life can benefit from this. Users can enhance their characters and the world with real life objects they own (for example relics brought along in a vacation).

**Future outlook** Mobile phones continue to be an attractive target for augmented reality application developers, while they continue to be hampered by hardware specifications. Hardware does get better though, paving the way for more demanding and more interesting applications to be developed. Most of the issues discussed above can be dealt with up to a certain amount by applying certain techniques. However, is the mobile phone a great device for augmented reality? It is available to many people, but most people do not want to be walking around while holding a mobile phone in front of them for even a short period of time. This could also distract the application users from e.g. traffic.

### Multimedia

The multimedia aspects of augmented reality are discussed in this section. These include augmented reality books and entertainment such as gaming.

**Success factors** An interesting new entertainment idea is augmented reality books [Grasset et al., 2008]. This could be used for educational purposes (young children). It could also be used to enhance the experience of reading books like poetry books [Scherrer et al., 2008]. There it uses a computer screen to avoid head-mounted displays.

With some historical sites it is nice to see archaelogical ruins that have been dug up. However, wondering what it looked like in earlier times before it fell to ruin, an augmented reality system can show that. Yuangminguyan was a royal garden in China that was burnt down in 1860. Augmented reality technology was used to reconstruct what it looked like [Huang et al., 2009].

Another idea is using augmented reality for advertisement in shopping venues [Hurwitz and Jeffs, 2009]. Because the technology is still relatively new, using augmented reality in this way might get people's attention. It will be interesting to see whether these ways of advertising work.

In the gaming industry, board and tabletop games could be enhanced by augmented reality with additional digital content to increase the experience and enjoyment [Leitner et al., 2009].

Other gaming ideas include an augmented reality outdoor game based on Lemmings [Engelhardt et al., 2009]. This game needs human players to move physical objects around.

An augmented reality enhancement to massively multiplayer online games like Second Life are described in [Lang et al., 2008]. These games can be enhanced by taking virtual world and real world parts and blending them together with augmented reality.

An interesting game thought up is a game which can be used for city exploration [Herbst et al., 2008]. This shows a cultural use of augmented reality.

A magician could use augmented reality for one of his shows [Carreras and Sora, 2009]. This could entertain people because of its newness. The audience was pleasantly surprised.

Augmented reality weather is being researched based on use of weather effects in games [Heinrich et al., 2008]. This research could help make augmented reality gaming more realistic or otherwise more engaging.

**Future outlook** We do not yet see augmented reality books become a success as a consumer product because we see people either reading a book or enjoying a video experience like tv or a movie. For specialized cases such as a training center or for children's learning they might become more succesful.

The historical sites are a very interesting applications of augmented reality, as it provides users a better experience of feeling that they are present in a historically significant area.

About the gaming ideas, we are wondering whether they will really take off. Maybe a company specializing in providing an entertainment experience using augmented reality could become a succes, making it a more interactive experience than other ways of entertainment like going to the movies. More research has been done to gaming. [Phillips, 2009] proposes different type of games that augmented reality can play a role in. These include puzzle hunts for guiding people in a museum, battle chess based on the location of physical pieces and laser-tag games. Most of the suggestions are augmented reality enhancements to existing games or adding augmented reality gaming elements to things like tours.

**Navigation**

Navigation includes navigating outdoors such as in cars.

**Success factors** Some research has been done as how to make navigation through a building easier. A head-up display was used in one of these researches [Tnnis et al., 2008]. Different types of arrows were researched here to find out whether these kind of navigation cues are effective while navigating large distances.

Other kinds of navigation researched are for use in a car and using augmented reality to enhance the vision of the driver in its blind spots [Yoshida et al., 2008]. This is especially useful for trucks as there are regularly accidents with truckers and people that are located in one of its blind spots. Another research placed the augmented reality application outside to e.g. help in assisting a driver to see through an obstructed intersection [Barnum et al., 2009].

**Future outlook** We see augmented reality applications becoming succesful in its use in cars. Cars get made 'smarter' by technological enhancements with computers all the time anyways, so adding augmented reality to the newer developed cars is made easier. They make navigation easier and could prevent accidents.

### 19.7.4 Conclusion

Currently, a lot of research is done towards augmented reality. The existence of conferences purely dedicated to augmented reality shows that at the moment this field is hot in the scientific world. The academic world believes augmented reality is a growing field, likely to find many more applications soon and increase the use of the already existing applications.

Mobile applications and industrial applications are very popular. Medical applications are not that widely used yet but this can change as specialists learn how to benefit from using these techniques. Many of the mobile phone applications of AR could be extended to another kind of device. A visor seems like a logical solution to people not wanting to hold their mobile phones all the time while using an augmented reality application, but they are not practical and economical for consumers yet.

An entertainment park like “The Efteling” in the Netherlands could benefit from augmented reality. It could host an environment and then display a scene by means of augmented reality. This could help the park by advertising with new technologies as well as having an entertainment value for visitors.

The succesfactors and possible problems that have to be overcome for augmented reality to become more successful have been discussed in earlier sections. All in all, augmented reality will eventually not be held back by technological problems from becoming a success. Researchers will likely find ways around the issues that do exist. However, it remains to be seen whether consumers will actively use augmented reality applications. Business applications will be used.

## 19.8 Conclusion

Research question: What are success and failure factors from a business, user and technological perspective for an implementation of a business model framework for Augmented Reality applications?

The business aspect of AR applications has been discussed through the use of a business model framework. The research was aimed at finding a suitable framework, and then adapting it to be specialized to the AR domain. The framework we chose was the Osterwalder Business Model Ontology, as this is widely used and applicable to the domain, to some extent. For each of the nine elements of the framework, we found AR specific sub elements. All in all, this has lead to a new ontology of business models, that specializes Osterwalder’s original framework. In the sense of success factors, the framework shows what elements are to be considered for any business. Combined with the knowledge of what successful business models are (by looking at successful applications), this can lead to a new venture also being successful. Further research is needed to find out what combinations and implementations of the elements of the framework are in fact a success.

For the user aspect of Augmented Reality, there has been a focus on technology acceptance. An adjusted UTAUT questionaire has been used to determine technology acceptance of two specific augmented reality applications, which might be used to geralize for augmented reality applications in general. There were 49 useful responses to the questionare. The analyses of the results shows that for both applications the constructs Performance Expectancy and Attitue to Technology have a signification explanatory preditible value. Factors that play a role within these groups are usability, usefulness, fun and productivity. It can be prudently concluded that technology acceptance factors for Augmented Reality in the researched application domain are related to usability, usefulness, fun and productivity. These factors may play an important role for certain customer segments (people who are used to new technologies etc.), or applications with a specific value proposition (business applications).

The technical aspect of augmented reality has been discovered in the technical section of this paper. A quantitative literature study has been done, with emphasis on a small number of relevant conferences and journals. Of the papers that came out of the search query, the papers were selected on title and then on abstract. The papers were categorized and per topic the success factors and possible problems were discussed, as well as a short future outlook of that application. The number of 285 papers was reduced to a number of 47 that were eventually used as references in this paper. The findings are that augmented reality technologies still have some problems. However, none of those problems cannot be overcome or worked around from a technical perspective. User acceptance and actual relevancy of the technology therefore play a greater role in determining whether augmented reality applications will see more succes in the (near) future.

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# Appendix A: Questionnaire

### Performance expectancy (PE)

- PE1 I would find *Augmented Reality* useful in my daily life
- PE2 Using *Augmented Reality* enables me to accomplish tasks more quickly
- PE3 I find benefit in using *Augmented Reality*

### Effort expectancy (EE)

- EE1 My interaction with *Augmented Reality* would be clear and understandable
- EE2 It would be easy for me to become skillful at using *Augmented Reality*
- EE3 I find *Augmented Reality* technology easy to use
- EE4 Learning to operated *Augmented Reality* is easy for me

### Attitude toward using technology (AT)

- AT1 Using *Augmented Reality* is a bad/good idea.
- AT2 *Augmented Reality* makes work more interesting.
- AT3 Working with *Augmented Reality* is fun.
- AT4 I like working with *Augmented Reality*.

### Social influence (SI)

- SI1 People who influence my behavior think that I should use *Augmented Reality*.
- SI2 People who are important to me think that I should use *Augmented Reality*.
- SI3 In general, my environment supports the use of *Augmented Reality*.

### Facilitating conditions (FC)

- FC1 I have the resources necessary to use *Augmented Reality*.
- FC2 I have the knowledge necessary to use *Augmented Reality*.
- FC3 *Augmented Reality* is not compatible with other systems I use.
- FC4 A specific person (or group) is available for assistance with *Augmented Reality* difficulties.

**Anxiety (ANX)**

- ANX1 I feel apprehensive about using *Augmented Reality*.
- ANX2 It scares me to think that I could lose a lot of information using *Augmented Reality* by hitting the wrong key.
- ANX3 I hesitate to use *Augmented Reality* for fear of making mistakes I cannot correct.
- ANX4 *Augmented Reality* is somewhat intimidating to me.

**Behavioral intention to use *Augmented Reality* (BI)**

- BI1 I intend to use *Augmented Reality* in the next 6 months.
- BI2 I predict I would use *Augmented Reality* in the next 6 months.
- BI3 I plan to use *Augmented Reality* in the next 6 months.

**General questions**

- Additional questions about experience with technology, usage of applications, gender and age were asked.

# Appendix B

<table>
<tr>
<td rowspan="2">Key partners<br>Development technology provider<br>Software platform provider<br>Device manufacturer<br>Internet service provider<br>Application broker</td>
<td>Key activities<br>Designing software<br>Implementing software<br>Testing software<br>Fixing problems<br>Documenting problems</td>
<td rowspan="2">Value proposition<br>In situ, utility, training, social gaming, location layers, virtual demo, experiential education, enhanced classifieds, 3D virals, personalized shopping, cooperation, blended branding, augmented events, intertainment, understanding systems, recognition & targeting</td>
<td>Customer relationships<br>-</td>
<td rowspan="2">Customer segments<br>Manufacturers, architects, "smartphone"users, students, teachers, gamers, shop customers, shopkeepers, museums, zoos, educational institutions, business professionals, home entertainment users, mechanics, marketers</td>
</tr>
<tr>
<td>Key resources<br>Patents<br>Expertise<br>Devices<br>Staff</td>
<td>Distribution channels<br>Internet<br>Application brokers<br>Stores</td>
</tr>
<tr>
<td colspan="3">Cost<br>Staff<br>Internet hosting</td>
<td colspan="2">Revenues<br>Advertisements<br>Application fees</td>
</tr>
</table>

Figure 19.10: Structure of Key Resources for AR applications

# Chapter 20

# Toward the indoor use of location-based augmented reality

*Section by Mattijs Ugen*

## 20.1 Introduction

The meaning of the term mobile phone has broadened over the past few years. While a mobile phone today is still capable of making telephone calls from virtually anywhere, its capability to do things other than telephony has greatly increased.

The technologies introduced to the user of the mobile phone include among others bigger screens, increased processing power, mobile internet connectivity and a range of sensors. With the rise of these new technologies and capabilities, applications for mobile phones can provide the user with richer content and gather more information about the surroundings of the user.

A survey of the technologies available to the user of the mobile phone and the programmer of mobile applications is provided in section 20.5.


Figure 20.1: An example of the augmented reality browser Layar.

An example of an application that uses modern mobile phone hardware and capabilities in the Layar augmented reality browser[1]. Layar searches the internet for information on objects of interest nearby the user. Furthermore, Layar overlays the locations of interesting objects on the image of the phone's camera. If the user would turn around, the image changes with the user, showing the interesting objects in the new direction. Figure 20.1 shows an example of Layar, overlaying houses for sale in the city of Amsterdam on top of the phone's camera image.

[1] Layar augmented reality browser, www.layar.com/

The Layar augmented reality browser is a prime example of mobile use of augmented reality; it augments information from a remote source onto the reality that is displayed on the mobile phone's screen. Many more such applications exist, all following the basic principle of augmenting information on the slice of reality visible to the user.

The principle of augmented reality on a mobile phone has little limits; the information that is overlayed on the camera image is limited by the information available and the imagination of the developer. In practice, however, the technology used for determining the position of the user and the direction the camera is pointed is not very well suited for use indoors. Possible use cases for augmented reality indoors would be finding one's way inside a large building or displaying additional information about art objects in a museum.

## 20.2 Motivation

The most logical way for a mobile device to determine its location is the Global Positioning System. The use of the Global Positioning System—or GPS—relies on signals from multiple satellites orbiting the planet. As the phone receives precisely timed signals from these satellites, it can determine its position by triangulating the distances from the different satellites. This works great outdoors, but is not feasible within a large building; the reinforced concrete in the building's structure will disrupt the signals coming from outside. This disruption makes GPS unusable inside a building.

The direction a device is held can be measured with the use of a compass. As the compass relies on the magnetic field of the earth, however, this can become unreliable inside of a building. Reinforced concrete and even nearby metal objects are known to disrupt the earth's magnetic field locally, causing a compass to occasionally measure the wrong value. This creates a necessity for the aid of some other means of measuring direction inside a building.

The problems with both GPS and compasses makes the use of augmented reality on a mobile phone inside of a large building a challenge. As the uses for augmented reality are virtually limitless, enabling the use of it indoors would create opportunities for the technology in a new area.

## 20.3 Research questions

Focussing on using a mobile phone, the research question for enabling the use of augmented reality inside of a building, given the usability of GPS and a compass becomes as follows:

> *How can augmented reality be used inside a building using standard mobile phone hardware?*

As becomes clear from the previous section, there are two specific measurements that fail inside a building: position and direction. In order to enable the use of augmented reality inside, then, ways to measure these two aspects inside of a building are needed. An answer to the research question stated above thus involves two aspects:

**Positioning** How can a mobile phone determine its position inside of a building without the use of GPS?

**Direction** How can a mobile phone determine its field of view inside of a building without the use of a compass?

## 20.4 Method

In order to provide an way of determining the position and direction of a mobile phone inside of a building, a survey of the components in a mobile phone has been compiled. From this list, suitable candidates for measuring position and direction have been selected. The expected accuracy of these measurements will form the basis of an assessment whether the use of augmented reality inside of a building is feasible.

## 20.5 Available hardware components

To be able to make a selection on candidate components for position and direction measurements, a list of available components for mobile phones is needed. The term "mobile phone" encompasses a great variety of devices, ranging from simple cellular phones with little more than a microphone and a speaker to devices packed with communication and measurement components. For the scope of this research, however, the type of mobile phone capable of augmenting real time information on a live image from an embedded camera is considered.

A pair of well-documented mobile phones will be the continued example of currently available mobile hardware in this section. The selection of these devices is based on their wide use and known capability for augmented reality applications like Layar and Wikitude[2]. The two devices selected for this section are the *Apple iPhone 4*, called "iPhone" from here on, and the *HTC Magic*, called "Magic" from here on.

The iPhone and Magic differ in manufacturer and hardware design. Based on information from their respective manufacturers, a list of available hardware components or compatible technologies is presented Table 20.1. [Apple Inc., 2010b; HTC Corporation, 2009]

Both devices are capable of running mobile augmented reality applications as stated before, so there are many similarities between the two. The iPhone, however, being released over a year later, has more powerful hardware. While the speed of its central processing unit is not provided by Apple, it is rumoured to run at 1GHz; about twice as fast as the processor of the Magic. The same goes for the amount of memory available on the iPhone, which is rumoured to be 512 Megabytes, significantly more than that of the Magic. A second noteworthy difference is the availability of a gyroscope in the iPhone, providing an additional means of measuring motion. The difference in operating systems is of little concern; many popular augmented reality applications run on both iOS and Android and both have a programming interface to access any sensor available in the selected devices. [Apple Inc., 2010a; Google Inc., 2010]

[2] Wikitude, www.wikitude.org/

| | Apple iPhone 4 | HTC Magic |
|---|---|---|
| Released | July 2010 | April 2009 |
| Operating system | iOS 4 | Android 1.6 |
| Accelerometer | ✓ | ✓ |
| *GPS* | ✓ | ✓ |
| Bluetooth | ✓ | ✓ |
| Camera | 5 Megapixels | 3 Megapixels |
| *Compass* | ✓ | ✓ |
| Gyroscope | ✓ | ✗ |
| Memory | Undisclosed | 192 Megabytes |
| Screen size | 3.5” (960×640) | 3.2” (320×240) |
| Processor speed | Undisclosed | 528MHz |
| WiFi | ✓ | ✓ |

Table 20.1: List of hardware components for the Apple iPhone 4 and the HTC Magic

## 20.6 Usability of hardware components

As is discussed in section 20.2, the use of GPS and the compass in the iPhone and Magic is not feasible inside of a building. In stead, the position of the device and the direction it is pointed in have to be measured using other components in the list presented in section 20.5. This section outlines the use of some of these components for the tasks of measuring the required parameters.

### 20.6.1 Triangulation of wireless signals

The mobile phones introduced in section 20.5 both have wireless communication capabilities other than cellular telephony (which is not listed in the table). Wireless signals all operate on the same basic technique, broadcasting information as radio waves at a predetermined radio frequency. One of the well-known properties of this technique is that the strength of the signal that is broadcasted becomes weaker when the distance between the sender and reveiver becomes greater.

By using the Received Signal Strength Indicator—or RSSI—of a wireless receiver, the fraction of the power that is measured at the receiving end gives an indication of how far the receiver is away from the sender. When multiple such senders are present, the distances from each of these senders and the locations of these senders can be combined into an indication of the receiver’s current location. [Harney, 2009]

The following sections provide an insight into the usage of wireless technologies available to the mobile phones discussed in section 20.5 for location estimation and their feasibility for the scope of this research.

#### WiFi

WiFi has been around for quite a few years as a means to create wireless local area networks in buildings. Its presence in buildings makes it an iteresting candidate to use for triangulating the position of a WiFi-capable device.

A number of teams around the world have researched the feasibility and accuracy of measuring WiFi signals to determine the position of a device. Researchers from the university of Pittsburgh concluded that WiFi signals can be triangulated into a position and show the accuracy of such a measurement can be considered accurate to about three meters. However, the results also show that the impact of walls on the measurements increase the position error of the measurement, drifting up to five meters when two walls are between the WiFi sender and receiver [Prasithsangaree et al., 2002]. Similar researches in 2004 back these findings, but add the note that even the position of the person holding the WiFi receiver can influence the readings, increasing error margins, reducing the accuracy of the measured location [Kaemarungsi and Krishnamurthy, 2004; Bill et al., 2004].

As becomes apparent in all the results provided above, location measurement with WiFi signals has a typical accuracy of three meters in the most ideal situation. Taking the increased position error caused by walls and the user into account, it would seem that using WiFi for a position measurement suitable for augmented reality application inside a building is not feasible.

#### Bluetooth

Some research has gone into using bluetooth as a means to measure the position of a device between a number of bluetooth base stations. Experiments by Silke Fedlmann and others in 2003 lead to the conclusion that measurements in signal strength of bluetooth technology is indeed a viable way of triangulating the position of a device in an office space. In this case, measurements were accurate to about two meters [Feldmann et al., 2003]. A second publication in 2006 by Hiroyuki Ochi and others implements a similar approach, lining a room with bluetooth reference points also achieves an accuracy of about two meters [Ochi et al., 2006]. Another research in 2009 by Thomas King and others leads to approximately the same result; the accuracy achieved in measuring position with bluetooth is about two and a half meters [King et al., 2009].

All approaches use a fixed infrastructure of base stations—in the case of bluetooth often called “dongles”. The two German teams use a bluetooth capable mobile device with software to measure the signal strength, while the Japanese team prove the principle with a number of fixed devices. King’s research methodology is the more interesting for the scope of this research, as it experiments with the impact of a few variations in setup. The most notable variation is the use of extra bluetooth dongles, halving the position error from about five meters with the use of a single dongle to two and a half meters when eight dongles are used while at the same time reducing the standard deviation of the position error to just over a meter.

Concluding from the results provided above, it seems that bluetooth would indeed be a viable way to determine the position of a mobile device inside of a building. The average position error of two meters is however high compared to the something like width of a corridor inside a building. Whether this would be a problem when used in a real implementation depends on the use case; a user requiring information on what is at the end of the corridor would experience little trouble with a location error of two meters, but a user looking at the wall of the same corridor might.

As an advantage of bluetooth over the use of WiFi for positioning, a typical bluetooth dongle is relatively cheap, costing around ten euros at the time of writing. As the accuracy of the measured position increases with the amount of available reference points, installing many dongles in a building would enable an indoor positioning system for bluetooth capable mobile phones.

#### Location knowledge

The use of both WiFi and bluetooth signal strength to measure location relies on knowledge of the location of the reference points provided at the location where an augmented reality application is to be used. For real world usability, an augmented reality application needs to be able to obtain this information either from the infrastructure itself, by having the base stations broadcast their locations, or from some central service provided by the location where the application is to be used. The actual implementation of this information exchange is however beyond the scope of this research.

### 20.6.2 Motion tracking with accelerometers or gyroscopes

The direction in which a mobile phone is held can be measured using the phone's compass and accelerometer; the compass being responsible for the values concerning the horizontal plane, the accelerometer being capable of measuring the direction of gravity and thus the pitch of a device. An accelerometer can however also measure change in direction in the horizontal plane. Combining accelerometer measurements of motion with the known direction of a reference point, a new direction—relative to the reference point—can be determined.

A gyroscope—a sensor that remains stationary when the mobile phone is rotated in any direction—can be used to continuously read the difference between the current direction and a reference point.

Research by Peter Lang and other in 2002 showed the feasibility of using the combination of accelerometers and gyroscopes to track motion. As both accelerometers and gyroscopes suffer from a certain drift over time, some other system is necessary to periodically reset the reference point for the accelerometer and gyroscope [Lang et al., 2002].

### 20.6.3 Specific visual recognition

As a camera is required to augment information on reality represented by the image of the camera, the availability of a camera on a mobile phone can also be used to determine the current location or direction of the phone.

Visual markers, placed at locations of interest or at regular intervals, could provide a mobile phone with both its current location if the marker is recognized at being at a certain location and its direction as the user needs to be in front of the marker to accurately capture it with the camera.

Research into augmented reality games in 2007 demonstrates the use of visual markers to determine the phone's orientation [Rohs, 2007]. In 2002, an Austrian team implemented a tracking system using visual markers on a mobile device. This solution uses visual markers near prominent objects like doors and a knowledge base that maps these markers to locations in order to determine the device's location and direction inside of a building [Wagner and Schmalstieg, 2003].

The use of recognizing visual markers at certain locations is very useful as a reference point for other sensors. By aquiring a certain value for the current location and direction of the mobile phone, scanning a visual marker resets all drift on sensors that are used to determine the location and direction as the user of the application moves through a building.

### 20.6.4 Combining technologies

Because the principle of augmented reality requires both a mobile phone's location and direction, the techniques described above to determine both inside of a building need to be combined in order to complete the picture.

Looking at the two described alternatives to the Global Positioning System as the source for a mobile phone's location, it seems that the use of bluetooth signal strength triangulation is the most feasible.

The use of accelerometers and gyroscopes when available for tracking the motion of the mobile phone will provide an augmented reality application with the direction needed to determine the correct field of view. Occasionally resetting the reference point of the accelerometer and gyroscopes will counteract the drift these sensors experience over time.

The mobile augmented reality application Junaio has recently introduced the implementation of indoor augmented reality using the combination of visual markers and the sensors of a mobile phone that work inside of building. [Metaio Inc., 2010]

## 20.7 Conclusions

Looking at the proposed ways of measuring location and direction using available hardware on a mobile phone, an answer to the question stated in section 20.3 can be provided.

Determining the position of a mobile phone inside a building is possible using the triangulation of wireless signal strengths. Based on the research available, bluetooth would be the technology best suited for this job, as it provides a slightly better accuracy and cheaper implementation than WiFi. Visual markers also form a feasible way of determining the current location of the user.

Both approaches require knowledge of the location of either the base stations in range of the wireless receiver for using triangulation techniques or the visual markers.

Measuring direction in cases where the compass of a mobile phone can not be trusted can be accomplished using accelerometers, gyroscopes and visual markers. Where accelerometers and gyroscopes provide a live value for the direction, visual markers may be used to reset the drift on the sensors, occasionally providing a new reference point.

As both issues for using augmented reality on a mobile device indoors have been addressed, it can only be concluded that the use of augmented reality is possible inside of a building. It should be noted, however, that the accuracy of the user's position inside of a building is in some cases required to be higher than in the outside world. In a three meter wide corridor, for example, a location error of three meters could put the user in an office adjacent to the corridor in stead on in the corridor itself. Augmenting information about the office in stead of the corridor would confuse the user at this point. Because of this, it is hard to say whether augmented reality would provide the same user experience indoors than it would outdoors.

## 20.8 Future work

Although the research results provided in section 20.6 make it apparent that augmented reality applications could be used inside of a building, these statements have to be checked in the real world shed light on the provided user experience. Implementing the proposed methods for determining a mobile phones location and direction will show the real world feasibility of indoor mobile augmented reality. A real world implementation could also uncover additional issues that need to be addressed before the user experience of indoor mobile augmented reality matches that of the use outdoors.

Furthermore, a real life implementation of the methods proposed in this paper could be compared to the implementation of Junaio's indoor methods, which Metaio claims to be absolutely accurate [Metaio Inc., 2010].

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# Chapter 21

# How augmented reality can help safety

*Section by Steven Sybenga*

## 21.1 Abstract

In this paper, different types of accidents are analyzed to see what the main causes of these accidents are. Most of the accidents are driver errors and therefore there might be an opportunity to use new technologies like augmented reality (AR) to help drivers.

In section 21.3.1 the different types of accidents and the main causes are explained. Section 21.3.2 gives a description of augmented reality and which augmented reality systems are currently on the market to help drivers. Section 21.3.2 and section 21.3.2 will give the advantages and disadvantages of these systems and the us of AR in cars in general. Finally, in the conclusion (section 21.4) future possibilities are given that do not have the disadvantages of the systems mentioned earlier.

## 21.2 Introduction

Augmented reality (AR) used in traffic might be a technology that could decrease accidents. There are different types of augmented reality, one of them is visual augmented reality but even this type has different forms. In this paper, possibilities, advantages and disadvantages of the use of AR will be mentioned.

### 21.2.1 Motivation

Augmented reality is being used in several disciplines nowadays but the use of it in traffic is rare. Road traffic injuries put significant strain on health care budgets. For everyone killed, injured or disabled by a road traffic crash there are countless others deeply affected. Many families are driven into poverty by the cost of prolonged medical care, the loss of a family breadwinner or the extra funds needed to care for people with disabilities. Road crash victims, their families, friends and other caregivers often suffer adverse social, physical and psychological effects. That is why it might be interesting to analyze the use augmented reality it this sector.

### 21.2.2 Research question

The research question of this paper will be:

| |
|---|
| *How can the use of visual augmented reality help to prevent road accidents* |

To be able to answer this question the following sub-questions have to be answered:

- What type of accidents occur the most?
- What are the costs, causes and consequences of these accidents?
- What is augmented reality?
- In what way is augmented reality already used in traffic and how do they decrease traffic accidents?
- What are the advantages and disadvantages of the use of augmented reality in vehicles?

Answers on the mentioned questions will be given after reading literature and internet studies.

## 21.3 Results of literature research

Road traffic crashes cause over 1.27 million deaths a year worldwide and are the second leading cause of dead [1][GRSP, 2008]. Apart from laws and regulations more and more technological innovations are used to help reducing traffic incidents. Anti-lock Braking System (ABS), Driver Alert Control (DAC), Lane Departure Warning (LDW) and Side Collision Prevention (SCP) are good examples of such modern safety precautions. Even with the help of these systems the most accidents happen due to mistakes of the drivers. Therefore it is necessary to search for more opportunities and chances to help the driver by providing him or her with information or warnings. Augmented reality is a technology that shows information for pilots but is not used regularly in cars yet.

