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Computer Graphics in Cinematography

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The purpose of this thesis was to cover the major characteristics about different techniques presently used in the field of CG and visual effects by giving a variety of examples from the famous movies. Moreover, the history of visual effects and CGI, and how the development process of it changed the industry of cinematography were studied. The practical part of this study is dedicated to analyzing what modern software are the most popular ones among professionals. Several studios were surveyed to find out the most preferred contemporary software for production of CG and visual effects in the motion picture among Finnish based and international studios.

The second part of this thesis covers a project which aimed at finding a solution for one of the contemporary motion graphics techniques. A modern method was used for production of VFX, in particular 3D compositing, by which a 3D character is implemented into a real video footage. For 3D compositing four different software– 3Ds Max, Boujou, Photoshop and After Effects were used. As a result of this thesis the leaders among the software designed for motion graphics used in Finland and other countries were discovered.

Keywords	software, VFX, CGI, motion graphics, cinematography, 3D, animation, movie

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1 Introduction

1.1 Background information

Computer graphics and visual effects are an essential part of the commercials and movie industry nowadays. The development of computer graphics (CG later in the text) dramatically rocketed up since the first computer animation effect was used in a movie. The industry of cinematography can hardly be imagined without visual effects and computer generated imagery (CGI later in the text). One of the main reasons of such a fast computer generated imagery development was the growing interest of viewers and progress of computer technology. The main possibilities that CGI provides for the industry of cinematography and advertising videos are different kinds of visual effects and 3D computer graphics, which are used in animated movies as much as in feature films and commercials. Currently, with the help of digital techniques it is possible to create a real looking environment in the movies, different ways of actions and even all kinds of creatures that animators and designers can come up with.

1.2 Thesis objectives

The main objective of the following thesis is to create comprehensive tables that will show a list of popular and most used software in visual effects (VFX later in the text) and CGI industry among professional companies in Finland and abroad. The research results are aimed to reveal a clear understanding in regard to the tools that are the most appreciated and preferred by the professionals of the film and video industry, which includes besides movies different types of music videos, TV/virtual commercials and non-commercials video filming.

In addition, one of the trending VFX methods will be done for this thesis, which is 3D compositing. The process development of this technique will be divided into several steps. The main purpose of this practical part will be learning new software and understanding the process of making a comprehensive VFX technique.

During the process of thesis development the consequences of the major changes in computer generated imagery that affected the industry as a whole will be analyzed. In addition, some of the major business issues of the digital art industry will be described in this work. Besides, several methods and techniques that are topical and actual in

professional production and post-production processes will be discussed in the current work. Finally, the alteration of the usage of CG and various connected to it aspects will be mentioned in this work together with the relevant support by real examples.

1.3 Research Design

The current research consists of two parts – theoretical and empirical. In the first one, the main concepts of the current work, which are CGI and VFX technical methods in cinematography, as well as the main trends of the industry will be covered. In addition, some of the crucial business issues of the field will be reviewed from different perspectives.

The second part, which is empirical, will be devoted to the real-life research of the software in the companies that are operating in the industry examined. The aim is to study which software are used by those companies with a purpose to create 3D-based content, visual effects or animations. There will be mainly two methods used in this research project for gathering this kind of information. The main method is to directly contacting the representatives of the companies in question, whilst the second way is getting the information by obtaining it from the agencies' online websites.

The software research conducted in the actual work, in its turn, will be divided in two parts. In the first part, the visual effects and CGI software currently available and most preferably used by the industry companies in Finland will be explored. In the second part, software that are used most the in major international companies located abroad will be discussed.

1.4 Commissioning party

This project has no direct commissioning party on the grounds of circumstances of researching purpose. This work is based on the exploration of horizons of current cinematography area, in its part of digital art in particular.

To make it clear, the actual thesis will be helpful for those who are going to start up their own business or associate professional life with this industry. Also, the research results should give a clear image for the students who do not know what software

might be more reasonable to scrutinize, or for those individuals who want to find out what software needs mastering in order to get in particular company as an employee.

On the other hand, the current thesis work is the author's personal goal to find out information about the present situation and understand the topical trends in this industry in order to increase awareness and contribute to my future professional life in the area of digital art.