Research of the World Health Organization concludes[2]:

- Road traffic crashes kill 1.2 million people a year or an average of 3242 people every day;
- Road traffic crashes injure or disable between 20 million and 50 million people a year;

[1] http://www.who.int/violence_injury_prevention/road_traffic/en/
[2] http://www.who.int/violence_injury_prevention/road_traffic/en/

- Road traffic crashes rank as the 11th leading cause of death and account for 2.1% of all deaths globally.

It is estimated that every year, road traffic crashes cost:

- US$518 billion globally;
- US$65 billion in low-income and middle-income countries, exceeding the total amount received in development assistance;
- between 1% and 1.5% of gross national product in low-income and middle-income countries;
- 2% of gross national product in high-income countries.

### 21.3.1 Types of accidents

"Nearly 80 percent of crashes and 65 percent of near-crashes involved some form of driver inattention within three seconds before the event. Primary causes of driver inattention are distracting activities, such as cell phone use, and drowsiness."[3]

There are three kinds of accidents that have to be distinguished in favor of this paper:

- Single vehicle accidents
- Non-motorist accidents
- multiple vehicle collision

There are more types of accidents like a collision between a train and a vehicle but as these accidents happen rarely, they will not be taken into account.

#### Single vehicle accidents

A single vehicle accident is an accident in which only one vehicle is involved. A vehicle crash against a tree is an example of a single vehicle accident. The causes of these accidents are often alcohol, drowsiness, speed, bad vision (visibility of the road) or a mechanical failure.

#### Non-motorist accidents

A vehicle-pedestrian or a vehicle-cyclist accident can be seen as a non-motorist accident.

In 2008, 4,378 pedestrians were killed and 69,000 injured in traffic crashes in the United States. Most pedestrian fatalities occurred in urban areas (72%), at non-intersection locations (76%), in normal weather conditions (89%), and at night (70%)[4].

Bad visibility of the pedestrian or cyclist is often the main cause here along with alcohol, drowsiness, speed and distraction.

[3] http://www.nhtsa.gov/
[4] http://www.nhtsa.gov/

### Multiple vehicle collisions

Research of the NHTSA (see figure 21.1) shows that the most occurring collisions are front-to-side (T-bone), front-to-front (head-on), Front-to-side (opposite direction) and front-to-rear (rear-end)

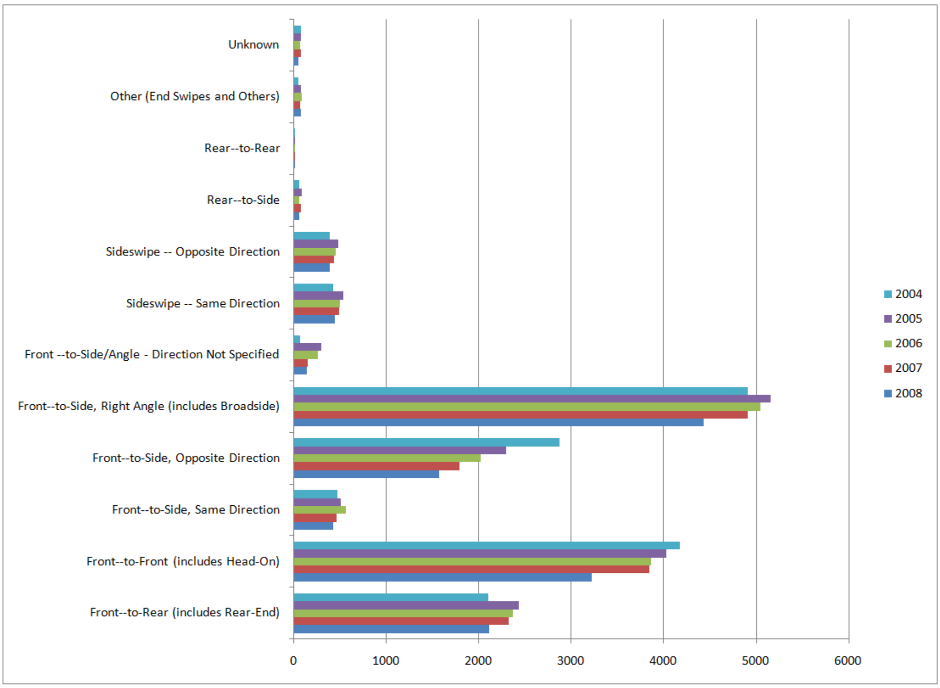


Figure 21.1: types of collisions

**Front-to-side collision** The Fatality Analysis Reporting System (FARS) of the National Highway Traffic Safety Administration (NHTSA) distinguishes three different types of front-to-side collisions:

- **T-bone**: where one vehicle rejects to yield and crashes into the side of another vehicle.
- **opposite direction**: where one vehicle fails to give way to a vehicle coming from the opposite direction
- **same direction**: where one car overtakes another while he turns left

**Front-to-front collision** Typical front-to-front or head-on collisions are when one driver hits an upcoming car while taking over or is at the wrong side of the road for any other reason. Driving into a one-way street in the wrong direction might also result in a head-on collision.

**Front-to-rear collision** Traffic jams can cause a front-to-rear collision when a driver sees the stopped traffic too late. Another cause of a front-to-rear accident is when one car is tailgating and the first car has to make an emergency stop.

#### Conclusion

In 90% of all traffic crashes driver negligence is the main contributor. "Nearly half of them are related to driver inattention, perceptual errors, or decision errors."[Lincoln et al., 2010] Darkness, fog or other circumstances that limits the vision of the driver are not in the top of this list. However, it can not be underestimated as it is often a combination of these causes that lead up to an accident. Late in the evening for example, when a driver is tired he might hit a pedestrian. The pedestrian is harder to see in the dark and the driver might have been able to see him or her in time if it was broad daylight. Furthermore, except for single vehicle accidents, there has to be someone else on the streets and therefore an accident is less likely to occur at 03:00h than at 17:00h [Schoettle, 2004]. Schoettle's Research shows that having a rear-end collisions in darkness is 2.4 times bigger than in daylight. For side and front-end collisions these numbers are respectively 1.1 and 1.2 times bigger.

### 21.3.2 (virtual) Augmented reality

According to Azuma et al. [1997] augmented reality (AR) is a variation on virtual reality (VR). VR is a technology where the user is in a virtual environment (VE) and cannot see and interact with the real world anymore. On the other hand, AR allows the user to see the real world with the virtual objects 'placed' in it. In short: "AR can be thought of as the 'middle ground' between VE (completely synthetic) and telepresence (completely real)".

For virtual AR at least any type of sensor is required, a camera or laser for example. Furthermore a computer and a display to display the virtual objects. This can be a computer screen (LCD), a window or see-through glasses.

#### Current use of AR in vehicles

There are two types of augmented reality currently in development or in use. One of these types is displaying critical information. Critical (or less critical but distracting) information is in most cars visible on different places. Looking at the speedometer and navigation for instance distracts the driver and is a moment where the driver is not looking what happens in front of him. With the help of augmented reality this critical information can be seen while looking at the road ahead. As for inattention, perceptual errors and decision errors can be reduced with the help of augmented reality [Lincoln et al., 2010]. Some examples are microvision[5] displaying for instance speed and navigation information (see figure 21.2) or the Opel insignia, with the 'Opel eye' which recognizes road signs and displays it.

The other type can be seen as an extension of the drivers view. General Motors is experimenting with a system where the side of the road is displayed on the windscreen[6]. The use of this system might reduce the number of single vehicle accidents in darkness or foggy weather.

[5] http://www.microvision.com/vehicle_displays/

[6] http://www.wired.com/autopia/2010/03/gm-next-gen-heads-up-display/


Figure 21.2: Microvision

Pedestrian recognition is another example. BMW has a system where infrared cameras detect humans and displays a warning sign and the thermal images on a LCD screen[7] (see figure 21.4).

### Advantages and disadvantages of these systems

The possibility to 'keep your eye on the road' is one reason why a system (like Microvision) displaying the current speed and other information on the windscreen can reduce traffic accidents. The traffic sign detection displays the traffic sign on the dashboard. This might result in distraction where the driver looks at his dashboard even more. However, accidents due to speed can be reduced this way.

The augmented reality system as can be seen in figure 21.3 has his advantages and disadvantages too. One advantage is better visibility of the road, especially in dark and foggy conditions. A disadvantage is the perception error which occurs when the system does not track the movement of the drivers head resulting in a misplaced object (e.g. line) and can be even more dangerous than driving without the system.

The pedestrian recognition can reduce the number of pedestrian fatalities by warming the driver. The consequence of this system is an increase in distraction for the driver. Looking at a warning on the LCD screen means the driver is not looking at the road in front of the car anymore. And the other way round, if the driver looks at the road critical information on the LCD might be missed.

### General disadvantages

The offset hypothesis predicts that users of new safety precautions will become more reckless [Winston et al., 2006]. Users of a system projecting thermal images in foggy conditions might drive faster than those without this system. This might be a prediction and therefore not be the case in this particular situation but it can be an negative consequence.

[7] http://www.bmwblog.com/2008/06/05/improved-night-vision-for-next-2009-bmw-7-series/

Figure 21.3: General Motors

Users of such systems might rely on a system too much. There can always be a situation where a system fails. If a driver does not has his attention to the other traffic anymore because he thinks he will be warned when he has to take action, he might have a problem when a system fails.

Another disadvantage is the information displayed. Too much information can distract or blind the drivers view and can cause serious danger (see figure 21.5[8]).

[8]http://www.wired.com/culture/culturereviews/magazine/16-01/found

Figure 21.4: BMW Pedestrian detection

## 21.4 Conclusion

Most of the accidents are caused by errors of the driver especially distraction, perceptual errors and decision errors.

The augmented reality already used in cars is primarily displaying information on the windscreen or an extension of the drivers view on an LCD screen or dashboard. There is no data whether these systems reduces the number of accidents. 'The offset hypothesis' predicts that such systems might even result in more reckless driving.

Instead of displaying the information on the windscreen or a LCD-screen, a head mounted display might be a possible solution to tackle the perception error and the distraction of the LCD-screen.

Some other interesting systems might be:

- one displaying the distance between the cars to prevent tailgating. Colors can be used to warn the driver being to close;
- one displaying the movement or speed of a car in front. For instance an arrow when a car indicates a turn or a note of exclamation above a car with emergency lights on.


Figure 21.5: Too much information

## 21.5 References

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# Chapter 22

# A survey of XML languages for augmented reality content

*Section by Thomas Visser*

## Abstract

In this paper, a survey of XML languages that are used to store content for augmented reality (AR) applications is presented. The goal of the study was to assess the possibilities for standardising the format of AR content to enable interoperability between different AR browsers. There are AR browsers that use a XML language based on KML, an existing standard, others use their own XML language or do not use XML. It was shown that none of the four treated XML languages did comply to all requirements that were gathered from the analysis of three AR browsers. ARML and KARML, both extensions of KML, were too limited in their functionality, and Junaio XML, which adhered to the most requirements, did reinvent aspects that could have been taken from KML. Further progress into creating a standard for AR content could be made by extending ARML or KARML or by rewriting Junaio XML as an extension of KML.

## 22.1 Introduction

Augmented reality (AR) has been an area for research for the last forty years. Only in the last two years, AR technology has found its way on a large scale to the consumer. After the introduction of the HTC Dream in 2008, the first mobile device with GPS, compass, accelerometer, camera, sufficient processing power and an open development platform, AR browsers came into existence which allowed consumers to view the world around them, augmented with all sorts of information [Lechner and Tripp, 2010].

An AR browser is an application that displays content on top of a view of the real world. Current AR browsers use the window-on-the-world approach, where a non-immersive display is used to display mixed reality [Milgram and Kishino, 1994]. This approach of augmented reality, as opposed to head-mounted-displays (HMD) or see-through HMDs, has been brought to the consumer using mobile devices, e.g. smartphones. The camera input is displayed on the screen, providing a window-on-the-world and is augmented with

AR content is information that is relevant to a certain location, also called a point-of-interest (POI). This information could entail a description of the location, contact information for the restaurant at that location, an image, a 3d model or an audio- or video fragment. An AR browser will display the content at the specified location to users who are near to that location.

Currently, each AR browser uses its own way to store AR content and to serve the content to the browser. However, in order for AR to become a mature, application independent platform where content providers, e.g. a company's marketing department, can push content to without having to adapt that content to every application, standardisation is required. Users then would be able to choose their AR browser based on its functionality and not on its content, as is the case with internet browsers today.

This paper presents the results of a literature study on the existing options for creating a standardised AR content specification. The study focussed on XML based languages. First, the features of current widely used AR browsers were assessed in order to get an insight in what requirements they impose on the content specification. This can be found in section 22.2. Then, existing XML languages for AR browsers, including standardisation attempts, were explored, as can be found in section 22.3. This paper continues with a discussion (section 22.4) of the XML languages against the requirements that were gathered, followed by a summary of the most important findings.

## 22.2 Requirement analysis

In this section, three AR application will be discussed to give an insight in the features of these applications and what requirements they thereby pose on how the content is specified. This is by far not an exhaustive list, many more applications exist, on mobile devices as well as on other platforms. The three applications do however represent three different approaches to storing AR data: 1) using a (proposed) XML standard, 2) using a custom XML language and 3) data storage other than XML. The selection of the applications was made based on their commercial success and role in the standardisation of AR data storage formats. All three applications are being developed by promising start-ups[1]. Mobilizy, the creator of Wikitude, Metaio, the developer of Junaio, and SPRX Mobile, the creator of Layar, are three of the eight founding companies of the AR Consortium[2]. The AR Consortium provides a forum for members to meet and talk about emerging standards and protocols.

[1] see http://social.venturebeat.com/2009/07/03/startups-push-augmented-reality-apps-to-market/

[2] see http://www.arconsortium.org/

### 22.2.1 Wikitude

Wikitude World Browser[3] is a mobile AR viewer developed by Mobilizy. Wikitude is available for mobile devices with iOS, Android and Symbian. The application displays points of interests (POIs) as floating icons on top of the camera view. The user can tap or click on an icon to view a description, link to a webpage, address or phone number. POIs are grouped into Wikitude Worlds. A user can subscribe to one or more worlds; only POIs in subscribed worlds are shown in the viewer. Every world has an accompanied icon, which is displayed at its POIs. An example of a world is the eduroam world. This world contains a POI at every eduroam wireless accesspoint location, describing the access point's name and WPA key. Mobilizy allows third party creation of Wikitude worlds. They created their own data format, ARML (Augmented Reality Modelling Language), in which these worlds have to be specified. Section 22.3.2 will discuss ARML in more detail.

### 22.2.2 Layar

The Layar Reality Browser[4], by SPRX Mobile, was launched in 2009 for iOS and Android capable devices. In June 2010, the company announced that their product will be pre-installed on 75% of the phones shipped around the world[5]. On top of the mobile phone's camera view, Layar displays POIs. A POI can be displayed as a simple solid coloured disc, an icon or a 3d-model. POIs are grouped into layers, similar to the Wikitude World notion, which Layar users can subscribe to. By clicking on a POI, more information is shown. POIs can also have actions linked to them, e.g. playing audio or video, launching another application or calling a phone number, which can be triggered when the user is within a given range. Third party developers can create layers for the Layar platform. A layer consists of a specification, which has to be sent to Layar and is then hosted on their server, and the content of the layer, the POIs, which has to be served from a web service returning JSON structured data.

### 22.2.3 Junaio

Junaio is Metaio's take on an AR browser[6]. Junaio has an extensive feature-set and it distinguishes itself most from the other applications by supporting AR in places where there is no GPS reception and a compass would not work, e.g. inside a building. In addition to positioning a POI using GPS coordinates, Junaio also supports positioning relative to a natural feature or AR marker. On Junaio's website, an image of a feature or marker can be transformed in tracking xml. Tracking xml is an encrypted representation of the input image and is used by the optical analysis of the AR browser that tries to find the feature in the camera view. Individual POIs with a 3d object can be 'glued' to the feature. Channels and POIs for Junaio are specified in a Junaio specific XML language.

Like Layar, Junaio supports POI with audio, video and 3d models. In addition to that, Junaio supports animated 3d objects. It is also possible to define what

[3]see http://www.wikitude.org/

[4]see http://www.layar.com/

[5]see http://mobile.venturebeat.com/2010/06/18/layars-augmented-reality-footprint-grows-to-one-third-of-global-smartphones/

[6]see http://www.junaio.com/

should happen when a user taps/clicks on a POI; the animation could change or the server could be asked for new xml that changes or replaces the clicked POI.

Because of the comprehensive feature-set and the open API, a rapidly growing group developers choose Junaio as their development platform[7].

### 22.2.4 Conclusion

From the discussion of the three applications above follow several requirements for an AR content XML language. The language should support all functionality that is currently present in the AR browsers. The requirements can be found in table 22.2.4.

| R# | Requirement: The language should be able to... | Wikitude | Layar | Junaio |
|---|---|---|---|---|
| R1 | define a POI with a location, name and description | yes | yes | yes |
| R2 | define a POI with phone number and address information | yes | yes | yes |
| R3 | define a 3d model for a POI | no | yes | yes |
| R4 | define multiple representations for a POI, which are shown depending on the distance of the user to the location | no | yes | yes |
| R5 | define a style for a group of POIs (i.e. world/layer/channel) | yes | yes | yes |
| R6 | define user interaction and its effect for POIs | no | yes | yes |
| R7 | define the location of a POI based on a natural feature or marker | no | no | yes |
| R8 | define animation behaviour of a 3d model | no | no | yes |

Table 22.1: Requirements for an AR content XML language, together with from which application they follow

## 22.3 Specifying AR content in XML

In the previous section it was shown that XML is already being used to store AR content. The two discussed XML supported applications differ in functionality. In this section, the differences in the underlying XML will be discussed. On the one hand, the Wikitude World Browser supports ARML, an extension of KML that was designed by Mobilizy as a new AR XML standard and on the other hand, Metaio uses a XML language that was designed for Junaio specifically. Before discussing ARML, Junaio XML language (referred to as 'Junaio XML' from now on) and KARML, another KML based AR language, a short introduction in KML is given.

### 22.3.1 KML

KML (formerly Keyhole Markup Language) is a XML based language that is used for geographic visualisation, e.g. the annotation of maps. KML was originally developed by Keyhole Corp. for their Keyhole Earth Viewer. In 2004, Google Inc. acquired Keyhole Corp. Within the year that followed, Google released a

[7]see http://www.arvertising.com/news/2010/04/rich-features-of-junaio-cause-rush-in-developer-sign-up/

new version of the earth viewer under a new name: Google Earth. [goo, 2004] Google continued developing KML and submitted the specification of KML 2.1 to the Open Geospatial Consortium Inc. The OGC is an international industry consortium of 399 companies, government agencies and universities participating in a consensus process to develop publicly available interface standards [8]. The current KML specification, version 2.2, is mainly based on Google's submission the and was adjusted for harmonisation with existing OGL standards, especially GML (Geography Markup Language, in collaboration with the International Standardisation Organisation (ISO)).

**Example**

The example below contains a KML document with one placemark, i.e. a POI. The most simple definition of a POI consists of a name, description and point location. In addition to a point, a POI can also be defined as a polygon or 3d model.

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://www.opengis.net/kml/2.2">
  <Placemark>
    <name>Zilverling</name>
    <description>
      Building 11 of the University of Twente
    </description>
    <Point>
      <coordinates>6.856869,52.239200,0</coordinates>
    </Point>
  </Placemark>
</kml>
```

### 22.3.2 ARML

ARML (Augmented Reality Markup Language) is an extension to KML that was presented in early 2010 by Robert Rice and Mobilizy, the company behind the Wikitude World Browser. The creators argue that KML lacks information that is essential for the AR user experience, e.g. the address information and phone number of POIs [Lechner and Tripp, 2010]. Within KML, this information can be provided in the description tag, but in order for an AR browser to provide a 'dial this POI' feature, the contact information should be provided in a machine-readable manner. Therefore, they introduce a number of tags, contained in the `ar` namespace, to do this. They also add the notion of content provider; each place-mark is linked to one of the providers, which are defined at the top of the document. The listing below shows an example content provider.

```
<kml xmlns="http://www.opengis.net/kml/2.2"
        xmlns:ar="http://www.openarml.org/arml/1.0">
        <Document>
                <ar:provider id="UT_CP">
                        <ar:name>
```

[8] http://www.opengeospatial.org/ogc

```
                    University of Twente
              </ar:name>
              <ar:description>
        The University of Twente is where talent
        can best realise its full potential. Students
        and staff are the key.
              </ar:description>
              <wikitude:providerUrl>
                    http://www.utwente.nl
              </wikitude:providerUrl>
              <wikitude:tags>
                    university, twente
              </wikitude:tags>
              <wikitude:logo>http://www.utwente.nl/
        media/images/logo_en-US.gif</wikitude:logo>
              <wikitude:icon>http://www.utwente.nl/
        media/images/logo_en-US.gif</wikitude:icon>
        </ar:provider>
        ...
    </Document>
</kml>
```

Each placemark contains a `provider` tag, which corresponds to the id of one of the defined providers:

`<ar:provider>UT_CP</ar:provider>`

This enables the AR application to show provider specific information at the corresponding place-marks, separate layers/channels/worlds (‘layers’ from now on) from providers and allows one file to contain data from multiple providers or contain multiple layers.

The authors of ARML argue that the full KML specification is not relevant for AR purposes. ARML is therefore an extension to only a subset of KML tags. The proposed standard is currently being reviewed by the W3C Point of Interest Working Group[9].

### 22.3.3 KARML

From the Augmented Environments Laboratory, part of the Georgia Institute of Technology School of Interactive Computing, comes another AR extension to KML: KARML[10]. KARML is part of the KHARMA (KML/HTML Augmented Reality Mobile Architecture) architecture.

The authors identify the lack of styling options for place-marks as the most important limitation of KML. KARML also enables more advanced placement of place-marks. One could not only define a location in absolute coordinates, but also relative to another place-mark, or the user itself. The authors also added the possibility to define place-markers relative to trackable features, e.g. markers or objects. The actual tracking is left to the AR application.

[9] http://www.w3.org/QA/2010/06/point_of_interest_working_grou.html

[10] https://research.cc.gatech.edu/polaris/content/karml-reference

KARML is an extension to the full KML 2.2 specification, including the Google KML extension [11]. This extension adds more advanced styling options, extensive fly-over tour specification and the definition of audio cues to KML documents.

### 22.3.4 Junaio XML

The content for Metaio's AR browser, junaio, is specified in their own xml language[12]. The example below specifies a point-of-interest in a straightforward manner:

```
<?xml version="1.0" encoding="UTF-8"?>
   <results>
      <poi id="hello_world"
interactionfeedback="none">
         <name>Waaier</name>
         <description>UT Waaier.</description>
         <author>Thomas Visser</author>
         <l>52.239200, 6.856869</l>
         <maxdistance/>
         <mime-type>text/plain</mime-type>
         <thumbnail/>
         <phone />
         <mail/>
         <homepage />
      </poi>
   </results>
```

The empty tags in the example can be filled in to provide more information to the client. With Junaio XML, a POI can be defined as a piece of text (e.g. in the example above), an image, a video or audio stream or a 3d model. When the results tag links to tracking xml (using the `trackinurl` attribute), the POIs it contains are placed relative to the tracked feature.

Junaio XML does not extend existing XML specifications, but is instead a new language, similar to KML but created especially for AR.

## 22.4 Discussion

In order for a XML language to be a good standardisation candidate, it should be suitable for major AR applications and be able to support their features. In section 22.2, these features were assessed and caught in a set of requirements. Table 22.4 shows which the XML languages satisfy to the postulated requirements.

KML only supports the basic location annotation and lacks AR specific features, only satisfying two requirements. It is an extensive standard, but the majority of its features are not relevant for AR purposes. It works well for earth viewers, e.g. Google Earth, and might see developments in the direction of AR, if Google would choose to combine Google Earth with Google Streetview. However, currently KML only little of KML can be used for AR, and much of it is not relevant.

[11] see http://code.google.com/apis/kml/documentation/kmlreference.html
[12] see http://www.junaio.com/publisher/serversetup

| R# | Requirement | KML | ARML | KARML | Junaio XML |
|---|---|---|---|---|---|
| R1 | define a POI with a location, name and description | yes | yes | yes | yes |
| R2 | define a POI with phone number and address information | no | yes | no | yes |
| R3 | define a 3d model for a POI | yes | no | yes | yes |
| R4 | define multiple representations for a POI, which are shown depending on the distance of the user to the location | no | no | no | yes |
| R5 | define a style for a group of POIs (i.e. world/layer/channel) | no | yes | no | no |
| R6 | define user interaction and its effect for POIs | no | no | no | yes |
| R7 | define the location of a POI based on a natural feature or marker | no | no | yes | yes |
| R8 | define animation behaviour of a 3d model | no | no | no | yes |

Table 22.2: An overview of which requirements are met by the discussed XML languages.

The functionality added by ARML makes it to satisfy three requirements. The notion of content providers enables the styling of groups of POIs and allows e.g. branding of content by a company. ARML, being an extension of only a subset of KML, however loses support for 3d models. The KML tags that are required for the inclusion of 3d models are not in the subset of tags that ARML is based on. In its current state, ARML would not be able to fulfil the needs of Layar and Junaio.

KARML extends the complete KML specification and thereby includes the use of 3d models. It does however lack the additional tags regarding contact information. KARML does have support for natural feature based locations (R7). The tracking itself is left to the AR browser, but KARML data could be used in a environment where GPS and compass are unavailable. A disadvantage of KARML is that if an AR browser would want to support full KARML, it would have to support the complete KML specification, which contains many irrelevant tags or even tags of which the meaning is unclear in the AR context (e.g. `lookAt` and `camera`).

Junaio XML satisfies the most requirements of all discussed XML languages. This can be explained by the fact that the Junaio browser is the most feature rich of the ones that were used during requirement analysis. Junaio does however have some useful AR features that could well be implemented in other browsers in the near future. Junaio XML lacks the capability of defining style for a group of POIs. This could be achieved by porting the content provider concept from ARML tot Junaio XML. A disadvantage of Junaio XML is however that it does not use existing standards. Junaio XML could however be modified to be an extension to a subset of KML, the subset being larger than the subset ARML used.

## 22.5 Conclusions

In this paper, the results of a literature study on existing options for creating a standardised AR content specification were presented. It was shown that none of the four treated XML languages did comply to all requirements that were gathered from the analysis of three AR browsers: Wikitude, Layar and Junaio. From the four XML languages, ARML and KARML did extend an existing standard (KML, also treated as one of the four languages) and Junaio XML was designed especially for an AR browser. The latter did meet the most requirements, but reinvents aspects that could be taken from KML. The two languages that were based on KML were limited in functionality and would not be useable for all AR browsers. Two options for further progress in the creation of a standard for AR content can be pursued: increase the feature-set of KML based languages or respecify Junario XML as an extension of KML.

## 22.6 References

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URL `http://www.google.com/press/pressrel/keyhole.html`

Lechner, M. and Tripp, M. *ARML - An Augmented Reality Standard.* 2010.

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# Chapter 23

# The future directions of mobile augmented reality applications

*Section by Ties de Kock*

## 23.1 Introduction

Augmented Reality (AR) is the augmentation of the visual field of a user by enhancing the current field of vision with additional information Caudell and Mizell [1992].

A mobile AR systems (MARS) is defined as a system which Papagiannakis et al. [2008]:

- Combines real and virtual objects in a real environment;
- Runs in real time and mobile mode;
- Registers(aligns) real and virtual objects with each other and
- The virtual augmentation is based on dynamic, 3-D objects (e.g. interative, deformable virtual characters).

These systems very in display type, reality, immersion and possible interactions. These differences influence their place in the mixed reality continuum Milgram [1995]. All applications discussed in this paper will use monitor based displays. Most applications will use (video) images of the real world as their substrate and show the world from a egocentric perspective. The applications will differ in reproduction fidelity, extent of presence and type of usage.

## 23.2 Motivation

The recent rise of smartphones[1] has sparked the development of multiple MARS and the market for MARS has been growing rapidly, with an estimated size of more then 400 million downloads in 2014[2].

The quick evolution of these applications warrants a overview of the current products in the market and an overview of recent technologies that have not yet made the transition from science to market.

In order to provide this overview a selection of popular and innovative applications is provided. Some of these are not classical AR applications. However, all the applications present an augmented version of the real world. The techniques used in these applications will be evaluated. Afterwards, techniques from selected papers and the relevant papers from the proceedings of the International Symposium on Mixed and Augmented Reality (ISMAR) 2006-2009 will be discussed.

## 23.3 Research Question

With a focus on mobile augmented reality using a mobile phone, the research questions follow logically:

*What are the future directions of mobile augmented reality applications?*

As discussed in the previous section, there are two specific subquestions that need to be answered:

**Market** What current MAR's are successfull;

**Techniques** What techniques are currently used in MAR's;

**Future techniques** Which techniques will appear in MAR's in the recent future?

## 23.4 Current Applications

A selection of applications will be discussed. Afterwards, we will present a overview of the technologies used in these applications.

Google Goggles, Google Navigation, Layar and Sekai Camera have been chosen because their popularity in app stores on the 7th of July 2010. Acrossair, Junaio, Toozla, Waze and Wikitude Drive have been selected due to their innovativeness.

### 23.4.1 Acrossair

Acrossair is a company that produces iPhone applications. In July of 2009 they launched the first variation of their augmented reality browser, the New York nearest subway application[3]. A mockup of this application can be seen in figure 23.1.

[1] `http://communities-dominate.blogs.com/brands/2010/07/an-8-segment-model-to-analyze-smartphone-market-consumers-and-handsets.html`
[2] `http://juniperresearch.com/viewpressrelease.php?pr=176`
[3] `http://www.acrossair.com/apps_newyorknearestsubway.htm`

A second application is a (paid) browser to view the nearest wikipedia content, NearestWiki, which can be seen in 23.2. Creating a paid app that enables users to view (creative commons) wikipedia content is considered harmfull by some reviewers[4].

The Acrossair AR browser is also used as a frontend for third party data sources. In contrast to most other AR browsers, Acrossair does not allow third parties to add their own point of interest sets.

Acrossair is a iPhone only application, which makes full usage of the iPhone's possibilities. The latest release of their software includes support for the iPhone 4G's gyroscope and the iAd platform[5]. The gyroscope gives a better experience indoors then the compass which most other applications use.

Figure 23.1: Acrossair nearest subway


Figure 23.2: Nearest wikipedia entry

### 23.4.2 Google Goggles

Google Goggles[6] enables users to search the web by picture. At the moment it is most suited for recognizing landmarks and other inanimate objects. However, it also has the ability to recognize text and read miscellaneous tags like QR codes or barcodes.

After the picture is taken, the picture is transmitted to Google's servers to be analyzed. The results are shown on the mobile phone. Depending on the detected content relevant options are shown. For example, translations of text might be offered depending on your current location and native language.[7]

[4] `http://itunes.apple.com/us/app/nearestwiki/id331305547?mt=8`

[5] `http://www.readwriteweb.com/archives/iphone_4_gyroscope_brings_silky_smooth_augmented_r.php`

[6] `http://www.google.com/mobile/goggles/#text`

[7] `http://googlemobile.blogspot.com/2010/05/translate-real-world-with-google.html`

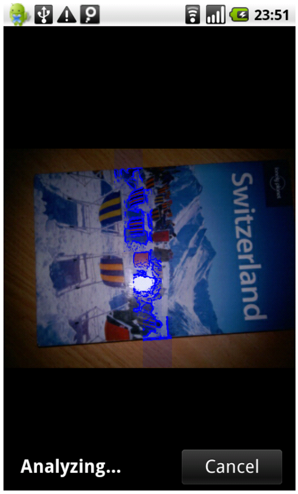


Figure 23.3: Photo processing

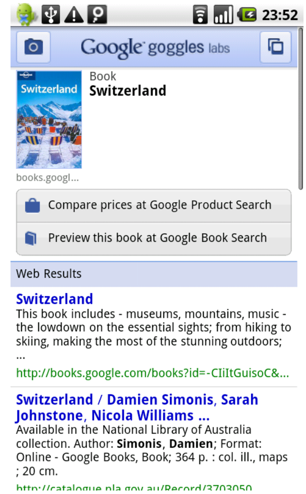


Figure 23.4: Goggles search results

### 23.4.3 Google Navigation

Google Navigation[8] is a navigation product that uses aerial photos (figure 23.7) and street view (figure 23.8) photo's to display a route. The route displayed is influenced by compass direction, location (GPS) and social traffic information. It includes both text to speech functionality and voice recognition.

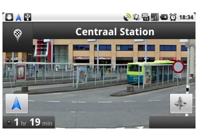


Figure 23.5: Arrival location in real world photo

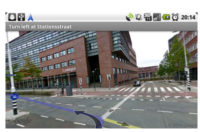

Figure 23.6: Overview of the next turn


Figure 23.7: Arrival location in an aerial photo

Figure 23.8: Direction overlay

### 23.4.4 Junaio

Junaio is a mobile augmented reality browser with a focus on interactivity. It can provide live context-relevant information, such as traffic information and the location of the nearest train station and arrival times. Users are able to give recommendations on shops and restaurants and are able to leave digital tags.

Junaio currently has a layer that gives live information on the Bay Area Rapid Transport (BART) network in San Francisco (figures 23.9 and 23.10).

[8] http://www.google.com/mobile/navigation/

When used indoors it can recognise LLA tags/markers[9][10]. Junaio's database stores these tags their position. The tags combined with the compass enable indoor AR (figure 23.12).

Junaio can also recognize other markers. Junaio Glue[11][12] is a technique that recognizes a 2d tag and it's orientation and adds a layer with a 3d model (figure 23.11).

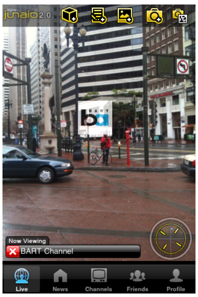


Figure 23.9: BART station location


Figure 23.10: BART arrival time


Figure 23.11: GLUE 3d model

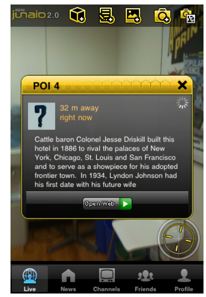


Figure 23.12: LLA tag used for positioning

### 23.4.5 Layar

One of the other augmented reality browsers is Layar, by SPRXmobile. SPRXmobile has made earlier mobile phone applications, but at the moment they are fully focussing on Layar[13]. The AR view in layer is based on the metaphore of an extra layer of data. Both user-provided as sponsored layers are available. Sponsored layers might appear higher in the list of suggested or popular layers. Layar also includes a store in which users can buy access to a layer with information.

Layar was one of the first browsers to monetize it's platform. Initially Layar added (sponsored) suggested layers. Later on Layar announced paid layer, with Layar facilitating payment processing and distribution. Layar received $3.4 million funding round in februari 2010[14].

Marker pointing in the direction of the nearest points of interest are overlaid on the camera images. Markers can include extra information, like pictures or videos.

Examples of the usage of Layar are sponsored layers with the location of casino's (figure 23.15), properties that are for sale or the location of nearby ATM's. Sponsored layers might include objects that allow the users to create funny snapshots. This has been done to promote avatar and for the "ronald gone mad" campaign (figures 23.13 and 23.14)

[9] http://www.junaio.com/publisher/llamarker
[10] http://blog.converget.com/2010/03/14/new-junaio-2-0-worlds-first-indooroutdoor-ar-pl
[11] http://www.junaio.com/publisher/junaioglue
[12] http://gamesalfresco.com/2010/07/07/5-things-to-do-with-junaio-glue-and-lla-markers/
[13] http://www.sprxmobile.com/
[14] http://techcrunch.com/2010/02/15/layar-scores-3-4m-in-funding-global-distribution-ag

Other uses for Layar include (paid) city tours [15][16] and a layer with user-provided information on the rolling stones [17].


Figure 23.13: Layar commercial for Avatar

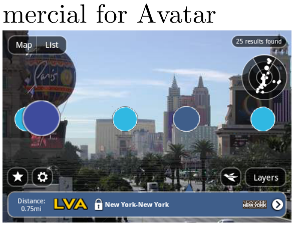


Figure 23.15: Layer with Las Vegas casino's


Figure 23.14: Ronald gone mad commercial

### 23.4.6 Sekai Camera

Sekai Camera is a augmented reality from Tonchidot, which was introduced at TechCrunch50 in 2008[18]. After the initial buzz, Tonchidot received $4 million in a first round of venture capital [19].

Initially Sekai Camera was the most popular iphone application the Japanse app store. Later on they deployed their application worldwide and released an android application.

[15] http://site.layar.com/paid-layer-launching-partners/
[16] http://www.nai.nl/uar
[17] http://site.layar.com/company/blog/layer-of-the-week-rolling-stones/
[18] http://techcrunch.com/2008/09/17/tonchidot-madness-the-video/
[19] http://blogs.wsj.com/venturecapital/2009/12/08/augmented-reality-start-up-tonchidot-m

Tonchidot allows users to place "AirTags" in the real world. Additional information can be added to a tag, which can be viewed later on (figure 23.18). The client also views and posts geolocated tweets (see figure 23.16). Recently Tonchidot has been experimenting with indoor markers (figure 23.17).

Sekai Camera has two methods for partners to advertise. The first, Sekai Camera eX enables publishers to display static information to visitors. The target group for the tags are visitors at shops/malls/museums or visitors at outdoor entertainment parks.

The second solution, the "Open Air API" is most suited to publishers that want to display up to date, numerous, geotagged data that is often updated[20].

Another usage for the Sekai Camera platform are augmented reality games. The first (Japanse only game) that was launched is Sekai Hero[21][22]. Sekai hero is a online augmented reality role playing game in the world of Sekai. A screenshot of Sekai Hero is in figure 23.19.

The combination of information from partners and tags from users, Sekai camera strives to deliver a very interactive environment for their users.

Figure 23.16: Cloud of Sekai tags on a street

Figure 23.17: Indoor Sekai tags

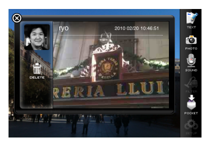

Figure 23.18: Viewing an AirTag

Figure 23.19: Sekai Hero

### 23.4.7 Toozla

Toozla is global audio guide[23]. Toozla provides multiple location-based streams of information. These streams include local chat, tourism information, the weather and stories on nearby objects from wikipedia.

Users can also record their own messages and share these with others.

### 23.4.8 Waze

Waze is a social mobile application developed by Waze Mobile providing free turn-by-turn navigation using crowdsourced traffic information[24]. The data in Waze is provided by it's users.

Waze extracts a roadmap from the GPS logs of travel patterns. These maps are annotated with extra data (for example road names) by it's users. Waze's source is publically available[25].

[20] http://openair.sekaicamera.com/about-api
[21] http://sekaiyuusya.jp/pc/
[22] http://support.sekaicamera.com/
[23] http://www.toozla.com/
[24] http://world.waze.com/
[25] http://www.waze.com/wiki/index.php/Source_code

While driving Waze shows a map with additional crowdsourced information. This information can be traffic information but also incidents like accidents, speed cameras or police patrols (see figure 23.20).

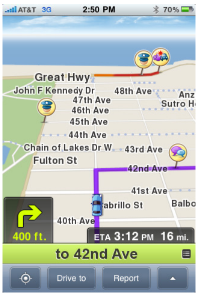


Figure 23.20: Waze navigation screen

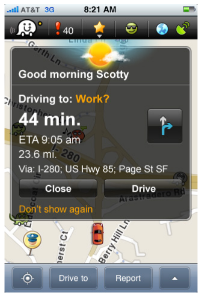


Figure 23.21: Welcome screen

## 23.4.9 Wikitude Drive

Mobilizy is a company that released one of the earlier AR browsers. Because of it's lack of popularity, it was excluded from this overview. However, their second product, Wikitude Drive is more interesting. After announcing it in september 2009, recently wikitude opened the beta of their navigation product.

Wikitude Drive is a navigation product that overlays the route on live camera images, providing a more natural driving experience. The user is able to switch between a 3d view of the route (figure 23.22) and an augmented road view (figure 23.23).


Figure 23.22: 3d map view


Figure 23.23: Lane overlay

## 23.5 Current Techniques

In the previous section a selection of MAR's was discussed. Table 23.1 section will give an overview of the techniques used in these applications. All applications share the usage of GPS and a data connection, thus this is not included in the table.

| | Camera | Compass | Accelerometer | Push data | Crowd sourced data | Markers | OCR | Gyroscope | Microphone | Speaker |
|---|---|---|---|---|---|---|---|---|---|---|
| Acrossair | ✓ | ✓ | ✓ | | | | | ✓ | | |
| Google Goggles | ✓ | ✓ | | | | ✓[26] | ✓ | | | |
| Google Navigation | | ✓ | | ✓ | ✓[27] | | | | ✓ | ✓ |
| Junaio | ✓ | ✓ | ✓ | | ✓[28] | ✓[29] | | | | |
| Layar | ✓ | ✓ | ✓ | | | | | | | |
| Sekai Camera | ✓ | ✓ | ✓ | ✓ | ✓[30] | ✓ | | | | |
| Toozla | | | | | ✓ | | | | ✓ | ✓ |
| Waze | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | |
| Wikitude Drive | ✓ | ✓ | ✓ | | | | | | | |

Table 23.1: Techniques used in the MAR's

As you can see, there is a large spread of techniques used in these applications. Google Goggles (image recognition), Waze (social sourced traffic information) and Toozla (augmented reality audio) stand out.

## 23.6 New Techniques

In order to give a overview of feasible new techniques, a selection has been made among the papers from the ISMAR 2006-2009 and selected papers have been added. The techniques that are discussed are grouped by similar subject.

### 23.6.1 Augmented Reality Audio

At the moment most MAR applications do not use audio. High quality audio adds to the immersion of a augmented reality application. Hrm [2004] researched the requirements that augmented reality audio needs to fulfill in order to have the wanted effect.

### 23.6.2 Seethrough

With the usage of additional cameras, augmented reality techniques can give the illusion of seeing moving objects through occluding surfaces. Both a source (near the user) and reference camera are needed. [Barnum et al., 2009] proposes a technique that is suited for ad hoc sharing of images in a dynamic network of camera nodes.

### 23.6.3 Object recognition, tracking and pose estimation

In order to recognize and track shapes and poses, high contrast and precise shapes are needed. [Hagbi et al., 2009] describe a object recognition and pose estimation system that is feasible on current generation mobile devices. The library size causes a problem, both for confusion rate and matching speed.

[Waechter et al., 2009] investigate the possibility of using camera's to track indoor positions of users. They suggest that indoor cameras could be used to provide a localisation method, but warn about the privacy issues it might introduce.

[Simon, 2007] proposes a new method to automatically detect and reconstruct walls in AR tasks. Walls can be detected and the performance is feasible on current mobile telephones. As a side product the position of walls is detected.

### 23.6.4 Positioning

Ubiquitous Tracking uses multiple sensors to increase the robustness and accuracy of position tracking. The dynamic combination of mobile and stationary trackers creates new wide-area tracking setups.

[Pustka and Klinker, 2008] introduces the concept of Spatial Relationship Graphs. The additional sensors could increase the precision of indoor position tracking and increase the relative accuracy overall.

### 23.6.5 Mobile applications

[Gunnarsson et al., 2006] use a MAR to visualize wireless sensor node data by overlaying the measurements on camera images. The orientation of the camera is detected with the help of markers.

An analysis of the delay and client-side processing required for server-side processing of camera images has been made by [Chen et al., 2009]. They show that the latency caused by the combination of local processing, network latency and server-side processing is under one second and should still provide a good user experience.

Marker tracking is a heavy operation. [Wagner et al., 2009] investigates the performance of various algorithms. In the end it is shown that multiple markers can be tracked on current generation telephones, while archieving sufficient performance.

### 23.6.6 3D/Displays

3D headsets have been used for augmented- and virtual reality since the 1990's. A better 3D headset increases the fidelity of reproduction and immersiveness, moving the application on the mixed reality continuum. Until recently, 3D headsets were very invasive and covered a large piece of the field of vision and face. The size of these headsets has been descreasing and the resolution has been increasing. [Rolland, 2005] suggest that 3D headsets are almost ready for primetime deployment because they have become a lot better and less invasive.

Most current MAR's their overlays provide inconsistent lighting. [Yeoh and Zhou, 2009] present a technique for rendering realisting shadows of virtual objects in a mixed reality environment by recovering the lighting positions by analysing the shadows of a known object.

### 23.6.7 Surface projection

[Gupta, 2007] explore the integration of projected imagery with a physical book. The book itself is markerless. In the end they create a "universal" book.

### 23.6.8 Interaction

A 3d object that is positioned near a marker can not always be directly controlled. [Seichter et al., 2009] propose additional markers near the main marker that control the 3d object.

[Benford, 2005] describe the mismatch between the movements that users perform, those that can be measured by a computer and the interactions needed to control an application. They provide an approach to evaluate potential problems with an gesture interface.

The combination of mobile-phone based input methods with a displayed image is explored by Hong et al. [2006]. Even though the usage of the mobile telephone input methods is feasible, they suggest the usage of other input methods when interacting with 3d objects.

[Thomas, 2007] evaluate three different modes of cursor manipulation as input methods for a user operated MAR. Their results show that a combination of a head cursor with a vision based gesture interface would provide the best interface.

## 23.7 Conclusions

At the moment two groups of MAR's are successfull. One group is focused on localised information retrieval. The second group has a focus on interactions and towards crowd sourcing.

Layar is very good at retrieving data, and while not technically excellent it has very broad support across platforms.

Sekai is a good example of the second group. The platform allows for interactivity and is one of the first augmented reality gaming platform.

Another group of applications is upcoming. These are the applications that use crowdsourcing for data acquisition and use the power of the crowd. Route planning applications are a good example of this.

Most applications share a common set of functionality. At the moment only acrossair uses a gyroscope. We assume this is because of hardware availability, since at the moment only the iPhone 4G has a gyroscope. A other exception is push data, which is relatively hard to implement at scale, but which is needed for real time interactions. Furthermore voice recognition and OCR are relatively rare. We assume this is caused by the limited quality of these solutions and server-side processing power needed to process this data at scale.

The main technique to appear in future MAR's will be object recognition. Some applications have already hit the market and proven to be feasible. The ability to reuse this technique to provide absolute indoor positioning is a nice bonus.

The second improvement will be among the display techniques. 3D headsets or image projection are ready for the main market and applications using them will be more immersive and allow more natural (gesture) interfaces to be used.

In the end augmented reality applications will become easier to use and more immersive. Augmented reality will become a easy, widely used information retrieval and interaction technique.

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# Chapter 24

# Recent developments in ray tracing for video games

*Section by Cecill Etheredge and Oğuz Meteer*

## 24.1 Abstract

Since the emerging of 3D video games, polygon rasterization has become the industry standard for projecting worlds onto the screen. As time progressed, graphics accelerators and other hardware was developed to accelerate the process of rendering polygons as games demanded increasingly complex scenes and lighting. And while there are good reasons to stick to conventional rasterization, a rapid increase of hardware complexity over the years has spurred interest in alternative rendering techniques. Now that modern hardware is becoming considerably faster, ray tracing may be considered as an alternative to rasterization. This paper gives a brief overview of the rasterization and ray tracing rendering algorithms, their characteristics and their latest developments and seeks to find out whether ray tracing could eventually be considered a practical rendering alternative for video games.

## 24.2 Introduction

In the past decades, video games have evolved from primitive two dimensional arcade to full-fledged three dimensional first person shooters. When computational power of computers and consoles increased, games and other graphical applications were made to utilize that increase to display more realistic graphics. As games become almost real to some, the truth is that virtually all computer graphics algorithms responsible for the real-time graphics in today's games are plagued by various visual and logical shortcomings. At the heart of each modern game engine lies a decades-old technique called polygon rasterization, accelerated by carefully designed pipelined graphics hardware that is capable of projecting many millions of 2D polygons per second. Through the years GPUs have become faster, but they also gained new features like hardware transforming and lighting, uniform shaders and tessellation. Especially because of uniform shaders, GPUs are now also used for general purpose programming, and are very powerful due to their highly parallel nature. While rasterization is heavily used in combination with different lighting techniques to achieve a high level of realism, an alternative rendering algorithm called ray tracing is becoming more interesting now that hardware is becoming more powerful. In this paper we will look at rasterization and ray tracing, we will discuss their advantages and disadvantages, and the practicality of using them in modern video games.

## 24.3 Rendering Techniques

Rendering in video games is the process of generating images from geometrical models. Geometry deals with the size, shape and relative positions of $n$-dimensional figures, and spatial properties. The properties of these models are stored in various types of data structures, depending on the nature of the used rendering algorithm and type of geometry the models consist of.

There are many rendering algorithms that can produce the desired images and each algorithm has its strong and weak points. In the case of video games, there are usually two goals:

1. to produce *realistic* images.
2. to render images at a high enough frame rate to achieve fluid animations.

Both the chosen rendering algorithm and the type of geometry used play a role in achieving these goals. In this section we will describe the rasterization and ray tracing rendering algorithms , and the advantages and disadvantages of these algorithms.

### 24.3.1 Rasterization algorithm

Rasterization is a rendering algorithm for converting a set of shapes to a raster image made of pixels. It is the industry standard rendering algorithm for rendering 3D graphics in video games and is mainly used in combination with *polygons*. One of the advantages of using polygons and rasterization is that all of today's GPUs have hardware support for this algorithm, making it very fast and suitable for real-time 3D graphics demanded by 3D video games. Another advantage is that most stages of the graphics pipeline on moders GPUs can be programmed, in contrast to the fixed graphics pipeline. This gives game developers the opportunity to use different lighting techniques to produce more realistic images.


Figure 24.1: A typical rasterization pipeline subdivided into functional stages. Image courtesy of [Antochi, 2007].

### Polygons

Polygons consist of vertices and each vertex is usually specified by four floating point numbers, one for each axis and a homogenous coordinate. The advantages of using polygonal geometry lie in the fact that they consist of vertices, because vertices can easily be transformed by using matrix multiplications. The most used transformations are translation, scaling and rotation, which can be achieved by multiplying the vertices of a polygon with the desired matrix as shown in figure 24.2. If multiple transformations want to be applied to a vertex, then the needed matrices can be multiplied with each other to obtain a matrix that has all the individual transformations. This new matrix can then be multiplied with the vertices of a polygon, which results in the transformations of the vertices with a single multiplication.

$$\begin{bmatrix}1&0&0&X\\0&1&0&Y\\0&0&1&Z\\0&0&0&1\end{bmatrix}\begin{bmatrix}X&0&0&0\\0&Y&0&0\\0&0&Z&0\\0&0&0&1\end{bmatrix}\begin{bmatrix}1&0&0&0\\0&\cos\theta&-\sin\theta&0\\0&\sin\theta&\cos\theta&0\\0&0&0&1\end{bmatrix}\begin{bmatrix}\cos\theta&0&\sin\theta&0\\0&1&0&0\\-\sin\theta&0&\cos\theta&0\\0&0&0&1\end{bmatrix}\begin{bmatrix}\cos\theta&-\sin\theta&0&0\\\sin\theta&\cos\theta&0&0\\0&0&1&0\\0&0&0&1\end{bmatrix}$$

Figure 24.2: Matrices for translation, scaling and rotation in the X, Y and Z axis.

These multiplications can easily be performed by modern GPU's, since they are massively parallel, which results in fast rendering. The downside is that it is impossible to model certain shapes with polygons, like round objects. In general, only triangles are used in rasterizers. This is because triangles have certain characteristics that make the rasterization algorithm (like clipping) much simpler:

1. Every polygon can be broken into a set of triangles through a process called polygon triangulation.
2. All triangles are convex. This means that every internal angle is less than 180 degrees and that every line segment between two vertices remains either inside or on the boundary of the triangle.
3. All triangles used in computer graphics are either planar or degenerate, i.e. there are no other cases.

### Projection

When all the transformations have been applied to the polygons, they have to be projected onto a two-dimensional plane. There are two types of projections, *orthogonal* projection and *perspective* projection.

Orthogonal projection (also called *parallel* projection) involves projecting each vertex onto the viewing plane by a ray that is perpendicular to the viewing plane. This is done by simply removing the z component of the transformed vertices. The result is a projection where two objects of the same size, that are behind each other, appear equally big. It is illustrated in figure 24.3.

Since one of the goals of most video games is to be realistic, perspective projection is often used. In this type of projection a pyramidal viewing volume is used instead of a rectangular volume, and the addition of the near and far z clipping

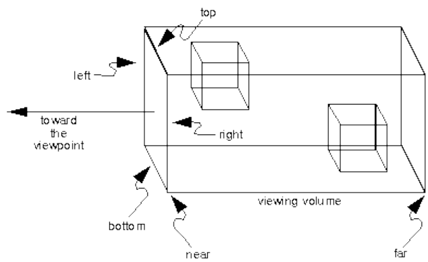


Figure 24.3: Orthogonal projection. Image taken from [Woo et al., 1999].

planes it becomes a *frustum*, which is a truncated pyramid. This emulates a perspective projection, where objects that are further away appear smaller. This is shown in figure 24.4.

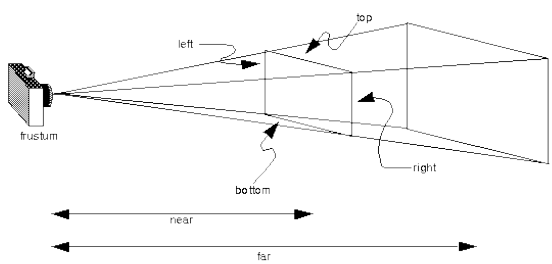


Figure 24.4: Perspective projection. Image taken from [Woo et al., 1999].

To perform perspective projection, one multiplies the transformed vertices with the matrix shown in figure 24.5, where $N$ is the near z clipping plane and $F$ the far z clipping plane.

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & (N+F)/N & -F \\ 0 & 0 & 1/N & 0 \end{bmatrix}$$

Figure 24.5: Perspective projection matrix

### Optimization

The performance of the rasterization algorithm depends on the amount of polygons that need to be processed. Although GPUs become faster, game developers usually use the increase in computational power for visual effects to improve realism instead of processing more polygons [Huddy, 2006]. So it is beneficial to truncate as many polygons as possible without any visual changes, to be able to maintain a high framerate, which is one of the downsides of rasterization. There are a couple of optimizations that do this, and it is the next step in the rasterization process.

*Clipping* is idea of clipping polygons, that are partially visible, to the boundaries of the viewing plane. This means that objects that lie outside of the viewing plane are truncated. For example, objects that are behind the camera, or beyond the far z clipping plane are not processed at all, as well as the non-visible parts of objects that are partially visible. There are a couple of algorithms that perform clipping and the most well-known is the *Sutherland-Hodgman* algorithm [Sutherland and Hodgman, 1974], which is the oldest and uses a divide-and-conquer strategy. Figure 24.6 illustrates the this algorithm.

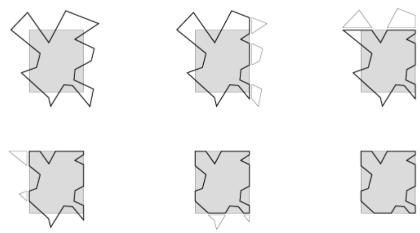

Figure 24.6: Example of the Sutherland-Hodgman algorithm.

*Backface culling* involves removing polygons that face in the opposite direction of the camera, and therefore are not visible. This of course holds true if all the objects are closed. It is performed by checking the winding order of the transformed polygons. For example, if the vertices of polygons facing the camera are defined in clockwise order, then every polygon with a counter-clockwise order is facing away from the camera. This is essentially checking if the surface normals of polygons are facing the camera.

*Occlusion culling* is another optimization that removes polygons that are behind other polygons, and is mostly used when there are a lot of objects in the viewing volume. There are different approaches to performing occlusion culling, with some being better suited for different types of video games than others. The most well known are *Potentially visible set* or *PVS* rendering, and *Portal* rendering.

Important to notice is that these optimizations assume that there are no (semi-)transparent or reflective surfaces. The same optimizations can still be used, but it must be taken into account that the amount of polygons that can be seen could increase, and that it could require that a tweaked variant of the optimization has to be used.

**Scan conversion**

The last step of rasterization is filling in the 2D polygons that are projected onto the viewing plane, or in other words, mapping polygons into pixels and texturing those polygons. Most GPU architectures use the scanline rendering algorithm in order to achieve this, although there are exceptions. One example of such an architecture is the POWERVR graphics chips by Imagination Technologies, which utilize a tile-based rendering approach and are used in embedded devices such as mobile phones [Imagination Technologies, 2009]. In tile-based rendering, the mapping of polygons to pixel does not happen per scanline. Instead, the viewing plane is divided in sectors called tiles, which are processed independently [Antochi, 2007] as can be seen in figure 24.7.

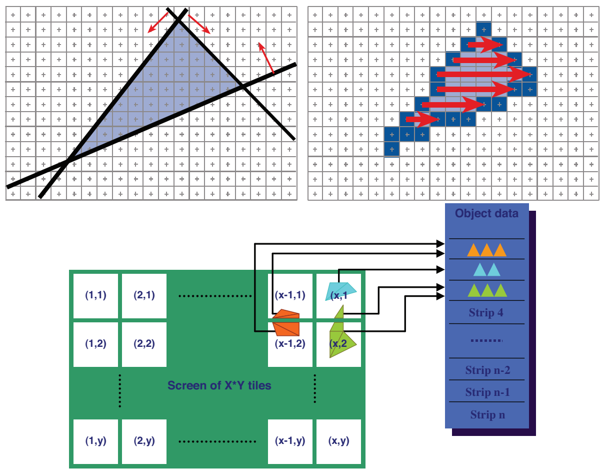


Figure 24.7: Different rasterization techniques. Left: scanline rasterization [T. et al., 2001]. Right: tile-based rasterization [Imagination Technologies, 2009].

Before the filling can be performed, one has to overcome a few problems, like if a pixel should be drawn. This is because the pixel could be occluded, or could not be inside a polygon. A solution to this problem is the *z buffer*, which is a 2D array that stores a depth value per pixel. Whenever a new pixel is to be filled, the current depth value of that pixel must first be checked so that only the pixel that is nearest to the camera is filled.

Another problem is finding the color of the pixel that needs to be drawn, and it requires color, texture and lighting calculations. When calculating which texel of a texture has to be used to fill in a pixel, some form of interpolation and filtering has to be used. After the needed texel is found, its brightness has to be determined by some sort of lighting calculation. This is one of the most important steps, because certain lighting techniques can produce very realistic results and make up for the disadvantage of having to build objects from triangles. Among these techniques are *bump mapping* and *parallax mapping* [T. et al., 2001], which give the impression that surfaces that are flat look detailed. An improved version of these techniques is *relief mapping* [Policarpo et al., 2005], which gives a better perception of depth as can be seen in figure 24.8. Another often used lighting technique is *environment mapping* [Blinn and Newell, 1976], which is basically a texture that is wrapped around an object that is supposed to be reflective. The texture used obtained by placing the camera at the position of the reflective object, and using the result of that viewing plane.

While these lighting techniques can produce realistic results, they consume a lot of computational power. With programmable graphics pipelines, better lighting techniques can be used, at the cost of performance, which is one of the goals of most modern video games. Another problem of rasterization with triangles is that

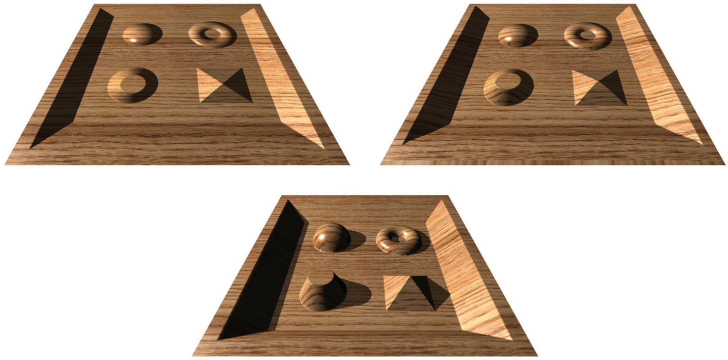

Figure 24.8: Development of displacement techniques. Left to right: bump mapping [Blinn, 1978], parallax mapping [T. et al., 2001] and relief mapping [Policarpo et al., 2005].

the performance scales linearly with the amount of polygons used [Schmittler et al., 2002].

### 24.3.2 Ray tracing

Over the past decades, there has been a tremendous amount of research on the topic of ray tracing: a popular rendering technique that is frequently used for photorealistic rendering of still images and television or film special effects. First introduced in [Appel, 1968], the fundamentals of ray tracing are built around a technique capable of generating an image by tracing a path (ray) of light that originates from an imaginary eye point through pixels in a virtual image plane and into a scene consisting of virtual objects, as can be seen in figure 24.10. As each ray travels through the scene, it is tested for intersection with the virtual objects in the scene. Once an object has been encountered, the algorithm typically uses the object's material along with the ray's properties and other known lighting information to calculate the final color on the screen. The ray may then bounce off the object's surface and continue in a different direction in the same fashion until it hits another object. Each ray is typically recursively traced for a specific number of bounces. Different algorithms exist for simulating a variety of optical effects, such as reflection, refraction, caustics and diffuse scattering through *global illumination* (lighting) techniques including radiosity [Goral et al., 1984], photon mapping [Jensen, 2001] and others. Because ray tracing resembles the physical characteristics of light, it is easily extended by physically correct lighting techniques without the need to use "fake" approximation tricks as is the case with conventional rasterization.

#### Real-time ray tracing

Because of the inherent complexity of tracing a considerable amount of rays (millions) per frame, high-quality ray tracing has traditionally been limited to off-line

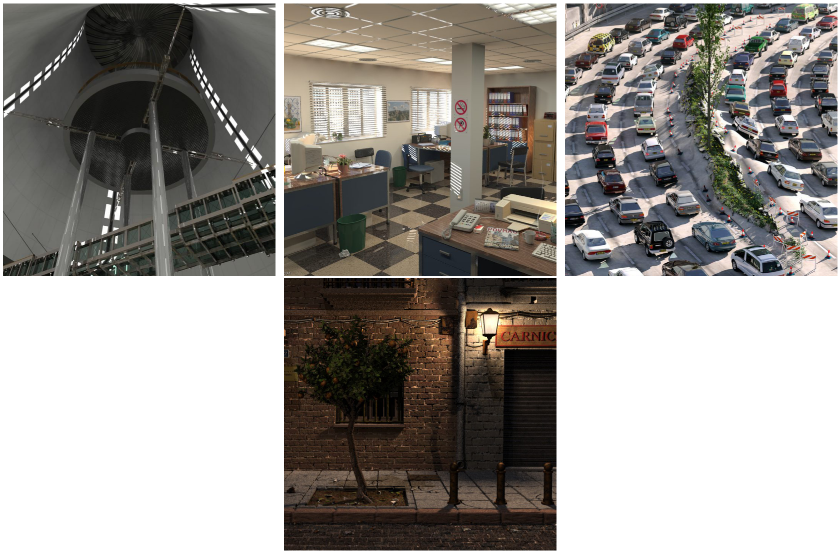

Figure 24.9: Examples of ray-traced scenes using the freeware POV-Ray ray tracing suite. Images provided by [POV-Ray, 2010].

dedicated hardware and distributed "render farms" in film studios. Although the first real-time implementations on SGI supercomputers have existed for a while [Muuss, 1995], the rapid increase of CPU performance and the introduction of programmable GPUs (GPGPU) over the recent years have spurred the development of speed critical real-time ray tracing algorithms running on consumer-grade hardware [Wald et al., 2001b]. Research into the practicality of ray tracing for video games has shown that, with the ongoing high-performance hardware trend, ray tracing may make its entry in the video game industry in the near future [Bikker, 2006].

**Spatial subdivision**

The major bottleneck of the ray tracing technique is the tracing of the rays through the scene and the subsequent hit intersection tests of the rays with the virtual objects in that scene. As the majority of the computation is spent in calculating whether a ray intersects a particular object, one of the first optimizations is to reduce the set of potential hit candidates for each ray. Instead of naively testing each ray with each and every object in the scene, the scene is spatially subdivided by an algorithm so that only a portion of the objects that are close enough to the ray are considered. A number of different algorithms and structures exist, such as the uniform grid [Cleary et al., 1986], quad- and octrees [Glassner, 1988], binary space partition (BSP-) or kd-trees [Fussell and Subramanian, 1988] and bounding volume hierarchies [Rubin and Whitted, 1980]. More recent research has shown special interest in the use of kd-trees for real-time use because of their efficiency and low complexity [Wald et al., 2001a]. Although these structures dramatically increase performance, they only capture a single "shot" of all the objects in the scene. Therefore, the scene is static, and if any of its objects are to be moved, the

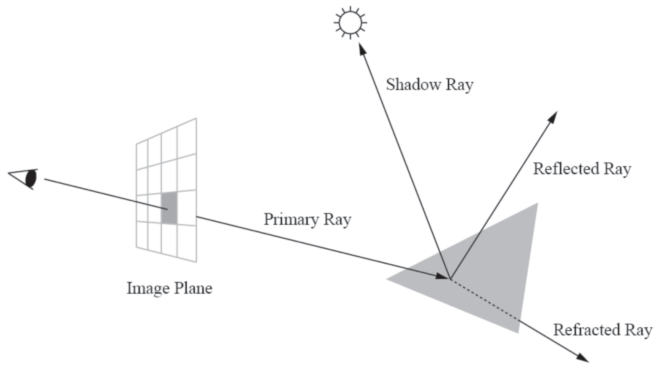


Figure 24.10: Typical example of ray tracing: a ray is cast from an imaginary eye point through an image plane of pixels, hits an object and is either reflected, refracted or absorbed.

spatial data structure will often have to be completely recalculated. This is one of the current issues that prevents real-time ray tracing from becoming an instant replacement for rasterization in video games.

### Geometry

The intersection routine is a critical part of the ray tracing technique. The typical choice for the intersection routine is a highly optimized triangle intersection test, allowing for objects to be made out of tesselated polygon meshes, the industry standard for video games. However, ray tracing allows for virtually any type of geometric primitive to be tested against a ray. It is therefore possible to define mathematically perfect primitives and quadrics with a single intersection test: planes, spheres, cylinders, cones, tori and even fractal sets [Crane, 2005]. One can even implement support for boolean operations on geometric primitives, also known as *constructive solid geometry* [Hijazi et al., 2008], as can be seen in 24.13.

### Hardware platforms

Modern CPUs provide an extensive high-performance platform for vectorized implementations with some degree of parallelism using Intel's SSE SIMD extensions, which can be used to significantly speed up the traversal and intersection routines in the ray tracing algorithm. For example, as neighbouring rays shot from the campera are inherently coherent (e.g. they follow similar paths through the scene), rendering can be sped up by tracing packets of multiple rays at once as explained in [Wald et al., 2001a].

In the past decade, the introduction of programmable GPUs from NVIDIA and ATI has caused a shift from pure CPU software implementations towards GPGPU (general-purpose GPU) implementations. One of the major benefits of the GPU hardware architecture is that it functions as a massively parallel platform with a large computational power that can be exploited when using frameworks such as NVIDIA CUDA [NVIDIA, 2010]. As can be seen in figure 24.14, the theoretical

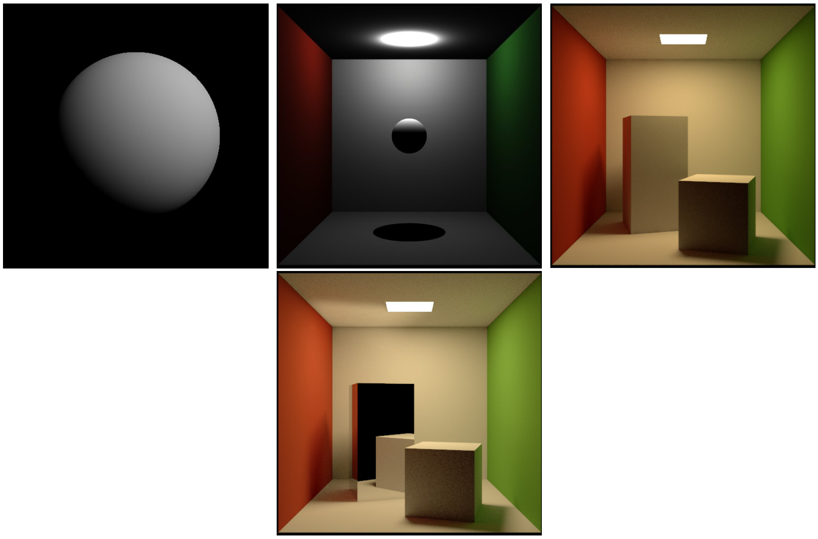

Figure 24.11: Development of a ray tracer with increasing complexity. From left to right: sphere tracing, simple phong lighting and shadows, realistic diffuse lighting using photon mapping, added reflections. Images courtesy of [Feng, 2006].

GPU peak performance has long surpassed that of state-of-the-art Intel CPUs. Because ray tracing is a process that can easily be parallelized (e.g. every ray can be processed independently and in parallel), a massively parallel implementation can dramatically benefit overall performance. This has resulted in increased academical focus on real-time GPU ray tracing [Günther et al., 2007] and the introduction of commercial interactive ray tracing engines such as NVIDIA OptiX [Parker, 2008] and AMD Fusion Render Cloud [Urbach, 2008] with the goal of improving future video games.

As an alternative to the software CPU and GPGPU implementations, there are also ongoing efforts to develop dedicated ray-tracing hardware. One such example is the Ray Processing Unit (RPU), a PCI-card containing one or more dedicated FPGAs accessible through an API called OpenRT and capable of ray tracing scenes at real-time rates of several frames per second [Woop and Schmittler, 2005]. Another promising example is the CausticRT graphics platform by Caustic Graphics that consists of a PCI-express real-time ray tracing accelerator card [Caustic Graphics, 2009]. Although these cards are still in the very early stages of development, the concept shows that real-time ray tracing has the potential to be implemented very efficiently by means of a dedicated hardware architecture.

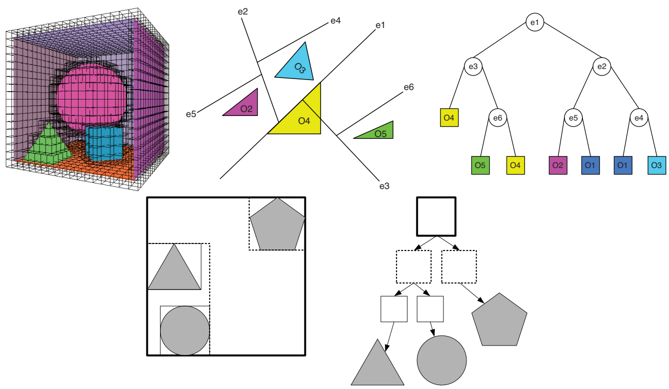


Figure 24.12: A number of typical spatial data structures. Left (cube): uniform grid. Middle: binary space partition tree. Right (grey): bounding volume hierarchy. Images courtesy of [Christen, 2005].

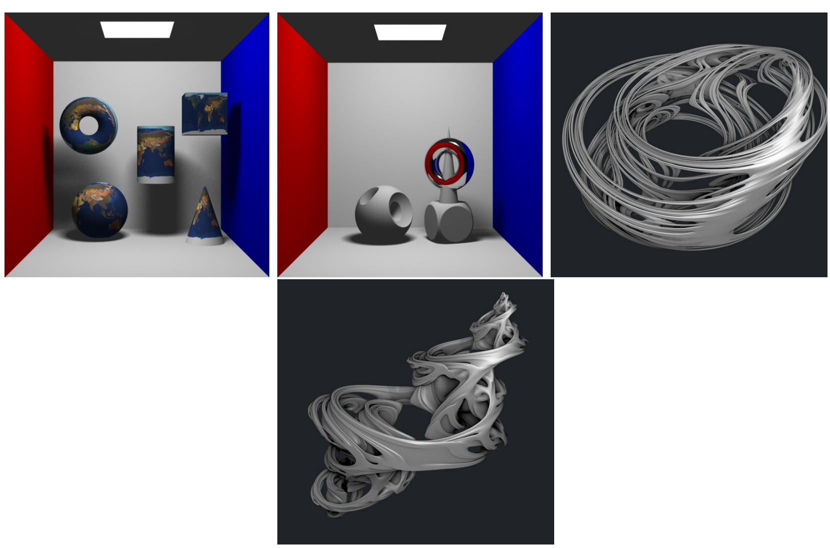

Figure 24.13: Left: various geometrical primitives and constructive solid geometry. Right: quaternion julia sets.


Figure 24.14: Left: NVIDIA OptiX real-time ray tracing engine being showcased. Right: Theoretical GFLOPs comparison between CPU and GPU architectures. Images courtesy of NVIDIA Corporation [NVIDIA, 2010].

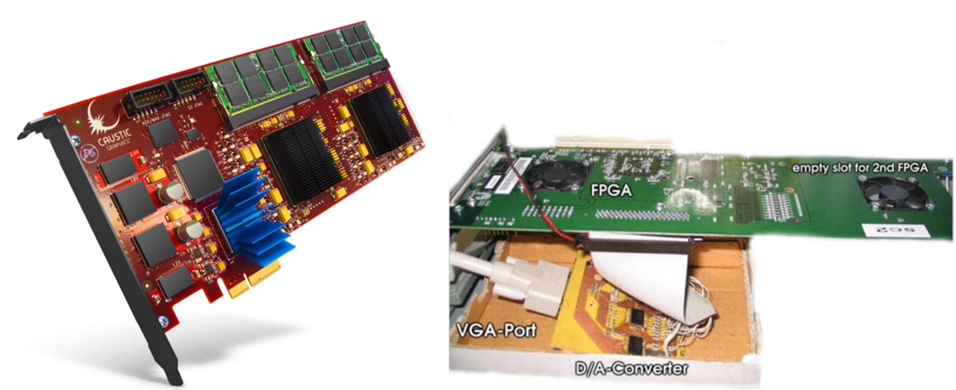


Figure 24.15: Examples of hardware ray tracing architectures. Left: CausticOne PCI-express card by Caustic Graphics. Right: Ray Processing Unit (RPU) in early development stages.

## 24.4 Conclusion


Figure 24.16: Ray-traced bottles of Jack Daniels. We drank the left one, cheers.

We have discussed two rendering algorithms, that are very different from each other. With the introduction of the programmable graphics pipeline, the quality of rasterization has increased dramatically, by the use of shaders capable of creating illusions of depth and detail without requiring a high polygon count. Polygonal objects are also very easy to transform by using simple matrix multiplications, making it very fast and dynamic, which is ideal for interactive video games. The downside is that the computational complexity of rasterization increases linearly with the amount of polygons used, whereas that of ray tracing, if done correctly, increases logarithmically. Still the minimum amount of computational power needed for interactive ray tracing is above the practical limit, even though the core of the ray tracing algorithm is inherently simple. The emergence of massively parallel GPGPU architectures and dedicated ray tracing hardware has increased the potential of the industry acceptance of real-time ray tracing in video games. We hope to see that recent developments will be incorporated in graphics engines so that we may witness the rising of real-time ray traced games within the next decade.

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# Chapter 25

# Challenges in Procedural Terrain Generation

*Section by Joeri van der Lei*

## 25.1 Abstract

*As demands for size and content in game worlds increases, procedurally created content offers an increase in productivity at the cost of control over the design process. This paper presents the results of a literature research in the field of procedural landscape generation. An introduction to terrain generation is given and current challenges in this field are examined. Where possible the advantages and disadvantages of proposed solutions are given.*

## 25.2 Introduction

The increase in size and scope of games has enticed game developers to look for methods to increase productivity and efficiency at content generation. Generating content per a set of rules or an algorithm is an interesting solution. Landscapes, plants and buildings can all be generated by use of fractals, grammars or noise functions. The use of these techniques is currently not widespread as exercising a sufficient level of control over the generation of content so it can be used in games is often difficult. Additionally, generation of manmade scenery is only recently being explored. This paper will provide a summary of the current state of procedural content generation examining the different techniques for generating terrain, such as the diamond-square algorithm, heightmaps based on perlin noise and examine current challenges in artificial landscape generation.

## 25.3 Generating Landscapes Procedurally

Generating things procedurally means using a set of rules and algorithms to generate a lot of data with limited need for programmer input. This often includes smart usage of random number generation to reduce time spent by programmers working on the landscapes. Fractal landscapes and noise-based landscaped are often generated from very small amount of data - as small as a single integer seed for a random number generator. Random numbers are not always used, as can be seen in the .kkrieger game[.theprodukkt GmbH, 2005]. Textures and levels are generated by building them at runtime using the artist's directions. This does reduce the space needed to store a landscape but fails to improve productivity. In this section we will look at algorithms that attempt to generate terrain with constrained random number generation.

### 25.3.1 Generating landscapes: the diamond square algorithm

The diamond square algorithm is one of the simplest algorithms for generating heightmaps. It generates fractal terrain by means of a slightly modified midpoint displacement algorithm. The working of a midpoint displacement algorithm is shown in Figure 25.1. This algorithm is shown iteratively the figure. The algorithm starts with a line which is divided in two segments by taking the midpoint and displacing it randomly by an amount $a$. We then iteratively do the same for the two segments produced but displace the midpoints by a smaller factor, $a/c$, until a sufficient level of detail is reached. The constants $a$ and $c$ respectively denote the amplitude and the roughness. By varying these numbers different functions can be generated as desired.

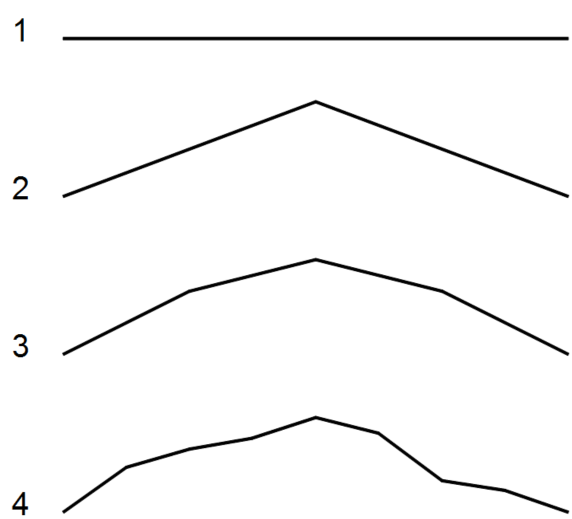


Figure 25.1: Stages of the midpoint displacement algorithm

In three dimensions the algorithm works by starting with four known points forming a square. This square is then subdivided into four smaller squares. The vertices that have to be added to form the new squares are displaced along the vertical axis similar to the midpoint displacement in 2d. First the middle vertex is displaced as part of the diamond step. Then, the vertices directly between existing points are displaced as part of the square step. The algorithm can, just like in 2d, be applied interatively until a certain level of detail has been reached. Figure 25.2 shows the diamond-square algorithm in action in three dimensions.

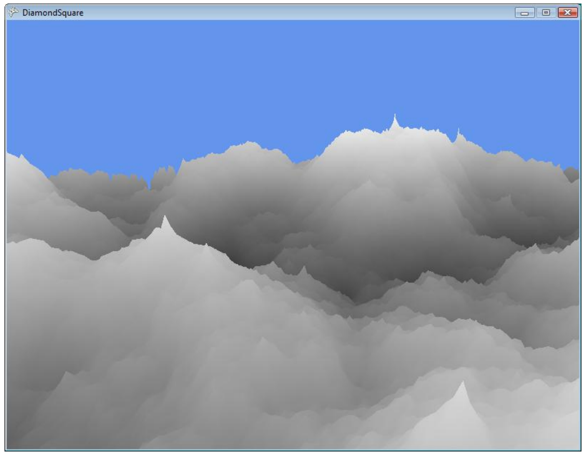


Figure 25.2: The diamond-square algorithm with a map size of 256x256. The map is colorcoded by height.

### 25.3.2 Noise-based landscape generation

The division-based algorithm explained in the previous section is a good example of procedural content generation. The algorithm itself is very small but can be used to create worlds of vast sizes. It has several flaws however, most noticably artifacts along major gridlines [Stanger, 2007]. In this subsection we take a look at several ways to heightmaps based on noise. Heightmaps are a representation of a three-dimensional world as could be generated by the diamond-square algorithm.

We take a look at fractal noise by taking two-dimensional perlin noise with turbulence as a basis. Perlin noise is generated in a number of steps. First, random numbers are generated along within a specific bandwith by means of a seeded random number generator. Secondly, a function is generated by interpolating between these numbers using for example linear, sinusoidal or cubic interpolation. This is repeated with decreased amplitude of the function, limiting then random number generating function whilst increasing the frequency. This is repeated as much as needed to create enough detail. As the final step, all generated functions are summed, as can be seen in Figure 25.3. The summation of multiple noise functions is know as turbulence and is essential for realistic heightmaps[Bourke, 2000].

Perlin noise has a distinct advantages over midpoint displacement algorithms. First and foremost, perlin noise looks more natural since it lacks the square and diamond artifacts along major gridlines. Both noise-based heightmaps and fractal heightmaps have some degree of control over terrain features by adjusting the input for the first step. After generation of a heightmap often more realism can be added by simulating erosion or smoothing the noise. These extension are beyond the

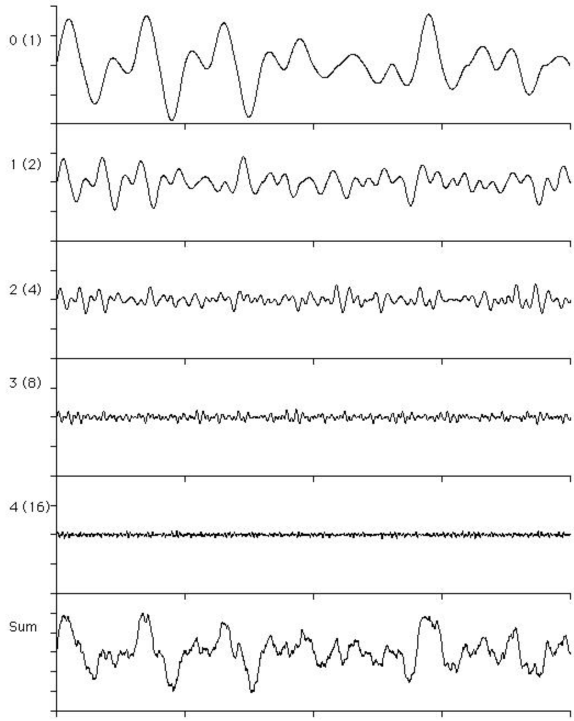


Figure 25.3: Generation of perlin noise. From [Bourke, 2000].

scope of this article as this paper only aims to provide a broad survey of procedural landscape generation.

### 25.3.3 Examples of games with procedural landscapes

Procedural techniques for generated landscapes are found within quite a few games, such as Spore and Darwinia. Spore features complety procedurally generated worlds, whilst Darwinia combines a premade part with generated content. Another way of using procedural terrain generation is examplified by The Elder Scrolls IV: Oblivion in the form of procedurally assisted terrain. The artists create the landscape but procedural algorithms that simulate things such as erosion refine it.

## 25.4 Challenges

### 25.4.1 Lack of control

A problem with procedurally created content is a lack of control. On a global level, thing such as roughness and elevation differences can be controlled. However, things like having a mountain range at a specific location in the landscape provide problems. Several techniques for additional control have been proposed.

Doran and Parberry proposed using agents in a seperate pass to alter the results obtained by traditional procedural landscape generating algorithms Doran and Parberry [2010]. Multiple agents were created such as smoothing agents, mountain agents, beach agents and hill agents. These agents redesigned terrain based on parameters given by the programmer, thereby allowing generation of terrain with specific properties.

Another approach is using real height-maps as a template for new terrain sythesys, as presented by [Zhou et al., 2007]. This allows for placement of specific terrain features by fitting real world data patched to a feature tree. Of course, often some work to adapt the landscape for a game world is still left after using all these tools and this will have to be done by hand.

### 25.4.2 Caves and overhangs

Caves and overhangs present a problem for most procedural terrain generating algorithms, since they usually generate a two-dimensional array height values as a result of two-dimensional function, illustrated by Figure 25.4. Generating overhangs either requires an additional dimension or an additional pass after the generationg of the heightmap. Some solutions using an additional dimension have been explored, such as generating an isosurface from three-dimensional perlin noise.[Gamito and Musgrave, 2001] present a general solution of generating overhangs by moving points on pregenerated heightmaps along a vector field. This solution has as advantage that it does not need to be adapted to new heightmap generating techniques and generates terrain that is completely connected and cannot intersect with itself.

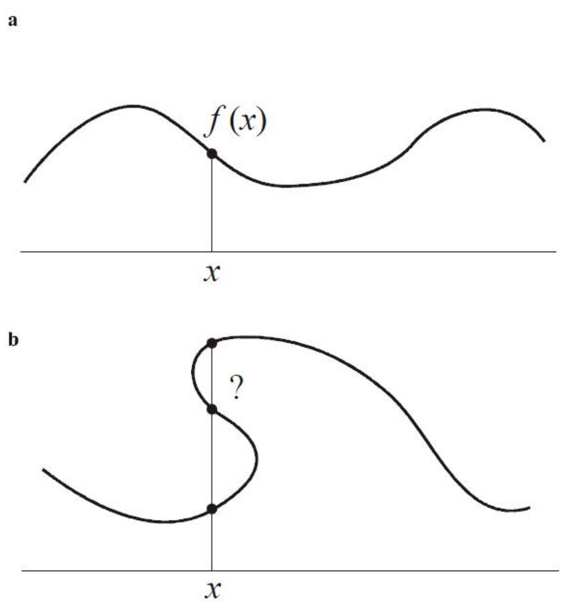


Figure 25.4: Generating an overhang or cave is a problem for most traditional algorithms. Image from [Gamito and Musgrave, 2001]

### 25.4.3 Urban environments, road networks and other unnatural structures

The algorithms shown in the previous section work fairly well for generation of terrain, but generating man-made structures requires a different toolset. Cities are inherently complex and are often a result of multiple centuries of work. The layout of a city is influenced by things such as geographical factors, population and the level of technological advancement. As of the past decade, procedural generation of urban environments has seen steady advancement and several techniques have been presented.

Lindenmayer systems or L-systems were used by [Mller and Parish, 2001]. L-systems are grammars originally used to describe the growth of plants but were adapted by Parish and Mller to generate roadmaps and buildings. A result of their work is shown in Figure 25.5. L-grammars provide a efficient solution to generating cities and by modifying the grammar control can be exerted over the result[Kelly and McCabe, 2006].

Figure 25.5: A street network generated in [Mller and Parish, 2001].

[Watson et al., 2003] proposed an agent-based solution to building cities. Agents were responsible for creating and connecting roads and developing residential, commercial and industrial sectors of the city. This method has multiple advantages: The design process can be controlled by modifying the rules of the different types of agents. Additionally, the city is plausible at any point in the generation.

## 25.5 Conclusion

In this paper we examined several techniques for generating procedural landscapes. The diamond-square algorithm was used as an example and compared to heightmaps based on perlin noise. Perlin noise was shown to be superior due to lack of artefacts and better interpolation between values. In the challenges section we noticed three different problems: Lack of control over the generated landscape, the lack of caves and overhangs is a problem inherent of using two-dimensional functions to generate terrain and we briefly examined the creation of urban terrain using L-systems and agent systems. Certain problems such as the speed of algorithms were not discussed as this paper was meant to provide an introduction to generating procedural landscapes.

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# Chapter 26

# Rendering techniques for photorealistic imagery

*Section by Jordy Molenaar*

## 26.1 Abstract

This paper tries to identify current techniques and trends in lighting methods for videogame and simulation engines. There exist some sophisticated algorithms that create near-photorealistic imagery but mostly the realism is at a cost of computational time.

## 26.2 Introduction

An important role of today's real-time game and simulation engines is the renderer. It can render a virtual three-dimensional scene to a two-dimensional image. Many game and graphics engine developers these days aim for an as photo-realistic as possible presentation of this virtual world. As computers and their Graphic Processing Units (GPU) get more processing power these developers are able to create even better looking scenes. Brute processing power however is not enough. In order to render an image that is indistinguishable from reality the system needs to simulate the behaviour of light as close to reality as possible. Even with all the processing power available in standard home computers a one-to-one physically correct simulation of the light's behaviour is not feasible. Therefore there is a need for efficient yet accurate lighting techniques.

In this article the conventional lighting methods of current day videogame engines will be discussed. Then there will be looked into the following question:

> *What are current trends in lighting techniques and how can they, combined with graphics hardware be used to render photorealistic imagery in real time?*

## 26.3 Conventional real-time lighting

In this section lighting algorithms are discussed that are used in todays virtual reality engines. First the function of the graphics hardware is described and after that there will be looked into conventional lighting algorithms.

### 26.3.1 The Graphics Hardware Pipeline

The first generation of GPUs took the rasterization process out of the CPUs hands [Randima Fernando, Mark J. Kilgard, 2003]. Also they were capable of applying textures to give the rendered triangles their colour. It was the second generation of GPUs (around 2000) that added vertex transformation and lighting to their featuresets. Later generations make the before fixed function pipeline programmable in the form of vertex- and pixelshaders. Since then the graphics harware pipeline has roughly looked as in Figure 26.1. A stream of vertices comes in, they get transformed by the programmable vertexshader, these transformed vertices get send to the rasterizer which transforms the vertices to the two-dimensional screen space and determines what pixels get affected by what vertices. After that the pixel shader can do its job and add the right colour to the right pixels. This is where the lighting or shading techniques come in.

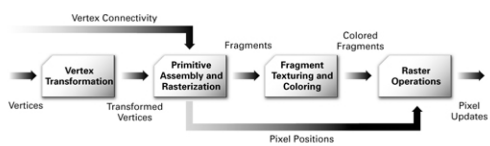


Figure 26.1: Graphics Hardware Pipeline [Randima Fernando, Mark J. Kilgard, 2003]

### 26.3.2 Shading

In the real (but simplified) world an object can only be seen by light. The colour of that object is determined by what colour light is reflected and what is absorbed. Its texture impacts the direction the light is reflected. These aspects ensure that we see the world as it is. It is something that we take for granted and a computer however, can not. A pixel shader needs specific instructions on how to calculate this end result. A very common lighting technique is the Phong shading algorithm. It uses a colormap in combination with a normal map, a specular map and an ambient light value. Figure 26.2 shows the different components of a Phong shaded object. The normal map provides the normal vectors of the object. These vectors point outward and determine the direction that part of the object is facing. These can then be used to calculate the amount of light reflecting from a light source to the camera. The specular map adds extra reflectivity on certain highlights of an object. A phong shader can use multiple lights when calculation the color of an object.

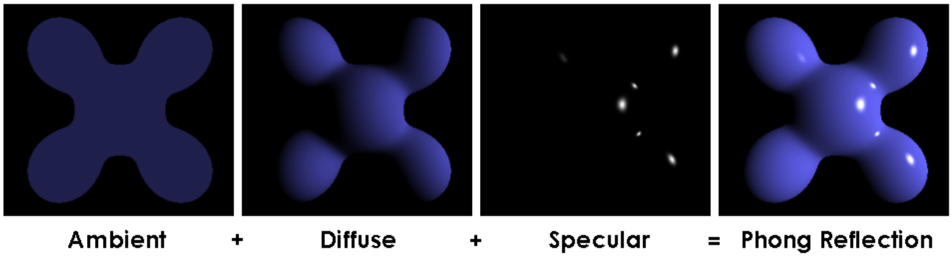


Figure 26.2: The components of a Phong shaded object [Wikipedia, 2010]

## 26.4 Global Illumination

Although phong shading seems fairly accurate in calculating the lighting on a scenic object, it does only take into account the direct lighting. To get an even more realistic result the shader needs to look at indirect lighting too. This indirect lighting can come from more than especially reflective materials such as glass and water. In fact, all objects in the scene (that can be seen) reflect at least some of the light they receive and very likely altering the colour of it in the process. This is called diffuse interreflection. A phong shader simulates this effect poorly by using ambient lighting. This acts as if all objects emitted some light themselves. Aside from reflection a realistic renderer needs to support the refraction of light. Refraction occurs when a beam of light passes from one to another material with varying densities. These phenomena, where the history of the lights path is used, in contrast to the one time reflection from source to object to camera are genereralized by the term global illumination.

### Radiosity

Global illumination can be achieved by various methods such as the radiosity method or photon mapping. The Radiosity method was actually introduced in the 1950s to compute heat exchanges between surfaces [Franois X. Sillion, Claude Puech, 1994]. It has been adapted to compute light exchanges instead. The radiosity method assumes all objects are perfectly diffuse. This property creates the colour bleeding effect where the reflected colour of one object slightly alters the colour of another.

### Photon mapping

Photon mapping is a two-pass raytracing algorithm. In the first pass rays from a light are traced and on each object collision energy is stored on the surface of the object [Henrik Wann Jensen, Niels Jorgen Christensen, 1994]. In the second pass a Monte Carlo - that is: a random sampling method [Jensen, 2003] -ray tracing algorithm is used to render the scene, using the photon maps created in the first pass.

### ISPM

Image Space Photon Mapping (ISPM) is an adaptation of the photon mapping algorithm by [Morgan McGuire, David Luebke, 2009]. It performs raycasting in image space (and thus is officially not global) and utilizes the GPU to offload the CPU. It has global illumination effects as colour bleeding but can render a relatively complex scene in realtime. This is a huge advantage to the previous two methods which are still too slow for real time computation.

## 26.5 conclusion

Global illumination algorithms are still too computationally complex to use in real time. There are however some real close candidates such as ISPM that create a global illumination approximation at decent real-time speeds.

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# Chapter 27

# The end of the horizon; A study on rendering planetary bodies.

*Section by Steven van der Vegt*

## 27.1 Abstract

In a lot of simulations, like flight or space simulations, planetary bodies are used. Rendering objects on such scale require special techniques. A lot of research has been done on these subjects and in this in-depth research I give an overview of the different aspects and problems in planetary rendering and explain techniques to solve these.

## 27.2 Introduction

A planetary body can be used for space and flight simulators, but also for applications like google earth or in the game industries. The rendering of such a large object can be very challenging especially as it has to look good and run fast.

In this paper I present my literature research about the different techniques available for rendering a planetary body from very large to small scales. First I look at how it is possible to render a body of such a large scale using different kind of level of detail. Than I will look at the terrain data to render. How is this data obtained etc. After the terrain I will look at techniques to render an atmosphere seen from the planet as well from space. In the final chapter I will look into hardware problems using large numbers which are involved in rendering large objects.

## 27.3 Level of detail

Image quality comes with a price: render time. How to push as much triangles into the render pipeline as possible and remain an acceptable frame-rate? This question is subject for elaborate research. One of the most used methods is: don't render what you don't see. Everything outside of the viewfrustum to begin with, then everything behind other objects. If (almost) all invisible polygons are excluded, the next thing to do is to reduce the level of detail (LOD) of far away objects. There are a lot of different approaches in LOD management.

For objects, every object can have several meshes. Every mesh has a different LOD. Dependent on the distance between camera and object, a mesh is chosen. There is no way to do a smooth transition between those meshes. This visual effect of switching between a mesh is called popping. It is considered a bad thing and must be avoided. Because of the static meshes, this method is called Discrete Level of Detail or DLOD. An other approach is dynamic meshes based on functions. A object is described in a function with a coordinate and LOD as input. Since there are 'infinite' levels of detail a smooth transition between the LOD is possible. For this reason this method is called Continuous Level of Detail (CLOD).

The above methods are are common applied to objects. I am interested in terrain rendering, so how can LOD be applied to terrains? Landscapes are harder to optimize because they are not naturally decomposable into parts which complexity can be adjusted independently. I will look at two different algorithms which can be used to generate the terrain mesh. The ROAM algorithm and geomipmapping technique developed by Willem H. de Boer. The first is a CLOD algorithm, the second one is a DLOD algorithm developed for modern 3d graphic cards.

### 27.3.1 ROAM

Realtime optimally adopting mesh or ROAM as we will call it from now is a dynamic level of detail algorithm which attempts to generate an optimal triangle mesh for quickly rendering large-scale terrain maps. The first edition is developed in 1997 by the Lawrence Livermore Laboratory. Later an improved reversion was introduced which was more optimized for modern 3D hardware. The landscape is build from triangles. To increase the level of detail a triangle can be split resulting in two children. To decrease the level of detail two children can be merged. These triangles can be stored into a binary tree data structure, with the children triangles as parent of there parent triangle. There are two priority queues to drive the split and merge operations. Each triangle is assigned a split priority which is roughly based upon the distance from the triangle and the camera. If a triangle priority exceeds a threshold the triangle is split or merged. To prevent cracks in the mesh, only a square can be split. An example is shown in Figure 27.1. Triangle T has to be split, but there is no square. Therefor edge 3 must be created first, but this isn't a part of a square either, so edge 2 is introduced but that one needs edge 1 to start with. This process continuous recursively until a square is reached or the edge of the map.

The mesh created by the ROAM algorithm is pretty optimal, but it takes a lot of CPU-time to calculate. With the introduction of modern fast 3D graphics hardware it is now considered as good practice to send a little bit more polygons to the render pipeline and save CPU power than to burden the CPU with graphics calculations. This is because the CPU has a lot of calculations to do for AI, game logic and physics.

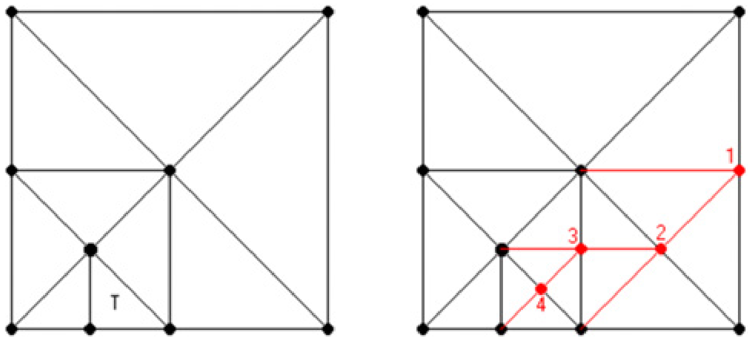


Figure 27.1: Splitting triangle T requires multiple splits to avoid creating cracks in the mesh.

### 27.3.2 Geo-mipmaps

Geomipmapping is a technique developed in 2000 by W.H. de Boer. According to his paper [de Boer, 2000] this technique is developed with hardware rendering in mind. This differs from algorithms like ROAM because they where developed before hardware rendering became the industries standard.

Geomipmapping works with a grid of vertexes all evenly placed from each other. The x and z coordinates are fixed, the y coordinate (height) can be loaded from a heightmap like a grayscale 2d image. A landscape is divided into smaller blocks. Each of these blocks is stored in a quadtree. Using frustum culling only nodes in the viewfrustum are marked as visible. This tree can be send directly to the render pipeline. But complex terrains can contain a lot of vertexes, so rendering can still be slow. Therefore a new LOD method is introduced here: Geomipmaps. Terrainblocks that are far away don't need the same detail as blocks that are closer to the viewer. They can be rendered in a lower resolution and thus drastically decreasing the triangle count. Like a texture mipmap, a geomipmap is a lower resolution version of the original. In this case for example a block normally consisting of 5x5 vertexes can exists in a lower LOD of 3x3 or even 2x2 vertexes. These mipmaps should be generated when the terrain is loaded.

Although this all sounds simple, a lot of the calculation time goes into determine the correct level of detail for a block. If the level is poorly chosen popping (noticeable transition between levels) occurs. The strength of this algorithm is its simplicity, it's weakness is that there can be noticeable gaps and tears between the blocks with a differend LOD. The idea behind this algorithm is that sometimes it is better to send a small amount of unneeded polygons to the GPU than burden the CPU with LOD calculations.

#### Alternative DLOD algorithms

There are several alternatives on this type of LOD algorithm. Clipmaps is a algorithm developed in 2004 by Losasso and Hoppe [Losasso and Hoppe, 2004]. They solved the cracks between the blocks problem and rewrote the algorithm so that is done entirely by hardware using the GL-Shading language [Asirvatham and Hoppe, 2005]. In 2006 Clasen and Hege released a paper where they modified the algorithm so it can be used on spherical surfaces [Clasen and Hege, 2006], planets for example.

### 27.3.3 Comparison between the algorithms

Above I have described two very often used terrain rendering algorithms. ROAM is the most optimal in triangle count, but as we have learned, with modern hardware it is sometimes better to send a little to much triangles to the render pipeline, than using up the CPU for mesh optimizations. The clipmap technique does even the view frustum calculation part entirely in hardware. The 2006 paper by Losassp and Hoppe even modifies it for spherical bodies, so in the perspective of planet rendering, this algorithm is probably the best option to choose from.

## 27.4 Terrain information

I described the algorithms for terrain rendering, but what terrain are we going to render? There are two often used methods here: real time generation of a terrain also called procedural generation, and the use of existing data. The first uses a algorithm to determining the height of the terrain, the second one has a dataset which contains all the information needed for rendering the terrain. In this section we will describe both these methods of terrain representation.

### 27.4.1 Procedural generation

For procedural generation of a terrain I need a function which takes a coordinate and returns a height value. The difficulty is making a function that generates naturally looking terrain. Often noise functions or fractals are used. I will show a perlin noise implementation.

Perlin noise is a noise generation method developed by Ken Perlin in the 1980's for the motion picture industries. In that time computer generated graphics looked very machine like and he wanted to develop a texture generation algorithm which made that textures looked more natural. It needed to look random, but also be controllable. Perlin noise doesn't take values from a random generator. The noise it produces must be the same for every computation. These values are stored into a grid. Onto this grid all spatial positions can be projected to compute a value. There are no problems with warping as textures have.

The use of perlin noise in a recursive algorithm can lead to a fractal landscapes. The amount of iterations determinate the level op detail. In this way you can have every LOD you want just by adding more iterations. See Figure 27.2 for an example. [Bourke, 2000]

### 27.4.2 Terrain dataset

Heightmaps store the topological properties of a terrain which are sampled uniformly. Height data that can be stored is a raster format, like an array. The look-up of data in this datastructure is very efficient O(1). This data can be represented as a grayscale texture Figure 27.3. Heightmaps are often created with a resolution of $2^n + 1 * 2^n + 1$ to provide height information for $2^n * 2^n$ quads or triangles in

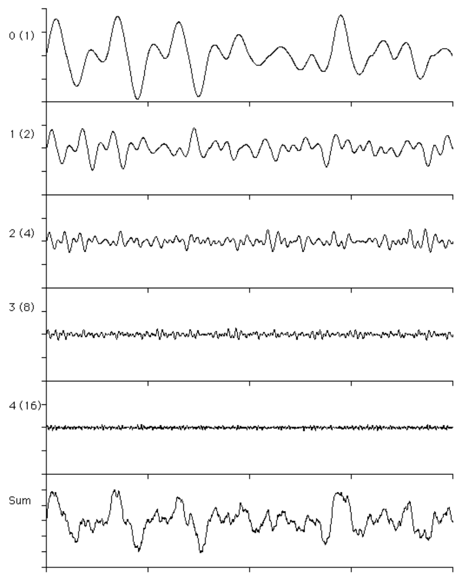


Figure 27.2: By adding the noise functions of different scales, it is possible to get as much detail as needed.

a mesh. An even number of quads makes dividing the mesh into smaller meshes easier. Subdividing a mesh is often done in algorithms to manage the complexity of large datasets.

Terrain datasets are available from a number of sources. For applications that intend to model real-world environments, such as GIS (geographical information system), flight simulators or virtual tourism, it is necessary to obtain an accurate description derived from aerial or satellite sources. Submarines, air crafts, space shuttles and satellites can be installed with remote sensing equipment that capture a large number of different descriptions using technologies such as multispectral photography, photogrammetry, sonar, radar and laser scanning. These are referred to as geospatial data sources. The topology of a land area can be represented with DEM's (Digital Elevation Model). These record the elevation below the observer, for some geographic area. This means that the surface topology is often polluted with the elevation of buildings and dense vegetation. For bare-ground terrain visualization another data source is more suitable. DTM's (Digital Terrain Model) captures the height of the terrain surface relative to some reference point (usually the mean sea level). Geospatial datasets covering the entire Earth can be downloaded freely off the Internet with a density of 500 meters. Datasets for smaller land areas can be downloaded with a density of 10 meters. Even higher quality datasets are being offered commercially.

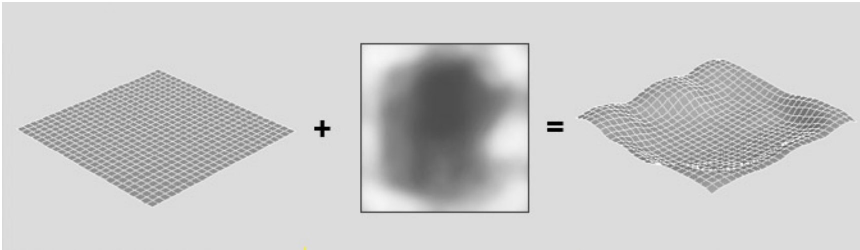


Figure 27.3: A heightmap can be represented as a grayscale texture. In this case lighter colors represents higher ground.

## 27.5 Atmospheric rendering

When you are outside and look up into the sky there are several things you can expect to see. Clouds, clear blue sky, the sun or the moon, stars, a rainbow etc. Most of the time it is a combination of these. Space is black, but the color of the sky isn't. How can atmospheric effects be rendered properly? There are several ways to approach this problem. The static one uses a sky dome and the dynamic one algorithms. In this section I will discuss both of them and give some examples.

### 27.5.1 Static sky

A static atmosphere using sky textures can be very realistic-looking. The textures are real pictures of the sky as shown in Figure 27.4. The rendering is fast since there are no calculations of light and the dome itself doesn't need much triangles. However, there are a few drawbacks with this approach which makes it unsuitable for our planet rendering:

- Lightning is static. There is no influence of the sun on the light of the sky
- Clouds always stay at the same place
- Perspective doesn't change. This can be a problem during flight scenes

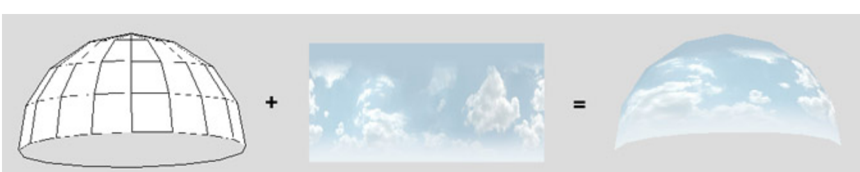


Figure 27.4: A skydome is a sphere in half with a texture on it.

### 27.5.2 Semi-dynamic sky

Instead of a skydome using a picture, a dome with vertex color is more dynamic. This is less realistic looking than a picture of the sky, but the change in sky-color can be made visible using vertex colors. Depending on the time of the day a color can be chosen. At dawn or sunset the sky above the east or west horizon gets a redish color, the opposite side a darker color. Given these two colors it is simple interpolation between these colors. To display clouds it is necessary to add an independent cloud layer since these are easaly drawn with a vertex colored dome.

### 27.5.3 full dynamic sky

The above approach for a vertex colored skydome is a lot better than it's static textured alternative, still it isn't very realistic looking. For true sky simulation we have to look at the physical phenomena's that take place.

One of these phenomena is scattering. When a solar beam enters the atmosphere it meets a lot of particles on its way down to the surface. This is the reason for change in the color of the light. After it's trip only 66% of the light reaches the surface of our planet. The rest is scattered back into the sky. The characteristic of the light beam itself also changed. Due to the particles on it's way the light is much more diffuse. All the above effects are ofcourse dependent on the amount of particles in the air. So, the altitude is of influence on the effect. At higher altitudes the sky gets darker and in space in completely black. The red color at sunrise/sunset is because the air scatters short-wavelength more than longer wavelengths. Since blue is on the short-wavelength band of the visual spectrum, it is stronger scattered than other light.

### 27.5.4 Planet from outer space

A good paper about this subject is written in 1993 by Tomoyuki Nishita, Takao Sirai, Katsumi Tadamura, and Eihachiro Nakamae. The paper descibes the math and physics to display the earh from outher space with the focus on the atmosphere [Nishita et al., 1993]. They use two layers which represent the surface of the earth (and ocean) and the outher layer of the atmosphere.

## 27.6 Precision on a large scale

The main problem with trying to model and render a really large game world, like a full scale planet, is precision. A 32-bit float has a maximum of 6 significant digits of accuracy, and a 64-bit double has a maximum of 15. This means, if the smallest unit you want to keeping track of is a millimeter, you start to lose accuracy around 1,000 km with floats and around 1 trillion km with doubles. Given the fact that the Earth's radius is close to 6,378 km, a 32-bit float isn't even enough to model and render one Earth-sized planet accurately.

### 27.6.1 Precision in rendering

When an object is rendered, it's depth stored in the z-buffer. This buffer is usually arranged as a two-dimensional array (x-y) with one element for each screen pixel. Each element is nowdays a 32bits number. If another object of the scene must be rendered in the same pixel, the graphics card compares the two depths and chooses the one closer to the observer. The chosen depth is then saved to the z-buffer, replacing the old one. This way objects behind other objects won't be rendered.

The resolution of this buffer is non-linear. It depends on the placement of the near and far clipping plane of the view-frustum Figure 27.5. Lets say that the value of the z-buffer is between 0 and 1. If the number is smaller than 0 it is before the near plane, is it greater than 1 it is behind the far plane. In both cases the pixel won't be rendered and thus clipped away. Taking in account that the near plane has value 0 and the far plane has value 1 we can come up with the following formula for the depth-value: $depth = (z_{pixel} - z_{near}) * (z_{far}/(z_{far} - z_{near}))$ [Codermind, 2010]. What happens if we place the near clipping plane towards 0? Than $(z_{far}/(z_{far} - z_{near}))$ tends to 1 and for large values of $w_{pixel}$ the resolution is almost 0. What happends is at low z-buffer resultion the graphics hardware can't distinguish if points are inside or ourside the viewfrustum (parts of objects are falling away) and it can't distinguish which objects are closer to the viewer than others. This graphical effects are often called z-fighting or flimming. So, the trick to keep resolution high is to keep the near clipping plane as far away as possible. But what to do if you want to render a object close by and a planet far away? There are several tricks you can apply to avoid z-fighting.

### Impostors

To have a scene with large objects close and far away you can use impostors [O'Niel, 2002]. An impostor is a dynamic texture used in stead of a real polygon model. The texture is made the same way as normal graphics but instead of a screen the output is written to a texture. This texture is placed onto a a rectangle which functions like a billboard. The big advantage of this technique is that the far and near clippong planes can be set separately for the impostor scene. This results in the highest z-buffer resolution as possible for this scene. And other advantage is that if the camera location doesn't change, this impostor doesn't have to be re-rendered. This results in a great decrease of polygon count. If the camera starts moving again, the impostor is updated. The impostor can be used as long as the planet is at great distance and should be replaced with the normal model if it comes closer to the camera.

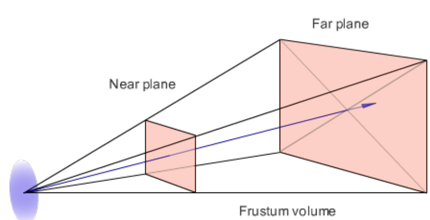


Figure 27.5: The view-frustum with the near and far clipping plane. Everything outside the frustum volume isn't rendered.

## 27.7 Conclusion

A lot of articles used for this research are not specially written with planets in mind. This biggest challenge is keeping the triangle count low. With a good algorithm like clipmaps the complete planet is just a large terrain set again, and there are a lot of very good papers written on how to render a large terrain set.

Another difficulty is swapping the terrain data into memory. A heightmap for the entire earth is approximately 4gb is size. This will never fit in memory, so a good disk paging system has to be written. Another thing that is done differently with a full size planet compared with just a large terrain is it atmosphere rendering. A simple skydome won't be sufficient and especially not when the planet has also be visible from outer space.

I hope this paper gives a nice overview of the challenges in rendering real size planets. I don't try to be complete. There are a lot more subjects to discuss like vegetation, buildings etc. But I tried to keep it to the basics which I hope I have accomplished.

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# Chapter 28

# gaming Motion tracking technologies for rehabilitation

*Section by Albert de Graaf*

## Abstract

Recently, there have been several motion tracking devices introduced by the gaming industry, like the Nintendo Wii with the Wiimote and the PlayStation3 Eye. This in-depth paper research investigated if these techniques can be used for home based upper extremity rehabilitation. The results are promising: Although current applications are not ready to hit the market yet, test results show that the techniques meet the requirements and already proved to help in rehabilitation.

## 28.1 Introduction

Stroke is the second leading cause of death and disability worldwide[1], with about 795,000 Americans experiencing a stroke yearly [2]. After six to nine months physical therapy is generally stopped, despite rehabilitation science evidence of the potential for improving motor function years after stroke [Holden and Todorov, 2002][Merians et al., 2002]. Acute rehabilitation currently concentrates on the lower extremity. Theferore, 30 to 66% of stroke survivors will not regain use of their affected arm [Truelsen and Bonita, 2003]. The literature is clear that intensive, repetitive practice of functional movement helps people recover [Butefisch et al., 1995][Feys et al., 1998][Dickstein et al., 1997]. Importantly, self-improvement does not stem directly from the therapist coaching and guiding, but rather from information processing by the subject with consolidation of everything inherent to the task leading to a refined motor output[Winstein et al., 1994]. Thus, subjects should be given opportunities to

[1]http://www.theuniversityhospital.com/stroke/stats.htm, last visited on juli 17, 2010
[2]http://www.strokecenter.org/patients/stats.htm, last visited on juli 17, 2010

train themselves to improve their (control of) upper extremity motions, especially arm and hand motion. The easiest place to do that would be at home, where people can train whenever they want. Recent developments in the gaming industry might be enabling the use of gaming consoles for home-based rehabilitation. With the introduction of the Nintendo Wii with the Wiimote[3], PlayStation 2's (PS2) EyeToy[4], PlayStation 3's (PS3) Eye[5] and the anouncement of Microsoft Kinect[6] and the PS3 Move[7][8] there is a whole new range of motion tracking devices available for gaming consoles.

## 28.2 Research question

The research question, which follows from the introduction:

*Which existing motion tracking technologies used in the game industry are usable for implementing upper extremity home based rehabilitation?*

In order to answer the research question, the following aspects need to be reviewed:

- information on and requirements for home based upper extremity rehabilitation
- The available motion tracking technologies and the usability of these technologies (with examples)

## 28.3 information on and requirements for home based upper extremity rehabilitation

To take advantage of home-based rehabilitation several tools are necessary. The first of them being a device showing an exercise. During the exercise, the movements of the user need to be recorded and processed. Considering that we will use gaming console's, the exercises will be shown as games. As already proven by several studies, games are an excellent medium for these exercises. They provide a way of measuring performance via scores and they add competitiveness to the exercises which motivates users to go on just that little bit longer[Burke et al., 2009]. Custom games could also save more information so a physician could use the results too.

Some of the consoles (the PS3 and the XBOX 360) have an internet connection, for the Wii it is necessary to buy addition equipment. This enables the option to upload results to a physician, so he/she can provide feedback to the user.

[3] http://nl.wii.com/wii/nl_NL/index.html, last visited on july 17, 2010
[4] http://www.eyetoy.com/index.asp, last visited on july 17, 2010
[5] http://us.playstation.com/ps3/accessories/scph-98047.html, last visited on july 17, 2010
[6] http://www.xbox.com/en-US/kinect/default.htm, last visited july 17, 2010
[7] http://us.playstation.com/ps3/accessories/scph-98060.html, last visited july 17, 2010
[8] http://us.playstation.com/ps3/accessories/scph-98061.html, last visited july 17, 2010

The most important aspect is recording the movements, because this is the only tool console's them self cannot provide. The first requirement for an input device is that it works on a gaming console (the PS2, PS3, Xbox, Xbox360 or the Wii) without big modifications. The most recent console's are preferred because they are faster and provide better graphics. The second requirement is that the device should be easy to configure, not everyone is very technical. The last requirement is that it works at home.

## 28.4 The available motion tracking technologies and the usability of these technologies

Currently there are two device categories, one which is using inertial sensors to detect movement (Wiimote and gloves) and the other which is using camera's (PS2 EyeToy and PS3 Eye). All

### 28.4.1 Inertial based

**the Wiimote**

When Nintendo released the Wii with the Wiimote a new idea of game control started. Players no longer used their fingers for game control, but rather used their whole arm[9]. When you see films of players they move their arms a lot. But is this a good platform for rehabilitation? [Deutsch et al., 2008] uses a Wii for rehabilitation with a patient who can already walk himself. The user plays Wii Sports for several sessions and he improved in visual-perceptual processing, postural control, and functional mobility. There are a few drawbacks though, it is necessary for one extra person to be there, in this case even two and the requirements are not fully met, because it is not used in a home environment, but on a school. Several others also use off-the-shelf games in combination with the Wii and also get positive results on using the wii for rehabilitation [Tanner, 2008][Fung et al., 2010][Saposnik et al., 2010][Anderson et al., 2010][Lange et al., 2009].

There are some other studies in which the Wiimote is used, but they don't use a gaming console (i.e. the Wii) but rather use some custom hardware and a pc[Tam, 2010][Decker et al., 2009][Alankus et al., 2010]. Although this is slightly out of our scope, it is still very interesting to see the research done here. In one study, the motion of the wrist joint was picked as an ideal candidate for their rehabilitation system. It consists of a wiimote in a casing with several LED's and reflective markers on the wrist, hand and arm. See 28.1 for a picture of the setup. They also confirm the rehabilitative working of the setup and the possibility to distribute it around the world for approximately $450 [Decker et al., 2009].

The Wii has so far only be used with stock games, this limits the use of results for physicians considering only game scores are provided. Wiimotes are used in combination with a pc for rehabilitation, some special hardware is required to use

[9]http://money.cnn.com/2006/11/15/commentary/wii_review/index.htm, last visited on July 17, 2010

Figure 28.1: The setup for the wiihabilitation study

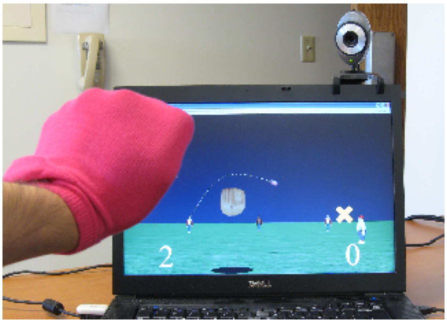


Figure 28.2: example of webcam based motion tracking using a coloured sock

Wiimotes on a pc, it might even be necessary to create custom hardware. Because this, and because pc's are no gaming consoles, this won't be considered an option.

**gloves**

Both the Playstation 3 and the Xbox360 have USB connections for extra hardware, and the first Xbox has the option of using USB via an adapter. This enables the use of gloves with sensors like the 5DT glove [10]. There have been several studies for the usability of such a glove in hand rehabilitation. One of them is using an Xbox together with a P5 glove. Before the Xbox could be used, several hardware modifications had to be made, including a Xodus Xenium Mod chip [11] and an additional CD-Rom drive. It was also necessary to install a customized operating

[10] http://www.vrlogic.com/html/datagloves.html, last visited on July 18, 2010
[11] http://www.modchipstore.com/Xodus-Xenium-ICE-Xbox-Mod-Chip-Official-16182.html, last visited on July 18, 2010

system to be able to use the glove. Unfortunately, there are not much results known for this implementation [Morrow et al., 2006].

Another study is using a PS3 together with the before mentioned 5DT glove, the PS3's software needed to be modified in order to use the glove, just like on the Xbox, although no hardware modification was required here. This modification could be prevented if the developer would buy the Sony Software Development Kit (SDK) for developing applications, which costs approximately $10,000. It would be an option if the cost could be spread over enough users. This system used the internet connection to upload results to an on-line database where a physician could have access to [Golomb et al., 2010].

The conclusion of the second study was that it is a good way to regain hand movement although there is a need for a better glove, which is more rugged and easier to put on and take off. More rehabilitation games to be developed and a more open platform than the PS3 is needed [Huber et al., 2010]. As already said, it could be solved by buying the SDK, another option would be to use another platform.

In short, it seems like a good option to use for rehabilitation, but it still needs development and further research.

### 28.4.2 Camera based

#### the PS2 EyeToy

Some research has been done on using the EyeToy for rehabilitation. Both studies report that the EyeToy has potential where one study suggests it could best be used for home-based rehabilitation. This study consists of two groups of individuals, one using of the EyeToy for 4 weeks and the other one just watching the games. This study reveals that it is useful to use the EyeToy games for recovery [Yavuzer et al., 2008].

The other study reports some limitations of using the EyeToy. The most important being the requirement of therapists, therapists are needed to make games easier or to change the movement patterns. Another limitation is the lack of recording the performance. If this was the case, the first could be remotely done in evaluation sessions, enabling more frequent use. It also states that it has potential to promote exercise for high-functioning individuals with stroke[Rand et al., 2008].

Considering the limitations found in the second study, it is not very likely that this system can be used directly, an alternative for the EyeToy should be searched[Rand et al., 2008].

#### webcam

Comparable to the EyeToy is the use of a webcam with a computer. Although it doesn't meet al the requirements, it sketches a good image of the possibilities. A very simple version of its use is found in a study done in [Alankus et al., 2010]. Here, they put a coloured sock over the hand of the user, which is being tracked by the camera. The pc to which the camera is connected translates this movement to movement in the game. See 28.2 for a picture. The only results reported is that 3 patients played the game called "baseball catch" for 25 minutes using the webcam.

Another system also uses a webcam. In order to track the players movements, the player holds a single-coloured marker in each of his hands, this might be gloves worn, or objects held. After calibration, the system can track these items. There were a few games developed using these techniques. The first game, Rabbit Chase, was developed for single-arm rehabilitation. In this game, the user tries to catch a rabbit popping out one of four holes. The player can see the rabbit running from one hole to another, so he can anticipate. A second game, Arrow Attack, was developed for rehabilitation of both arms. 2 arrows, one corresponding to the left, and one to the right hand, move between four boxes on the screen. The player must try to touch the arrows at the moment they hit a box. Finally, two variants of a game called Bubble Trouble have been created: one for rehabilitation of the affected arm and another which requires the use of both arms. In this game the user needs to pop bubbles by touching them in the virtual environment. If the version is played where both arms are used, each bubble is colour-coded to match the marker colour. Although there are no results on improvement of motor function, the test results are positive. The able-bodied users and three people from a stroke group, all enjoyed playing the games. One person from the stroke group actually really wanted to have the games herself[Burke et al., 2009].

Although there are no results on rehabilitation importance, the second article clearly states that people enjoyed playing these games, which makes it more likely to do repetitive movements.

## 28.5 Discussion and Conclusion

Of the motion tracking techniques reviewed, the use of data gloves seems the most advanced. Although there is a need for more rugged equipment, it works. One of the reviewed systems even had the ability to upload results to an online database. The Wii has no custom games developed for rehabilitation, the only research done so far is using off-the-shelf games. These games were not primarily designed for rehabilitation, which renders the results almost unusable for physicians. Almost the same problem occurs for the EyeToy. Although it has potential, it also has the drawback that no games made for rehabilitation on this platform exist. One of the reasons for this could be the expensiveness of a SDK for these devices. In the near future, Microsoft will come with a new camera device called Kinect[12], which is supposedly able to track 3d movements using two camera's. This, and the availability of Microsoft XNA Game Studio Express[Burke et al., 2009] for only $99 a year could make sure the disadvantages of previous systems are being solved, but further research has to be done after Kinect hits the market in November[13]. Webcam technologies reveal some parts of the potential of Kinect and PS3's Eye, the latter already on the market, but not used for rehabilitation purposes yet. Overall, there is high potential in using gaming techniques for rehabilitation.

[12] http://www.xbox.com/en-US/kinect/default.htm, last visited july 17, 2010

[13] http://www.computerandvideogames.com/article.php?id=250862, last visited on July 17, 2010

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# Chapter 29

# Trends for operating and integrating functionality into common household devices

*Section by Ernst Fluttert*

## Abstract

This in-depth research will explore the evolution in functionality and input for the television, telephone and the personal computer. These devices have evolved from relatively simple devices towards more complex devices with additional functionality and/or changed internal working. The focus will lie on the functionality and input of the common household devices, that are focused on the consumer market. First core purposes of the three devices will be explored, followed by the trends of integrating additional functionality and services in the devices. After the functionality is defined, the trends of operating the devices is reviewed. The state-of-the-art will conclude with an outlook on the devices and the operation of it.

## 29.1 Introduction

In common households of developed countries you are most likely to encounter the following three devices: television (TV), telephone and the personal computer (PC). For the United States the following statistics provide a view on the diffusion and penetration of the devices: Since 1962, more than 80% of the U.S. households has telephone and in 2007 73% of all households had a mobile phone (or cellular phone). Since 1958 more than 80% of the U.S. households has a television, although this technology became available later than the telephone, it was adopted in a much faster rate. The PC was also adopted in a high rate: whereas in 1990 only 22% of all households had a computer, this has grown to 74% in 2007. [U.S. Bureau of Census, 2001] [PricewaterhouseCoopers, 2008] [Fischer, 1994]

The current counterparts of the original devices are more advanced in functionality and usability. The core purpose of the device has hardly changed: the current devices are more sophisticated, integrate additional services and usually have alternative ways to operate the device. To exemplify the changes:

- The telephone has been around since halfway the 19th century and connected mostly to a local area. Currently we use tiny mobile telephones with can support internet applications and can have miniaturized keyboards and joysticks.
- When the TV was introduced in the 1930s, people could watch monochromatic images on just a few channels. Modern TV's have a great design, support full-HD, have flat panels, and can be connected to the internet.
- The PC became available in the early 1980s and was primarily focused on computational intensive tasks, text editing and administration. Current computers have evolved into different sizes (netbook to workstation), mobility (laptop to dekstop) and function (mediacenter to game machine).

### 29.1.1 Research question

The television, telephone and personal computer are consumer electronic products that have been innovated and evolved for many decades. These devices have evolved from relatively simple devices with limited functionality to complex devices with additional functionality and services. Another aspect is that the usage and interaction can change dramatically with added features or changing input devices. In this paper the following research question will be explored:

> *What are the trends in operating and integrating multifunctionality into the common household devices: TV, phone and PC?*

The main research question will be divided into the following subquestions:

- What are the main purposes of the original devices?
- What are the trends with integrating additional functionality and/or services into these devices?
- What are the trends in operating these these devices?
- What are the future trends for these devices?

## 29.2 Main purposes of the devices

To investigate the main purpose of the device, a look is taken at the early models which demonstrate more clearly what the core purpose was. This also shows a functionality boundary of the original device and what features have been added later on. Early models of the phone, TV and PC can be found in Figure 29.1. Additional and changing features will be discussed in the next chapter.

### 29.2.1 Core purpose of the telephone

The telephone is the oldest of the three devices; its roots date back to the 1870s with the most prominent name being Alexander Graham Bell. The telephone can be seen as the successor of the telegraph, where morse-code is replaced by human speech. The main purpose of a telephone is to transmit and receive sounds, the end goal being connecting people. In the early devices this was done through wires, the so called land-lines. The phones were quite limited and most needed an operator to patch a call through to another phone. Another limitation was that in the beginning most phone calls could only be made locally (small radius) [Fischer, 1994] [Mueller, 1993] [Britannica, 2010b].

- Purpose: A device that enables people to communicate with each other through speech
- Initial functionality: Transmitting human speech, using analogue techniques

### 29.2.2 Core purpose of the television

In the 1920s the electronic television was invented, mainly due to the cathode ray tube (CRT). The television can be seen as a natural evolution from the radio: not only sound but also images are transmitted. In the 1930s the first commercial TV's, which could display monochromatic moving images, became available for the public. One of the most famous earliest broadcasts would be the 1936 Olympics in Germany, which illustrates the core purpose: infotainment and entertainment. The images were sent through analogue signals on a specific place in the television-band (channels), which the television could receive and decode [Wasko, 2010] [Britannica, 2010c] [Flow TV, 2005].

- Purpose: The purpose of the TV is to distribute visual information (infotainment) and entertainment
- Initial functionality: The device is capable of displaying monochromatic moving images accompanied by sound. These images are transmitted in analogue waves in certain channels of the television-band.

### 29.2.3 Core purpose of the personal computer

Before the computer became widely available for consumers, it was purely used by research and military organizations. The first digital computers emerged in the 1940s, but it took another four decades before the PC emerged as a platform. The biggest inventions towards the PC are the transistor and the microprocessor, which made the computer much more suited towards general purpose, more reliable and smaller. In the 1980s the PC became popular and usually appeared in the form of a computer, monitor and a keyboard. With this the consumer could operate the computer for various tasks like text editing and games; hobbyists could even write their own programs for the computer [Tannenbaum, 1998] [Britannica, 2010a].

- Purpose: The PC was used for entertainment, computational intensive tasks, text-editing and administrative tasks
- Initial functionality: The PC could store, manipulate and retrieve data. Performance and (graphical) output were often limited by the hardware. Initial operating systems and programs often used textual interfaces.

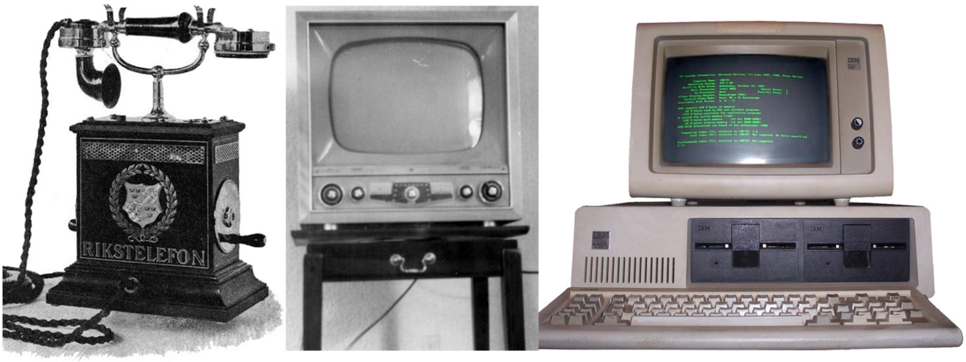


Figure 29.1: Early models of the devices. From left to right: Telephone (1896), TV (1950s), PC (1981).

## 29.3 Trends in additional and changing functionality

The youngest device (PC) has already been around for at least 30 years, and with the focus on consumers it is vital to innovate and further develop the product. Some of the general key factors of innovations for the phone, TV and PC are:

- Internet: Digital networks which connect computers/devices based on the Internet Protocol (IP). The internet provides users instant access to information that can be retrieved from databases, servers and even other users. Another factor is that the internet operates on a digital infrastructure that is widely available. In 2007 68% of all U.S. households had internet access at home, whereas 51% of all households even had broadband internet connection [PricewaterhouseCoopers, 2008]. In 2009 74% of all U.S. adults use the internet [Rainie, 2010].
- Miniaturization: Most digital components have become smaller due to smaller production procedures and more integrated functions into chips. Moore's law predicts the doubling of the number of transistors in integrated circuits every 18 to 24 months, which has been true for the last 40 years[Koch, 2005]. This contributes towards smaller but more functional and powerful digital devices which require less energy consumption. Another benefit is the cost reduction of chips.

The visualization of the evolution from introduction of the device towards more diverse and cross-market products can be seen in Figure 29.2. All paths in this overview will be further discussed in this section.

### 29.3.1 From land-line to mobile phones and voice over IP

The evolution of the telephone is quite remarkable as it started out as a medium where only speech is transmitted from one person to another. For a long time this remained the same, and only design and additional apparatus changed (cordless phone and answering machines). The emergence of mobile or cellular phones

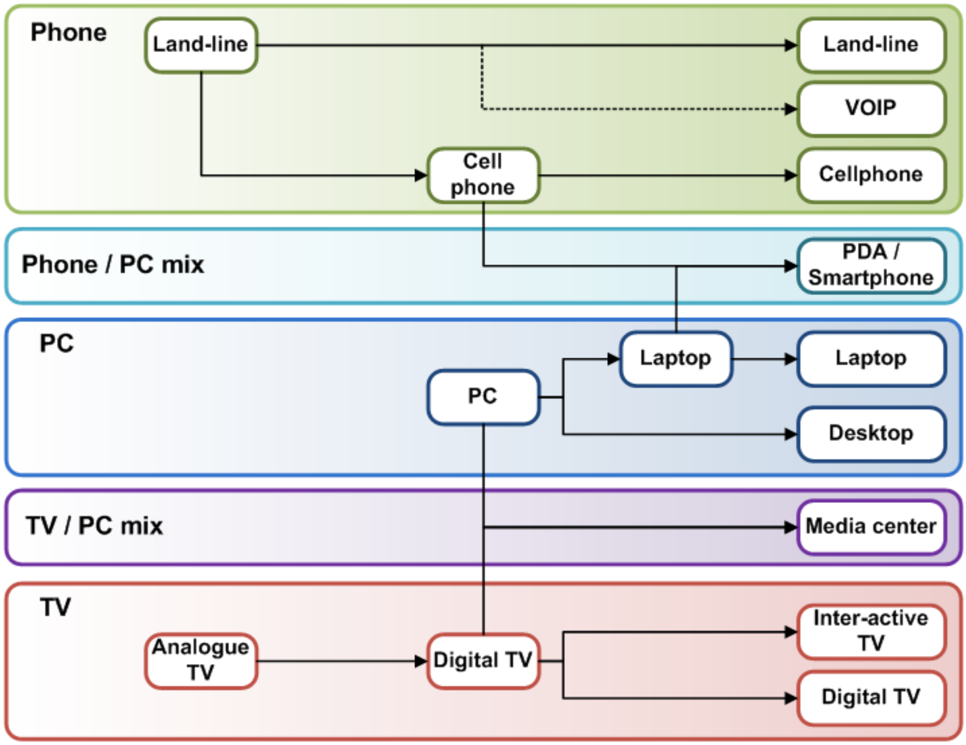


Figure 29.2: Diagram displaying possible relations in the evolution and innovation of the TV, phone and PC.

(end 1970s) became a turning point, which also lead to the rise of digital wireless networks such as the GSM [Dunnewijk and Hultén, 2007]. From that point on the mobile market would grow enormously and in 2002 there were more mobile phone subscriptions than land-line subscriptions [Comer and Wikle, 2008]. Developments in functionality grew dramatically for the mobile phone: text messages (SMS / MMS), radio receiver, mediaplayer, computing capabilities and photocamera [Rice and Katz, 2008]. Land-line phones are in further withdrawal because of the digital revolution and VOIP (Voice over IP), where phones are connected through the internet instead of the regular phone-lines. VOIP phone designs are mainly based on land-lines, but possible additional features are webcam and text functionality[Anderson, 2008].

### 29.3.2 From moving monochromatic images to interactive television

The first commercial televisions could only display monochromatic images, but within years sound was added. In the early 1950s the first commercial color televisions were available but it took until the 1960s for them to dominate over the market. A feature that was added was teletext, which made it possible to serve textual information. Another feature is digital TV, where the input signal was digital instead of analogue. The digital signal would slowly replace analogue transmissions and in some western countries like the U.S. analogue signal is no longer available [Hart, 2010]. A current trend is the rise of LCD-TV, which is a flatter TV than the TV based on CRT [Geelhaar, 1998]. The newest trend is interactive TV (iTV), which enables the consumer to interact with the television through various options. [Chorianopoulos and Lekakos, 2007] The core functionality stayed the same: displaying moving images accompanied by sound. Major improvements were mostly technical, but the functionality remained the same.

### 29.3.3 From the personal computer to laptop

The PC is a general purpose device and after the initial PC, many branches and markets were created that would be aimed at specific properties, such as mobility, size and functionality. The PC has probably profited the most from the rise of the internet and the ongoing miniaturization of integrated circuits. When the LCD panel became available, it created opportunities on the market for laptops [Geelhaar, 1998]. The laptop is a device that has all the PC features in it, but is aimed at mobility. Another feature of the laptop is the far integration of all loose components into one device: monitor, computer, keyboard, mouse [Francis, 1997]. This is actually the most distinctive branch for the PC. Furthermore all computers aimed at faster processing of (visual) data, more interoperability and connectivity with peripherals. The PC evolved into the desktop (a non-mobile computer).

### 29.3.4 Crossovers of original devices

With smaller devices and the rise of new technology it was only a matter of time before new devices would emerge from a mix of the initial devices. A short list is shown below:

- PDA and Smartphone: These can be viewed as hand-held computers, which combine the functions of the cellphone (calling) with that of the computer (platform for manipulating data). Although not as fast as laptops, the computing power is enough to run programs on the PDAs and smartphones [Sweeney and Crestani, 2006]. Most models incorporate a full keyboard.
- Media center and consoles: This is not a real mix as the devices are still separate (Computer and TV), but the computer is fully configured to maximize the TV-experience for the consumer. Specialized computers intended for games are consoles, which usually have special input controllers for optimal gaming.
- VOIP: Although VOIP is a technique to call somebody, it can always be used on computers that are connected to the internet.

## 29.4 Operating the devices

Whereas functionality evolved the past decades, so did the input devices for the telephone, TV and PC. In this section the trends in operating the devices will be reviewed, with the focus on the input devices and interaction.

### 29.4.1 Operating the telephone

The functionality and operation of land-line phones has not changed, a number has to be dialed in order to connect with someone else. An example of an innovation was the development of push-button, which replaced the earlier dial-rotor. Later-on the push-bottons were replaced by the telephone keypad, which is displayed in Figure 29.3. With mobile phones becoming more popular and having more functions, the keypad became an important input device to enter text into the phone [Dix et al., 2004]. However, input on phones and mobiles do not solely depend on the keypad, as there are various alternatives. Examples are a mini-joystick, touchscreen and speech. To illustrate speech commands and recognition think of the following: a user says a name and the phone automatically dials the correct number. The joystick adds a quick way for navigation in user menus and is useful in entertainment applications. Newer mobile phones also incorporate touchscreens, up to a point that the touchscreen is the only way of input for the device. This technology currently also allows multitouch (operating the phone with commands, executed with more then one finger [Buxton, 2007]). For VOIP there is another standard, as it can operated like a normal land-line phone but could have additional features such as touchscreen and webcam. The additional features are used in interactive programs and video-conferencing.


Figure 29.3: Schematic of a normal telephone keypad

### 29.4.2 Input for the television

The TV stayed loyal to the core of its functionality (displaying moving images accompanied with sound) but it also remained a passive device. There is little need for extensive input as most consumers only switch channels. The first TV's only had buttons on the device itself for switching channels, but in the 1950s the first wired remotes became available. It did not take long before the remote control became wireless and additional buttons were created (teletext, TV options and fine tuning). Current remote controls for the television have incorporated the keypad as well for textual input and usually have additional features to operate peripherals like a VCR and DVD-player. As the remote control is the primary source to operate the television, newer functions of internet applications and interactive TV require a less rigid device. The need for alternatives for the remote control arises when consumers are required to provide a large amount of input. This can be the case with real interactive applications. [Lekakos et al., 2001] Alternatives for the keyboard would become gesture based controlling, touchscreen and mobile phone as an input for an application (e.g. a browser). Research shows that gestures are the hardest to learn for users. [Pirttikangas et al., 2008] [Baudel and Beaudouin-Lafon, 1993]

### 29.4.3 Keyboard and mouse

The first PC's only needed a keyboard as most programs had textual interface. The keyboard is very efficient for textual inputs, experienced users can type up to 300 or 400 characters per minute. When applications with graphical user interfaces emerged, the need for a pointing peripheral grew. The (computer) mouse fulfilled this need and improved the user experience of computer interaction. Today the mouse and keyboard combination is most used for desktops. A laptop uses a touchpad and/or keyboardstick instead of a mouse for pointing and positioning. Although the keyboard, mouse and touchpad are dominating the input on computers, there are also other techniques: [Dix et al., 2004]:

- Joystick: Although this peripheral cannot match up to the mouse for normal usage it is ideal for games and (flight) simulations. A small variant, the keyboard stick, can still be found in laptops and/or phones.
- Touchscreen: Touchscreens work very well for pointing and small operations, but are very expensive and not really accurate. Users favour since the input-device is also the output device. Touchscreens are more succesfull in PDA's and smartphones than in computers. A niche market would be the tablet PC where the whole screen of the laptop is a touchscreen and is preferably operated by a stylus.
- Handwriting and speech recognition: Both techniques are very normal for users, but require tremendous effort for a computer to correctly interpret the input. In most cases the computer is "trained" by the user before this technique works properly, and even then the commands are usually limited.
- Eyegaze: A niche market where applications are controlled by gazing at it! Although it can be very fast and accurate, it is also very expensive and unsuitable for drawing. A drawback is that gazing and glancing is sometimes mistaken, which causes the application to malfunction. This technique is used in the military but also for disabled users and users who are not able to use their hands in the environment they are in.
- Trackballs: This was an alternative for the mouse, where not the mouse was moved for positioning but a big ball on the device. The main drawbacks are the difficulty for large movements and drawing.
- Controllers and motes: These are specific devices designed for games and entertainment, although highly popular on consoles these are not used often in combination with the PC.

## 29.5 Future trends

With the digital revolution and the internet the household devices began to take on more functionality and some required additional ways for input to make user experience as easy and comfortable as possible. In this section the main purpose of the device and trends and experimental developments are reviewed.

### 29.5.1 Trends of the telephone

Although some predict the end of the land-line [Thompson, 2003]this still remain to be seen: more then a billion people are connected through land-lines. The rise of VOIP will certainly continue as more households get internet access. Probably the most interesting branch of the phone is the mobile phone where innovations and developments are rapidly succeeding each other. While the core purpose has remained the same (talking and communicating with each other), the functionality has changed dramatically in the case of mobile phones. Current mobile phones have multi-functionality that surpasses calling: fm-radio, camera, computer-functionality (PDA/smartphone) and more. Trends for normal phones tend towards favoring VOIP, which has additional features like videocalling and more options for the interface (as is the case with touchscreens) [Anderson, 2008].

When looking a the trend of cell phones, devices are getting smaller and are capable of more features and functions. Also, interconnectivity with other devices is further improved. Trends for input on mobile phones combine touchscreens, keyboards and phonepads. Connectivity plays a major role and textual input will increase as well as entertainment.

### 29.5.2 Trends for the television

The television itself has evolved from displaying monochromatic images towards colored digital high definition images, but it could well be that the next generation TV will go towards the interactive instead of the passive TV. There are three trends visible for the television.

The first trend would be that the TV becomes more interactive, where users can do more than only watching in a passive way.The second trend would be that the TV connects to the internet and IPTV could be the next big thing in television-land. Digital media such as the cable and satellite are replaced by broadband internet. This could also open up more opportunities towards interactive television and television on demand [Claro et al., 2009]. The last visible trend is the change of input and interaction with the TV. It is clear that the standard remote control is insufficient for interactive application and textual input. A new development maybe the introduction of gestures [Freeman and Weissman, 2004] as a means of operating the TV. Other developments are the paperremote, which customizes the remote considerably[ Hess et al., 2008].

### 29.5.3 Trends for the personal computer

The desktop will most likely continue like it is now: faster processing of data, more interoperability with other devices, smaller components, and better connectivity with other devices.

The laptop will follow the same trend as the deskt with some additional requirements: higher energy efficiency, even smaller components, more integrated features, and more wireless connectivity.

There are no signs and trends for changing the input for the PC, as it is mainly textual input and moving cursors. Additional input devices as videocapturing (webcam) and microphone (speech) will probably be used more for connectivity between persons and applications like VOIP.

## 29.6 Conclusion

This paper started out to explore the question "What are the trends in operating and integrating multifunctionality into the common household devices: TV, phone and PC?". For all three devices the trends are going to more interactive and more connected. The developments for each device is listed below:

- Phone: The telephone is still available with the core functionality: the landline. But major improvements in integrating functionality and input has been made with mobile phones. The cellular phone has an additional purpose: to be mobile and be connected everywhere, also it can have many additional features. As a third category is VOIP-phones which starts with the main functionality, such the landline, but can have additional features like video and text. The trend for the phone tends towards further digitalization, and focus on mobile phones as this is currently the biggest market. As for input for mobile phones, when the regular keypad is not sufficient, the touchscreens seems like the logical alternative which further improves interactivity.
- TV: The television is the device that has changed the least, although most broadcast-signals changed from analogue to digital. The core functionality stayed the same: displaying moving images accompanied and the purpose is still to bring infotainment and entertainment. Major trends are pointing towards an increase in interactivity between consumer and TV, possibly supported by IPTV and interactive services provided by digitial TV. As far as operating the TV goes the remote control is still by far the most popular. Trends indicate towards more customizable layouts for the remote, touchscreens, gestures and mobile phone as input device.
- PC: The PC has benefited maximum from the digital revolution and internet. From the three devices, the PC is the most general purpose and flexible in operation. The main input for computer remains the keyboard and mouse, but other input peripherals can be attached likes (game)controllers and touchscreens depending on the needs of the consumer and application. The main functionality has been improved although be it on processing speeds and applications. The purpose has not really changed in a household: entertainment, administrative tasks and computational intensive tasks. For the laptop another purpose was added: mobility.

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# Chapter 30

# Brain-Computer Interfaces as a supplementary for Human Computer Interaction in computer games

*Section by Mark Oude Veldhuis*

## 30.1 Abstract

This report investigates how Brain-Computer Interfaces (BCIs) can act as a useful supplementary when playing computer games. Not only can a BCI be used as a control input, it can also be used in the sense of Physiological Computing. The report covers current research and developments in the area of Brain-Computer Interfaces, Human Computer Interaction, Physiological Computing, as well as combinations between these three concepts. It also contains a section that tries to determine how people experience using these concepts.

## 30.2 Introduction

Research regarding the subject of Brain-Computer Interfaces is most of the time focused on using a person's brain as a direct input to control a computer system [Cutrell and Tan, 2008]. However, it is also argued that the concept of Brain-Computer Interfacing could be — perhaps better in the sense of computer games — be used as a supplementary to assist a computer system. In thise case the system can make the correct choices, based on the physiological state of the person using that system [Fairclough, 2008]. In this research paper we will try to determine how BCI can be a useful supplementary to computer games as we know them today.

This research paper has been written by Mark Oude Veldhuis, student at the University of Twente in Enschede, the Netherlands, in preparation for the 2010 study tour to the United States of America. The theme of the study tour is *games and simulation*.

## 30.3 Research question

Most of the research done regarding BCI is focused on how neural signals can be used to control an application running on a computer. The problem with this however is that there is a very steep learning curve for the users, since those systems most of the time require some form of training. One question one might ask is whether to use Brain-Computer Interfacing as a form of control input is the most intuitive way of applying Brain-Computer Interfacing for computer games. [Fairclough, 2008]

The rapidly growing development and availability of physiological sensors, e.g. sensors that can detect a person's heart rate and brain signals, allow the existence of Physiological Computing. Physiological Computing systems use data from physiological sensors to detect changes in the user's mood or physiological state. In this subject it is not so much about using physiological sensor data as control input for a system, but rather as an input that allows the system to adapt to the user's physiological state. The difficulty of a computer game could for example be adjusted according to how agitated, frustrated or bored a gamer is indicating that the game respectively is too difficult or easy. [Fairclough, 2008] [Allanson and Fairclough, 2004]

To be able to classify someone's state of mind during a certain activity, the term "Flow" was introduced by Mihaly Csikszentmihalyi in 1990 and refers to the mental state of a person during an activity in which he or she is fully immersed, feeling good, feeling energized and succeeds in what needs to be done. Flow is reached when an optimal combination of a person's skill and challenge levels is found. If the skill level is very low and the challenge level is very high you will end up in a state of anxiety, according to Csikszentmihalyi. On the other end if the skill level is very high and the challenge level is very low you will find yourself in a state of relaxation. The ultimate situation is when the activity requires both a medium to high skill and challenge level. [Csikszentmihalyi, 2008] [Csikszentmihalyi, 1998]

During this research paper we will try to answer the following research question:

*How can the concept of Brain Computing Interfacing be applied in the context of computer games, and what are the current development regarding this subject?*

Before immediately answering this question there are a few sub questions that will be answered in order to obtain a better understanding of the concepts, so that a valid conclusion can be made:

- What current research is done in BCI?
- What are the current developments in Physiological Computing?
- How are BCI, HCI and Physiological Computing combined?
- Do people find themselves in the "flow" when using a BCI, or possibly in combination with Physiological Computing?

## 30.4 Brain-Computer Interfaces

This chapter will take a closer look at the concept of Brain-Computer Interfacing. We will start by providing a definition of the term, after which we will take a look at the different paradigms that have been developed that allow us to actually use the neural signals recorded by electroencephalographic (EEG) equipment.

### 30.4.1 Definition

A Brain-Computer Interface is, as the name suggest, an abstract notation of a system that interacts as an interface between a human brain and a computer. Electroencephalographic activity from the human brain can be used as a way of communicating between a human brain and computer system. To date, most research regarding the subject has focused on how to use these EEG signals as a control input to a computer system; as a replacement for the keyboard and mouse. [Blankertz et al., 2006] [Cutrell and Tan, 2008] [Wolpaw et al., 2002]

### 30.4.2 Paradigms and current developments

Applying BCI to gaming is a research subject in which several projects have been performed. In this section we will explore some of the paradigms, including an example application — which are games most of the time — that demonstrates the paradigm.

#### Event Related De/Synchronization

Event Related De/Synchronization (ERD/ERS) is a paradigm that is based on imaginary movements. When users imagine moving their left arm, leg or any other body part, this can be seen in the recorded sensorimotor rhythms as an increase of activity, which in humans is called the $\mu$-rhythm. The frequency of the signals is usually between 8 to 12 Hz and is observed over the primary sensory or motor cortical areas of the human scalp. [Gurkok, 2009]

An example application that uses ERD/ERS is Hex-o-Spell. Hex-o-Spell shows a hexagram in which the six segments contain the letters of the alphabet and a few special characters. In the center there is an arrow that points to the current selected segment. By imagining right hand movement the arrow turns clockwise thus pointing at a different segment. By imagining right foot movement the arrow extends and as soon as the arrow touches the segment, the letters in that segment are placed in the hexagram. Now the same method is used to select a letter, after which the hexagram will return to its initial state. Using this way of typing text, experiences subjects can type up to 7.7 characters per minute. [Blankertz et al., 2006] [Muller and Blankertz, 2006]

#### P300

P300 is a paradigm that is based on presenting a certain target stimulus to the user that the user is aware of, e.g. a word that suddenly is displayed or highlighting certain pieces of text. The probability of this stimulus should be lower than other standard stimuli. The target stimulus is known to the user and is presented during a series of other standard stimuli. As soon as the user sees the target stimulus and realizes this, a positive peak in brain activity can be measured over the center and parietal cortex — that is respectively in the center and a little on the back of the human scalp — 300 milliseconds after the target stimulus was presented, hence the name of the paradigm. [Gurkok, 2009]

The P300 speller is an example application of the P300 paradigm. Just as with Hex-o-Spell in the ERD/ERS paradigm, this is also a speller application. The P300 speller displays a 6x6 matrix containing the characters of the alphabet in which all rows and columns are separately highlighted in a random order. The row and column in which the letter the user wants to use are the two target stimuli. The other rows and columns are the more frequent standard stimuli. When the system has detected that a P300 occurs 300 milliseconds after a certain row and column, it knows the letter that the user wants to use. [Sellers and Donchin, 2006]

#### Steady State Evoked Potentials

Steady State Evoked Potentials (SSEP) exist in three different types: visual, auditory and somatosensory — respectively abbreviated to SSVEP, SSAEP and SSSEP — and is a paradigm that determines what stimuli the user is focusing at. SSEP is a certain frequency of signals generated by the human brain in response to a visual, auditory or somatosensory stimulus. If the user of a certain system based on SSVEP would look at a checkerboard that flickers at 12 Hz this same frequency of signals can be detected in the EEG measurements. [Gurkok, 2009] [Ko et al., 2009] [Posthumus and Oude Veldhuis, 2010]

An example that uses the Steady-State *Visual* Evoked Potentials is a game called *Mind Balance*. The game involves a character that is balancing on a pole. Randomly, every 1.5 to 5 seconds the character loses its balance and the user must either look at one of the two checkerboard on the left and right side of the screen to correctly re-balance the character. These checkboards flicker at different frequencies, which allows the system to determine whether the user wanted to correct to the left or right side. [Gurkok, 2009] [Ko et al., 2009]

## 30.5 Physiological Computing

This section provides an introduction to Physiological Computing, which may be abbreviated to PC from here on in this report. We will start with a definition of the term Physiological Computing after which we take a look at the current developments in this area of expertise.

### 30.5.1 Definition

Physiological Computing involves monitoring changes in a user's psychophysiology and then translating those changes into input for a computer system so that it is able to adapt to the user of the system, with the goal of enriching the user experience. Where traditional BCI's most of the time are meant as a control input for some computer system, PC is aimed at monitoring changes of a user's psychophysiology in order to have a computer system adapt itself to the user. When BCI is used as a control input, this usually involves some form of training for the user or system which can sometimes be very difficult. With Physiological Computing this is not the case since such a system monitors the user's psychophysiology, without them having to do anything but using the system. [Fairclough, 2008] [Allanson and Fairclough, 2004]

Psychophysiology is a combination between psychology and physiological. Psychology is related to a person's mental state, and physiological is related to a person's body. With psychophysiology one of the main research topics is how the human body responds, i.e. the physiological part, to a person's mental state, i.e. the psychological part. This involves measuring the heart rate, blood pressure, the amount of sweat that is produced from a person's hand, movements, et cetera, and of course neural changes that can be measured with EEG equipment. All this physiological data can be used as input for a computer system, which is what Physiological Computing is about. [Fairclough, 2008] [Allanson and Fairclough, 2004]

### 30.5.2 An example of current developments

Already in 1988 there was the idea of using the computer as a way of learning. The term *learning companion* was in that time introduced regarding Intelligent Tutoring Systems as an idea of presenting tutoring agents as a peer companion [Chan and Baskin, 1988]. Kapoor, Burleson and Picard [Kapoor et al., 2007] developed a system for research regarding such tutoring agents. It integrates affective sensors — including physiological sensors — that is used by a inference, behavior and character engine. The research setup involves sitting on a chair in front of a wide-screen plasma display with some controls. The seat is equipped with pressure sensors. The mouse that is used for control also contains a pressure sensor to measure the applied force while used. The user also wears a wireless skin conductance sensor on a wristband. Finally, two cameras are also used. One regular camera and a Blue-Eyes camera to record elements for facial expressions. The setup of this experiment can be seen in figure 30.1.

This core of this research is related to psychophysiology. The user must try to learn something but can become agitated (psychological) when the user has a hard time learning, and is expressed by the human body via several body parts such (physiological). During the experiment the user could press a *I'm frustrated*-button whenever he or she is feeling so. The goal was then to predict when the user would press this button. The accuracy of this prediction was 79%. [Kapoor et al., 2007]

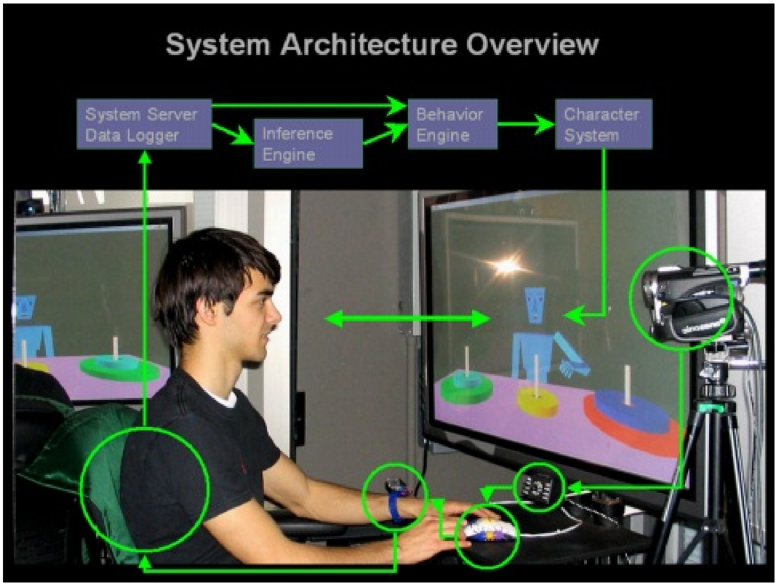


Figure 30.1: An Intelligent Tutoring System using a Learning Companion [Kapoor et al., 2007]

## 30.6 Combining Brain-Computer Interfaces, Human-Computer Interaction and Physiological Computing

In this section of the report we will investigate how Brain-Computer Interfaces, Human Computer Interaction and Physiological Computing can all be combined to create a state of the art application. First we will define the term Human Computer Interaction since we do not have a definition of that term yet. Immediately after the definition we will investigate how these three concepts are combined in current research.

### 30.6.1 Definition of Human-Computer Interaction

Human-Computer Interaction — abbreviated to HCI — is the study that concerns the interaction between humans and computers, as the name does suggest. HCI used to be a specialty area in Computer Science and had merely to do with designing user interfaces, but nowadays this area has expanded greatly. BCI is also directly related to HCI because it obviously forms a method of interaction between a human and a computer. BCI is what HCI is all about, it allows designers and developers to create usable and useful systems that just work and work intuitively [Cutrell and Tan, 2008]. [Caroll, 2009]

### 30.6.2 Combinations

Research studies or applications that combine the three concepts of BCI, HCI and PC are really only using Brain-Computer Interfaces in a specific way. As soon as a BCI is used to collect information about the user of a computer system and is not used as a control input, we can speak of Physiological Computing. When using a Brain-Computer Interface, Human-Computer Interaction is a concept that is also used since a BCI is either used as a control input, or as a method of collecting information about the user's psychological state. In the latter case a BCI is used to adapt to a user's psychological state which often changes how a computer system responds to the user. A BCI can however always be seen as a method of interaction between the human and a computer.

## 30.7 User experiences with Brain-Computer Interfaces

This section of the report will discuss how users of Brain-Computer Interfaces experience the use of a system that uses a BCI paradigm. After we have investigated how people experience using such a system we will try to determine if they are in the *flow*. First, we will provide some background information of the term *flow*.

### 30.7.1 Flow

As mentioned in the introduction, *flow* is a term that was introduced by Mihaly Csikszentmihalyi in 1990 and is the mental state in which a person feels fully immersed, good, energized during an activity and succeeds. The experiences of persons during a certain activity are related to their skill level, as well as the challenge level. In figure 30.2 the skill and challenge level are shown, including the mental state a person experiences in a certain combination. The ultimate goal, according to Csikszentmihalyi, is to achieve *flow* by performing activities that require a both a high skill and challenge level related to the person in question. When achieving the mental state *control*, a person is skilled in the activity she is performing but the activity is not challenging enough for the person to actually 'learn something new', and thus she is not experiencing *flow*. [Csikszentmihalyi, 2008] [Csikszentmihalyi, 1998]

In the next two paragraphs we will try to identify mental state of persons using Brain-Computer Interfaces either as a control input, or in Physiological Computing, according to the mental states that are presented in figure 30.2.

### 30.7.2 With Brain-Computer Interfaces as a control input

When BCIs are used as a control input for computer systems, the user of the system must be able to manipulate his or her neural rhythms in order for the system to work as a control input. Most of the time users are experiencing a very steep learning curve when trying to control their neural rhythms [Pineda et al., 2003]. Instinctively we would classify the mental state of novice users then at a low/medium skill level and a high challenge level. According to figure 30.2 this is classified as either anxiety in the beginning, or after some time when users start learning, arousal. Over time

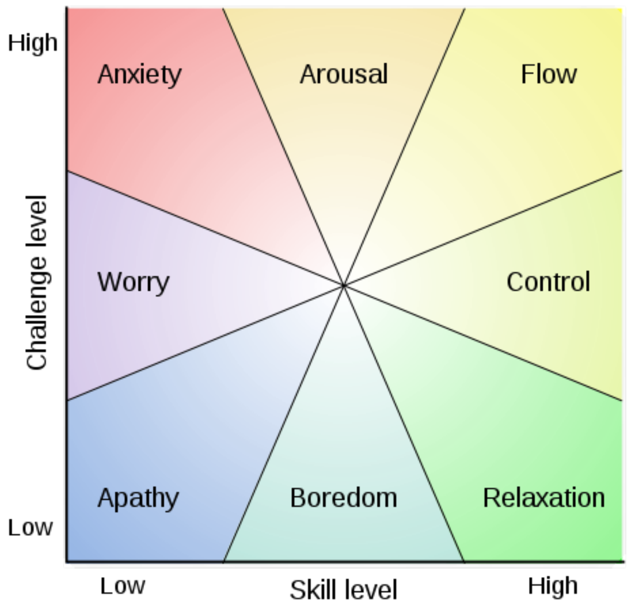


Figure 30.2: Challenge versus skill level. Mental states including "flow" [Csikszentmihalyi, 1998]

however, when users become more experienced in controlling their neural rhythms while playing a computer game for example, the skill level becomes higher but the challenge level remains the same. Playing a game could become lots of fun when you are able to do it with your mind and users may in that case achieve *flow*. If the game stays exactly the same, however, the challenge level for a highly skilled gamer will decrease and the user will feel as if he or she is in full control.

From my own experience I know that when I was playing $\alpha$WoW [Oude Bos, 2008] [Oude Bos, 2009] — an addition to the popular computer game World of Warcraft that uses a Brain-Computer Interface to change forms of your character according to your level of relaxation — it was quite difficult to become relaxed when your character was under attack for example. However, you had to relax in order to heal the character. When gaming, those kinds of situations are rather stressful and it becomes even more difficult to control your state of mind. Other gamers needed less effort to relax or become more aggressive. I experienced the challenge level as medium to high and my skill level was low, which suggests that I felt either worried or anxious according to figure 30.2.

### 30.7.3 Brain-Computer Interfaces applied as Physiological Computing

Physiological Computing is a much less intrusive method of Human-Computer Interaction then when applying Brain-Computer Interfaces as a control input. The reason for this is that with Physiological Computing most of the time you do not need as many channels as with using BCIs as a control input, which can require up to 32 or even more EEG sensor nodes that are placed on the person's scalp. When PC is applied it most of the time does not only rely on Brain-Computer Interfaces, but on a combination between multiple physiological sensors. This data is very valuable when combined with each other.

When Physiological Computing is applied while a person plays a computer game, he or she is just playing the computer games as when playing without PC. The only difference is that with PC there are multiple sensors acquiring data about the person playing the game. This means that when looking at skill and challenge, this is not different in the first place then when playing the game normally. A difference is however made when the acquired psychophysiological data is applied while playing the computer game. In that case, the challenge level can change depending on how the game adapts to the gamer. The goal is to adapt the game so that is does not become to easy and not to hard either. In other words, the game will try to achieve *flow* for the user.

When BCIs are used as a control input, the user playing the computer game must achieve *flow* him- or herself. If BCIs are applied during a computer game that uses Physiological Computing, the responsibility of achieving *flow* lies no longer with the user, but with the computer game that is combining all psychophysiological data.

[Fairclough, 2008] [Allanson and Fairclough, 2004] [Kapoor et al., 2007] [Nacke et al., 2009]

## 30.8 Conclusion

As we have seen in the several sections of this report, a lot of research has been, is, and must be done in the area of Brain-Computer Interfaces. Using BCIs as a control input for a computer system requires training from the user and can have a steep learning curve for novice users. On the other hand, BCIs can also be used with Physiological Computing.

Physiological Computing is a concept that does not necessarily require a BCI but is often used with all kinds of physiological sensors, BCI provides a direct link between a computer system and the user of that system that may be very valuable if designed and built properly. It allows the system to analyze the neural signals from the user which can be translated into mental states, allowing the system to adapt itself so that user experience increases.

In the area of computer games, BCIs are already used as a control input for several games and other applications that were developed during research, as we have seen earlier in this report. Because of the steep learning curve BCIs have when used as a control input, it may be a good idea to explore the possibilities of Physiological Computing in computer games first. This method is less intrusive and requires no training from the user, but the computer game in question can take great advantages from the extra and valuable information that is directly acquired from the gamer.

Although it may still take a while before BCIs become useful in computer games, much research is being done and lots of ideas are present. The same goes for Physiological Computing. The current problem is that both concepts still require quite some setup of sensors and other measuring equipment, that it is not yet useful for end users. But that time will sooner or later arrive.

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# Chapter 31

# Onto registering emotions in videogames

*Section by Gijs van Veen*

## 31.1 Abstract

Detecting emotion could be the next step in interactive storytelling. Techniques for detecting basic emotions are presently available, but have not yet been introduced to the gaming public. This paper will compare different techniques on detecting emotions in order to determine their usefulness with respect to interactive storytelling.

## 31.2 Introduction

More and more, gaming is turning into an alternative form of telling a story, much like books and movies. Recently commercial titles such as Heavy Rain[Quantic Dream, 2010] and Alan Wake[Microsoft Xbox, 2010] have been promoting themselves as deep cinematic experiments. The potential advantage of gaming as a storytelling medium is without a doubt the interaction a player can have with the game, allowing for manipulation of the story. Nevertheless modern gaming input devices mostly focus on conscious input. Whether the player is pushing a button or making a motion, all the controller will register is input that was actively produced by the player.

When looking at the possibilities of interactive storytelling, no doubt an aim of modern game designers, development is restricted to response to conscious reactions of a player. A game designer can try to achieve an emotion to the player, but never actually knows whether this is successful. Arguably detecting the basic emotions of players could help designers respond to unconscious input by players and thus allow the game to adjust to that input. No longer would a developer have to assume that a player is scared or excited, but rather in-game events could be responses to the emotions of a player.

Despite the countless gameplay options detecting emotions could give, as of now no commercial company has produced the input device that would be required for emotional games. Rather, the current trend seems to be towards motion detection, such as with Nintendos Wii-mote or Microsofts Kinect. Still numerous useful techniques can be found on detecting emotion of a user [Picard and Klein, 2002; Pantic and Rothkrantz, 2000; Polzin and Waibel, 1998, 2000].

## 31.3 Research Question

Assuming detecting emotions for interactive storytelling and games in general will eventually become desirable, research towards the possibilities ought to be done. This leads to the following research question:

> *What modern techniques can be applied in the near future to commercial input devices to determine emotional input for interactive storytelling and gaming and what developments should still be made for them to succeed?*

In answering this question multiple subjects should be taken into account. Not only should different techniques be identified, but their usefulness for interactive storytelling should be taken into account as well. This leads to several criteria against which the different techniques should be measured.

- **Emotional range:** Which different emotions is the technique able to identify? Some techniques might not be able to determine the difference between distinct emotions.
- **Reliability:** Is the technique able to determine the proper emotion with a low error margin or is there a large chance that it detects the wrong emotion or even no emotion at all?
- **Altruitiveness:** Can the technique be easily used in a common living room? Since the technique should be applicable to emotional detection for commercial video games, the resulting input device should work for any user in any environment.
- **Development Costs:** How expensive is the production of an input device using a given technique? As a commercial product, the input device should not exceed a consumer friendly price.
- **Computational Costs:** Is the technique capable of determining an emotional state in an almost real-time time frame or is more computational time required. In many cases direct response of the system might be required and thus a technique should be as fast as possible.

Identifying different techniques for detecting the emotions of a user and comparing them based on these criteria will be the main focus of this paper.

## 31.4 Detection types

In order for the scope of the research to not become to big, three distinct detection techniques where considered. Often these techniques can be split up into several different appliances. For the scope the techniques are only reviewed in general and when possible in the form that is considered most suitable for the detection of emotions for commercial purposes.

The three considered techniques are facial detection, speech detection and brain computer interfaces. These are very broad techniques and as such they can not be detailed fully. The function of this paper is thus to consider the different possibilities and give a direction to further research.

## 31.5 Emotional types

In order to evaluate the different techniques for the detection of emotions it is important to determine which emotions should be detected. Since the techniques will be used for gamedesign it seems logical to consider which techniques would be most useful for game designers. Not much research has been done to this respect and thus we will try to determine them based on our experience as gamers.

In his research on emotions in facial expressions Ekman considered six basic emotions, *happiness, sadness, fear, anger, surprise* and *disgust* [Ekman and Friesen, 1975]. All these basic emotions could have their use in game design. For example anger detection could indicate the players frustration with the game, while happiness shows the player is enjoying the game. In other instances fear could be used to give the player some extra scares. Thus an ideal system would be able to atleast detect these six basic emotions.

## 31.6 Facial detection

Research on the reflections of emotions through faces have been done for years and play already play an important role with respect to game design, as they are used to animate virtual avatars. It can also be used the other way around, where the computer reads the face of the player to determine the experienced emotion.

### 31.6.1 Facial reflections of emotions

When looking at communications between humans it seems that facial expression accounts for 55 percent of the effects of a spoken message [Mehrabian, 1968]. The face thus carries a large part of the message and humans seem to be able to detect some sort of emotion from the faces of the person they speak to. The question which facial expression corresponds to a certain emotion can thus be raised.

Much research on this subject has been done by Ekman [Ekman and Friesen, 1975, 1978], who decribed multiple facial expressions and their corresponding emotional implications. Ekmans work has become important in psychology but can also be applied to facial detection.

### 31.6.2 Technical Details

To detect the emotions in a facial expression the face has to be analysed. To do this, systems need to process the face in some way. The most logical form of doing this is through an image stream, where the system uses a camera to capture the face and process the given images in order to determine the emotions. Processing an image leads to three distinct problems that the techniques should be able to handle. First of all, the technique should detect the face in the given image. Then is should extract all facial features from the image and finally use this new data to determine the emotional state of the user [Pantic and Rothkrantz, 2000]. All these steps will be described in general, but no overview of all the possibilities of implementation will be given due to the scope of the research.

#### Face Detection

In most research done with respect to automatic facial expression detection the conditions in which the face is detected are controlled. That is, the image or image sequence is usually captured through a frontal view camera that has a full view of the front of the users face. It is ensured that the face is in the image and some global location is known beforehand. The exact location of the face however is still unknown and the algorithm thus needs to find the face. This is still a complex problem as the face could differ in scale and orientation between images due to movement of the subject. Especially when the camera is positioned at a fixed position these differences could be large from frame to frame.

Accuracy of the face detection could further differ depending on lightning, differences between several faces such as age and ethnicity head motion and head obstruction, such as by a hand in front of (a part of) the face. There have been many different techniques over the years and some perform better on these conditions than others [Pantic and Rothkrantz, 2000].

#### Facial Expression Data Extraction

Once the location of the face is detected in the image, information about the facial expression has to be retrieved. When done for a static image this is called *localizing*, for image sequences it is referred to as *tracking*.

A distinction between facial features and face model features should be made. The former are all the elements of a face, such as the eyes, nose and mouth while the latter refers to the features used to represent the face in the model. There are several of these representations. In the holistic representation the face is represented as a whole, in the analytic representation as a set of features and in the hybrid representation as a combination between the two. Depending on the chosen representation information about the face will be extracted from the image.

Almost all representation models are based on Johansson's point-light display experiments [**?**], which suggest that the visual properties of the face describing the facial expression could be extracted by describing the movement of points belonging to the facial features and their relationships with each other [Pantic and Rothkrantz, 2000].

The different representation models differ in the way they located and analyse these specific points. In many analytic representations the face is modelled as a set of points or a set of templates that are fitted over the facial features. In the holistic approach the face is usually represented as a 3D-wireframe with a texture or as a spatio-temporal model.

The data extraction is often made more difficult by several factors that result in loss of information. Facial hair and glasses could obscure some facial features, variations in size make it harder for algorithms to find fixed patterns and noise and occlusion will always play some part.

#### Facial Expression Classification

There are several systems for classifying facial expressions. The most famous of them is probably the *Facial Action Coding System* FACS [Ekman and Friesen, 1978] which describes a large amount of emotions. FACS provides a linguistic description of all visually conceivable facial changes in terms of 44 *Action Units*. A trained human can use these descriptions to determine the emotion of a subject. There are however only a few systems capable of the automatic encoding of FACS [Pantic and Rothkrantz, 2000].

Instead most techniques simply follow Ekmans six distinct categories. Despite this model being more simple than the FACS-classification still several problems arise [Pantic and Rothkrantz, 2000]. First of all the description of Ekman where linguistic and are thus open for different interpretations. The emotions have no unique description in terms of the corresponding facial expressions. Secondly emotions could show in combination of each other, for example anger and fear. A system should be able to properly detect this.

Other issues come from the face the automated system has to read. A system should be able to read a face for any gender, ethnicity or age, where expressions could differ. At the same time, some people show their emotions more intensely than others. To account for these differences most systems start with a generic detection system and later adapt to the user through artificial intelligence [Pantic and Rothkrantz, 2000].

### 31.6.3 Real Time techniques

Over the recent years techniques have become more reliable and better at detecting faces in less controlled environments. One of the leading techniques in this respect is the research of Bartlett et all [Bartlett et al., 2004, 2005].

Their research has resulted in a system capable of fully automatic emotional detection for each frame in seven emotional states: the six states as defined by Ekman as well as the neutral state. The system uses a face detection algorithm that scans each frame for a face by scanning across all possible 24x24 pixel patches in the image. Through the use of a trained AI the system is then able to properly detect the face of the user.

Once the face is automatically detected a subset of Garbor filters is used followed by seven support vector machines, each trained for a specific emotion, to determine which emotion the face is showing. Only one emotion could be chosen. Through the use of self training artificial intelligence the reliability of the detection would increase over time. Bartlett showed an accuracy of 93 percent with this system [Bartlett et al., 2005].

### 31.6.4 Evaluation

Facial detection seems to be on its way to become a reliable way to detect several distinct emotions based on facial expressions. The current techniques are capable of determining the emotion of the subject in real time and thus are a possibility for future commercial uses. Since only a camera is needed the solution is simple and possibly effective. That is not to say that the technique still needs to be researched further due to some complications.

The weakness of the current technology currently is the limitations of facial detection. In order to detect the face properly and in real time the face has to be facing the camera. Whether this is a problem for the considered application is still open for debate, as one can ensure that when playing a game, the player is watching towards a screen and thus in the direction of the camera. More concern follows from the possible required conditions to detect faces properly with a camera. Not all detection systems are capable of handling glasses or dark light conditions, which might be controllable in a testing environment but not in the home of consumers.

## 31.7 Speech detection

In human conversation more than just a message is exchanged. Additional information about the emotional state of the speaker is encoded on the acoustic level of the message as well [Scherer et al., 1984]. Extracting this information could thus lead to a form of emotional input.

### 31.7.1 Emotion in speech

When measuring speech the difference in pitch, voice level and speech rate on the acoustic level give hints towards the emotional state of the speaker. The exact characteristics of different emotions are still much in debate. This mainly has to do with the ways in which the acoustic variables are retrieved [Sobin and Alpert, 1999]. When retrieving these acoustic values researchers usually ask test subjects to encode an emotional message (encoders) and other people to decode the message (decoders). To encode these messages however, many different strategies can be used, some resulting in other acoustic values than others.

For example, there is a difference between letting encoders use a sentence that makes sense and is clearly a specific emotion or letting them use non-phrases. The former could result in decoding being based on the words used, while the latter loses the information on speech rate and differential articulation of syntactical features /citepsobin. Furthermore, there seems to be a difference in the acoustic values of emotions when used in real sentences and when acted out by drama students [Greasley et al., 2000]. It should also be noted that decoders only determine a single emotion and as such no combination if emotions can be determined.

Despite these possible problems Sobin and Alpert have done extensive research towards the acoustic values of four different emotions in speech: fear, anger, joy and sadness using thirty-five female encoders and twelve female decoders. The use of female encoders ensured homogeneity but prevent generalizability and thus still require future research. For the four measured emotions however, the research showed that fear results in an increased pitch and variance in pitch and speech rate, sadness by reduced pitch, volume and speech rate. Anger results in low pitch rate, increased volume, volume variance rapid speech rate and increased pitch variance while joy shows increased pitch variance, volume and speech rate [Sobin and Alpert, 1999].

Other variables revealed by the research where increased volume variance and longer pause durations for joy when compared to anger. The research was not fully extensive however as decoders where still better at determining emotions of the speaker than the researchers when only looking at the acoustic values [Sobin and Alpert, 1999]. Some research thus still has to be done.

### 31.7.2 Technical details

Based on the acoustic values of emotion laden speech an artificial intelligence can be trained to determine the emotion of the speaker [?]. This makes it possible for the computer to listen to the user speak and determine the correct emotional state. Besides the acoustic level ais can also be trained to listen to the words used by the speaker in order to determine a possible emotional state.

Polzin combined both acoustic and prosodic information in a Hidden Markov Model showing near human accuracy of 72.25 percent [?]. For the experiment a corpus of spontaneous speech was used. To determine the emotional state three steps where followed. First the utterance was recognized using an emotion independent recognition system. Second, an emotion dependent recognition system based on the acoustic and suprasegmental models for each emotion was used to determine the highest probability that the sentence determined in step one was made by the model for a specific emotion. Finally the highest probability for a specific emotion based on step two was determined the emotion used by the speaker.

### 31.7.3 Evaluation

Though emotion through speech is still a field where research needs to be done. Recent developments show it as a valuable technique to determine the emotional state of a person however. Still, whether emotion detection through speech would succeed for the field of gaming remains to be seen as some restrictions follow from the use of speech.

First of all speech might form some barrier for the player to use. One could expect two different forms of spoken emotions. Expected spoken, where the player is asked to speak after which the emotion is determined, and spontaneous emotion, where the player utters a phrase not just to the game itself but to the entire area, such as out of frustration when a game is too hard. The former would require some clever game design in order for it to not feel to forced to the player.

Secondly, since the system uses a corpus a barrier of language might form. With expected spoken emotion one can require the player to speak in a specific language, but in spontaneous emotion it would seem logical that the player uses words and phrases that are in another language. Especially for smaller languages this might form a barrier for spoken language to become a viable solution.

Lastly the calculation time might form a small problem. Since an entire sentence needs to be spoken in order for there to be an emotion to detect even when the system knows the emotion directly after the sentence ends a small delay might be noticeable. This might not matter as the input would not be viable until the end of the sentence but research still needs to show this.

Despite these possible problems emotion detection through speech seems a good possibility for the required techniques however. The accuracy is high and even though currently only four emotions can be detected it might be easily extendible. Furthermore, since the technique only requires a microphone (albeit a good one) production costs could be low and work in most common living rooms where background noise should be at a minimum.

## 31.8 Brain-machine interfaces

The final technique considered is the use of brain computer interfaces.

### 31.8.1 Technical details

Brain-machine interfaces (BMI) so far have mainly been researched for the use of prosthetic limbs. Through BMIs a humans brain waves can be used to control some arbitrary interface. Measuring these brainwaves however is not without its problems. There are two types of BMIs, invasive and non-invasive. For the invasive type a detector has to be placed within the brain. While useful for steering prosthetic limbs, such an invasive technology should not be used for consumer entertainment.

What thus remains is the non-invasive type of BMIs. These types primarily use electroencephalograms (EEGs). Demonstrations have been given with a helmet that acts as a BMI. Though the non-invasive BMIs are without any risks of use, they bring in their limitations. The typical transfer rate of the non-invasive BMIs is currently 5-25 bits per second. This is enough for simple interaction such as moving a cursor but not enough to do advanced interactions. Detecting an emotion and sending it over should however be possible [Lebedev and Nicolelis, 2005].

### 31.8.2 Emotion in the brain

The largest bottleneck for emotion detection through BMIs however is likely the current understanding of the brain and emotions in the brain in particular. Until the last few years scientific interest in emotion in the brain was much less significant than interest in cognitive parts of brain functionality. Though recently many advancements have been made much is still unknown on the emotional centres of the brain [LeDoux, 2000].

Much research has been done however on the emotion of fear and hopefully the results from these researches will speed up research on other emotions. If these emotions could be located to a specific part of the brain emotional detection could in theory expand to as many emotions as required.

### 31.8.3 Evaluation

BMIs, though in potential the most advanced form of emotional detection, are a type of technique currently far from a consumer version. Much research still has to be done on detecting emotion through EEGs. At the same time it is still necessary for the BMIs to improve upon their data limit so that more information can be sent. Even without a better data limit the technology seems capable of transferring information of a select amount of emotions.

Even if technical improvements could ensure a complete emotional spectrum and hundred percent reliability however, BMIs might still not pick up as a consumer product. Producing an EEG helmet could become relatively expensive when compared to simple controllers, though mass-production would likely decrease the costs significantly. Also, no market research has been done towards whether consumers would consider wearing such a device to extend their gameplay experiences. BMIs thus require extensive market research.

## 31.9 Conclusion

In review, we found three distinct technology types that are potentially suitable for the use of detecting emotions and applying them to gamedevelopment. All three technologies where measured against several factors in order to get an oversight of their chances and limitations.

When looking at emotional range most systems offer a set of distinct emotions. Though BMIs potentially have the largest emotional range, research on the emotional state of the brain still limits their current use. Both facial features and voice recognition offer a group of emotions, face recognition a few more than speech detection. Facial detection also offers a better detection of combinations of emotions, though most algorithms might choose to favour only one emotion.

Since there are no working versions of a BMI operated emotional detector its reliability remains uncertain. Both facial and speech recognition seem to have a high reliability however. Speech recognition has a reliability of 72 percent, almost as high as a human listener. Some facial recognition examples even registered a reliability of over 90 percent.

When it comes to altruism all three systems have their limitations. Facial recognition requires a camera to be aimed directly at the front of the users head, restricting the direction in which the user can look. Though not necessarily technology breaking, as the player is almost guaranteed to watch in some general direction, the limitations need to be researched further. A speech detector has the limitations that a user has to be actively asked to speak, which will not always work from a game designing perspective. Also, voice control limits people who do not have a game in their primary language. Limits on BMIs are the highest, as using a helmet to play a game might pull some people off. Extensive market research on this field would be required.

On development costs, no actual figures could be found. It would seem likely however that the speech detection would be cheapest, as a microphone is likely cheaper than a camera or an EEG-helmet. Cots of a BMI solution would be the highest, as currently no mass-production of an EEG-helmet excists.

All three systems where capable of real time performance. Though some of these processes might require a high performance, real-time can be ensured and thus all technologies are usable for gaming purposes. Nevertheless some limitations apply. The BMI can currently only transfer 5 to 25 bits per second and thus can not carry a large amount of information to compute. The speech detection might not be limited by this but still needs some extra processing time as a sentence has to be ended to give a proper reaction.

Overall, the BMI seems the least likely candidate for a emotion detecting system. Though potentially the most reliable system with the widest range, the BMI currently is still to deep into research to become a valuable commercial product over the next years. Next to the many things that are unknown about the technology it would seem unlikely that consumers would want to wear an EEG-helmet to measure just their emotions. BMIs for gaming thus seem more likely when they can transfer more information, so that movement detection can also be done through them.

Though speech also shows a good reliability and range, requiring the user to constantly talk to the game would require a relatively limited game design. As such it seems most likely that facial detection is the best solution for detecting emotions. More research needs to be done on the limitations of the camera angle, as well as possible light conditions, but the technique itself is in theory capable of the fastest, most reliable estimation of the emotional state of the user.

If developers want user-emotion to become a part of their game-design, much research remains to be done. Not only on the technology to be used, but also on the possible implications and requirements for game-design itself. Emotion detection still seems far away but with some good ideas of appliance and further research on emotion detecting technologies emotion-detection could become the next big thing in gaming.

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# Chapter 32

# Serious Games in Business

*Section by Yme Joustra*

## 32.1 Abstract

This paper will talk about serious games and their effectiveness on the learning aspect. Serious games have another purpose than entertainment. In this paper three serious games will be introduced, each with a different way of using the definition of serious games. The first game that will be introduced is the game Enterprise, which is an entrepreneurial game and is used for students who want to learn more about entrepreneurship. The second game in this paper is American's Army. This game has the purpose to recruit people to join the army. This goal will be reached by using a real soldier life, which informs the players about the army. The third game in this paper is called GRIP, which is a serious game made for children with diabetes and their parents. With this game parents can learn how to handle with specific behaviors of their children. All three games have positive results. Students increase their entrepreneurial skills with Entreprise, while more people are joining the army because they played American's Army. After playing GRIP parents can handle better with the behavior of their children. These three games show that serious games do have effect on the learning aspect of serious games.

## 32.2 Introduction

Serious Games are not just simple games. These games have another kind of purpose than entertainment and can be found in any sort of area, like military, government, healthcare and education. The importance about serious games is that these games are developed to increase the way of learning or training.

Asking people around about serious games, most people answered: "What are serious games actually?" And after explaining the definition of serious games, some people said: "How can serious games be serious?" or "How will serious games have influence on learning?" After hearing this reaction a few times, it was clear that many people do not precisely understand the learning aspect of serious games. This leads us to the following research question:

*How are Serious games effective in the learning process?*

Serious games are effective in the learning process because it is another way to interest people. Learning and training people by using a game is sometimes more interesting and more entertaining than listening to a teacher. Serious games mostly contain the environment in which the players will work, therefore a serious game contributes to the knowledge of their profession. In the future they will know exactly how to handle a specific situation, because they are familiar with it.

The research question will be answered by firstly discussing the definition of serious games. Secondly some serious games will be introduced. These serious games will show what kind of effect they have. The first game will be the Enterprise game, the second game will be American's Army, and the last game will be GRIP. These games will give an answer on the main question which will be presented in the conclusion at the end of the paper. This paper is based on a literature research.

## 32.3 Methodology

The information in this paper is coming from the Internet. Online-papers, and online-books have been used. Also a lecture given by Ben Sawyer is used.[Ben Sawyer, 2009] Information about the games mentioned in this paper is coming from the site of the game. The keywords used to find all these information are the following: Serious Games Definition, Serious Games, American's Army (results), GRIP, Ranj, Ben Sawyer, Business games, Examples of Serious games.

## 32.4 Definition of Serious game

Before investigating serious games, is it important to know the definition of serious games and what kind of purpose a serious game has. First some examples about how some companies think about serious games.

> *The company 'RANJ' sees serious games as a serious matter. They say 'Serious games are computer games that have been developed not only because of the entertainment value but also to serve another purpose'. They also say that serious games try to reach an educational, promotional or marketing goal by using Game-Industry developed techniques.*[Ranj, 2010]

> *The company L.I.B. BusinessGames believes that the thought behind serious games the following is: 'Experience is your best teacher.'*[L.I.B. Businessgames, 2010]

Looking at these kind of meanings of serious games one can conclude that there is no specific fixed definition of serious games. Looking at these definitions one sees some corresponding facts. Both say that serious games are not about entertainment and have more purposes than only entertain people. Analyzing these given meanings, one can conclude out of the keywords 'educational' and 'teacher', serious games have a purpose of 'learning'. Question is, what is exactly meant by learning? According to L.I.B. BusinessGames the learning purpose consists out of for example:

- Training of skills and experience;
- Sharing knowledge;
- or experiencing a new business strategy.

Ben Sawyer is president of Digitalmill. Digitalmill has worked on a number of game projects and served as producer for the Virtual U project, a serious game-simulation about University management that was an Independent Games Festival finalist in 2001.[Serious Games Initiative, 2010]

Ben Sawyer is also an author and producer of books on games and development of games. In addition Sawyer's firm produces market research on the games industry for private clients and DFC Intelligence - a well known research firm focused on the games industry. He has also stated a definition about serious games. According to him the basic definition of serious games, is to use game-related resources for purpose other than entertainment. He means that serious games are all about 'Solutions to problems.' Entertainment is a solution of a problem.[Serious Games Initiative, 2010]

Games have the purpose of entertaining, so the problem will be to make the game in such way that it is entertaining for the players. Ben stated also that Serious games are not all about learning. [Ben Sawyer, 2009] This is noticeable from the definition of the company RANJ, where words as 'promotional' and 'marketing' are used. There are also non-game examples like data visualization, or non-learning examples like American's Army which has the purpose to recruit or to persuade someone.

With summarizing these definitions, serious games are:

- *Game-related resources for purpose other than entertainment;*
- *Not only focused on learning;*
- *Solutions to problems.*

## 32.5 Enterprise - The Game

Enterprise is an entrepreneurial game. The game is a multi-player game and has the purpose to learn more about how a successful business operates. Everyone who has contact with any kind of entrepreneurship, can play the game. By playing this game players will develop their own competencies for the entrepreneurship.

### 32.5.1 The game

The game offers several possibilities and situations that also arise in the business live. At the beginning of the game players can select a company they want to run. Four players will run their own company and one player will play as a banker. The players have to make decisions that can result in a success or a failure for the company.

The game takes between one and two hours to play and the winner will be determined by the player with the company with the highest value.

Some reasons that makes the game appealing to schools:[Halton Education Business Partnership, 2010]

- The 'Enterprise' Game lends itself for use in ordinary lesson time, as part of Enterprise or Industry Day and as an extra-curricular activity.
- The secondary game provides options to use accounts and spreadsheets to challenge more able GCSE & "A" level students. An advanced version introduces sub-contracting, requiring negotiating skills.

### 32.5.2 Results

The results presented here are quotes from some people that have seen or played the game. [Halton Education Business Partnership, 2010]

Barbara Gowans at Liverpool City Council:

*"I really think the primary enterprise board game is going to be a great hit with our Liverpool pupils. Hopefully i will get the chance to order more games, have another training day and roll out the game to more schools 2010-2011"*

Leonie at Christ the King school:

*"I tried the game with my class, it was amazing to see how much the children learnt in one lesson. The video explanation from the website's children "Eddie & Ellie" is fantastic and allowed the children in my class to easily understand the rules of the game. My only negative is that since we have played the game the children have not stopped asking me can they play again!"*

Tom, a student of The Bankfield School:

*I would recommend it to anyone*

Looking at these reactions the game has made a positive influence.

## 32.6 American's Army

In July 2002 the serious game American's Army game, developed by Colonel Wardynski, was released. The game is now one of the most popular first-person shooter game genre in the world. American's Army is designed, developed, and distributed directly by the United States Army. The game offers real-live adventures of an American soldier and has as main goal to help the United States Army with its recruitment and is the first game with a purpose like this. With the game the U.S. Army wants to educate young adults, aged of fourteen and older, about the Army culture and to interest them in volunteering to serve. During playing the game participants will notice that it is based on realistic situations and that it is a team-oriented game. In this way the Army gives a sense of all the different aspects of being a soldier in the U.S. Army. For example, while playing the game, players have to start with basic training. During this training players learn how to use weapons and complete courses before the players can participate operations. The way this basic training proceeds is exactly the way real recruits in the Army would do. So the game has in fact two purposes, recruitment and training. Both purposes have much in common. While participants are being recruited they also are being trained.[The Career Innovation Group, 2007]

The game has different kind of trainings. Participants will start with the basic training. After the basic training there are also trainings for advanced individual training, advanced marksmanship, airborne school, medical training, and special forces training.[U.S. Army, 2010]

### 32.6.1 Analyze of American's Army

The game American's Army is a well developed serious game. This game is a serious game because it meets the requirements a serious game has. The main purpose is not to entertain people, but to recruit participants. Besides the fact that recruitment is a purpose, also learning applies. The training, soldiers have to do before they can get onto the field, tells that the soldiers have to learn before can take any action.[The Career Innovation Group, 2007]

### 32.6.2 Results

The game has become one of the most popular games in the U.S. and draws tens of thousands people over the world. It is unclear how many people exactly joined the army because of playing the game. Based on statistics it is clear that since the game has been launched in 2002 more than two million people has passed the basic training of the game. Looking at the total statistics American's Army is the most effective recruiting tool the Army has.

Players who play game tournaments are 40% more interested in joining the Army as a career goal. Recruits who have played the game before are better than recruits who do not have played the game. This is because the recruits who have played the game have a better idea what to expect.[The Career Innovation Group, 2007]

## 32.7 GRIP - Self management for children with diabetes en their parents

Grip is a interactive web-bases self management system for children between the age of seven and eleven years old. The game is developed by The Health Agency together with RANJ serious games and the foundation Diabeter. The main purpose of GRIP is to learn the patient en their parents how to handle with diabetic. Another lesson is how to treat the patient in a most effective process.[The Health Agency, 2010]

### 32.7.1 The game

GRIP contains aspects of diagnostics, treatment, prevention, and guidance. Besides the fact GRIP is a game it contains also a personalized library with background information.

In the game children can make decisions and develop skills about diabetes. This way it becomes visible what kind of influence their behavior has on their disease the child has. If one knows the effects of a specific behavior, one can take action to prevent these effects. This last part is a way to make it easier for the parents, because it is difficult to learn living with diabetes.

With information about the patient and a game to detect the effects of behavior, GRIP allows patients and their parents to be directed to their own illness.[The Health Agency, 2010]

### 32.7.2 Results

The game is still in a experiment phase, but it is already certain that the quality of the communication between the patient, parent and clinician is increasing. A part of the face-to-face contact is being replaced by the electronic communication. According to the first results children, parents and clinician are very enthusiastic.[The Health Agency, 2010]

## 32.8 Conclusion

In the introduction the research question *'How are Serious games effective in the learning process?'* is stated. Here we will give an answer on the research question.

Serious games are effective. This is noticeable from the three mentioned games in this paper. The three games are all serious games, because all have another purpose than entertaining. The first game Enterprise is a game that has the purpose to train the players and develop their skills for entrepreneurship. As mentioned in the Enterprise sections, the game offers possibilities and situations that also arise in the business live. The game American's Army is also built this way. The game has the purpose to train, but also to recruit people. This is another purpose than entertainment, which makes the game a serious game. American's Army also contains just like Enterprise the element of a real environment, but instead of using a business live, a real soldier life is used. The last game presented in this paper is GRIP. This game has just like the Enterprise game the purpose to learn. GRIP uses the input-output element. This game will show the effects of a child with a specific behavior. By showing these effects parents learn how to handle with their children's behavior.

Now the answer on the research question is clear. How serious games effective are in the learning process is based on how the game has been made. With using real-life situations or environments in the games, people get a better view of how to handle with the effects of a specific behavior or people will be persuaded. This results in a better learning process.

## 32.9 Discussion

The research is based on three relevant serious games. For further research it would be interesting to use more serious games to verify this research and conclusion. This research is based on just one aspect of serious games namely, the learning process aspect. Serious games consist out of more than just one aspect, so it would be interesting to do research to the other aspects.

## 32.10 References


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