2 Theoretical part

2.1 Brief history

Back in the days, when the digital computer technologies were on the embryo stage, all the props, fantastic environments or creatures in the science fiction films and horror movies were created for real out of rubber, silicon and on the base of hydraulic systems and aid of robotics. In fact the result gave these conditions:

- Limitations
- Poor technologies
- Big expenses
- Time consuming
- Unrealistic look
- Lack of movements

However, because of CGI, there is almost no use of these materials anymore. It is much cheaper to generate the "Pandora" world with all its' "Avatars" using computer graphics than creating it for real. [2] [4]

These days, digital effects are so intelligent and delicate that it is hard to recognize the unreality of them, but it should be taken into consideration that it was not always like that. There were several movies in the history of cinematography that one by one started completely changing the industry of digital effects and computer generated imagery. One of the first and the most significant steps for digital effects was the legendary "Star Wars" in 1977. Spaceship battles in Star Wars were created using the motion-control photography technique and, moreover, it saved a lot of time for movie creators in contrast if they had done space wars manually. [5]

Afterwards, in 1991 the "morphing" technique was first used in "Terminator 2 - The Judgment Day". It was layered in the scenes of transformation from a human looking view to a liquid robot humanoid. [5]

In 1997 the outstanding "Titanic" managed to make a huge jump to the field of digital effects and 3D development in the feature films as you can see in the image on the right side. It is not possible even to try mentioning all the scenes in which it was so useful for movie creators to use CG because they are numerous. All the difficult parts for filming scenes like moments with a huge mass of people, Titanic crash, people falling overboard, the water, which fills up the ship, and many other parts, movie creators did with the help of CG (shown in the Figure 1). It was CG that made this movie so attractive for people of all ages, because it was one of the newest ways to display things and fulfil them with believability, but for the creators it was at the same time the cheapest and easiest way to materialize their vision. Of course, "Titanic" as a movie was not the first which used the CG option in the filmmaking process, but obviously one of the first which took the maximum possibilities from the computer usage and made it on a professional way, the way which allowed "Titanic" to be the leader of box-office takings for 13 years. [1] [4]

Figure 1. Frame from movie"Titanic". [9]

The other subsequent step in the digital graphics development was "Lord of the Rings" in the year 2001. "Lord of the Rings" got a place in the history of digital effects because of the colossal battle scene where the movie makers created the CG platform that pro-

duced intelligently moving and fighting warriors who battle against each other making movement decisions by themselves. It saved a lot of money in the movie production because it was not necessary to create thousands of costumes, weapons, equipment as also it reduced the work of operators and others. [5]

Each step forward in computer hardware development provides new opportunities for computer graphics. One of the best evidence to that is "The day after tomorrow" which was released in 2004 as it got to the list of top digital effects of the movies because the creators took about 50,000 photos of New York to create a real 3D model of a city and only after that they applied a digital wave that destroyed the metropolis in the movie. Obviously, destruction of the city in "The day after tomorrow" generally was an easy part for creators. It means that any kind of cataclysm animation or any other kind of digital effects is now possible to apply to a single shot or a good quality picture. [5]

Every decade since CG was first applied in the movie industry was triumphal for the cinema industry and it is possible to assume that triumphs will last as long as technologies are improving, so even nowadays effects most probably will just become pieces of far history (in the meaning of CG leap) after some time.

2.2   New era of the movies

It should be noticed that all the above mentioned movies were not the only ones that brought something new to the industry of cinematography. However, the demand for the digital effects, 3D visualization, computer graphics and all the other modern technologies was growing and is still mounting up constantly since it emerged. Furthermore, the sequential fact and testimony of this is the fabulous "Avatar". Of course it was impossible not to involve this film in the work with such a topic.

It should be remarked that the idea and even the script of the "Avatar" movie was written by James Cameron long before they started the movie production itself and the reason for that was the lack of CGI possibilities and absence of knowledge for creating some scenes where new technologies of computer graphics were needed in a very high level. Different kinds of new techniques were used in the movie for the first time ever. A rain forest, which amazed everyone who saw it on the screen, can be seen in the movie most of the time. That is why the creators also developed a system that grows a lush forest in three dimensions or, for example, they invented a new and highly performed lighting technique which changes throughout the movie and in fact gives

different impression and types of mood. What is even more interesting is that every single thing in the luxurious Pandora world is digital starting from jungles, waterfalls and plants to six-legged creatures, avatars and flying dragons. However, as a matter of fact renovation of the method of real-time motion capture of facial expression and muscles between a 3D model and a human was a completely new step further in the industry of digital effects. James Cameron and other movie creators invented a so called "rig helmet" with special lights and camera pointing at the face. The camera recognizes the human face, expressions and muscle movements without stand out points and sends information to a computer hardware which has a 3D platform with already made textured and rigged 3D model. At the time when a human starts to move a 3D model starts to move identically. This technique helped to create the feeling for audience that avatars are realistic human-like creatures, because of detailed facial expressions and real looking movements. [7]
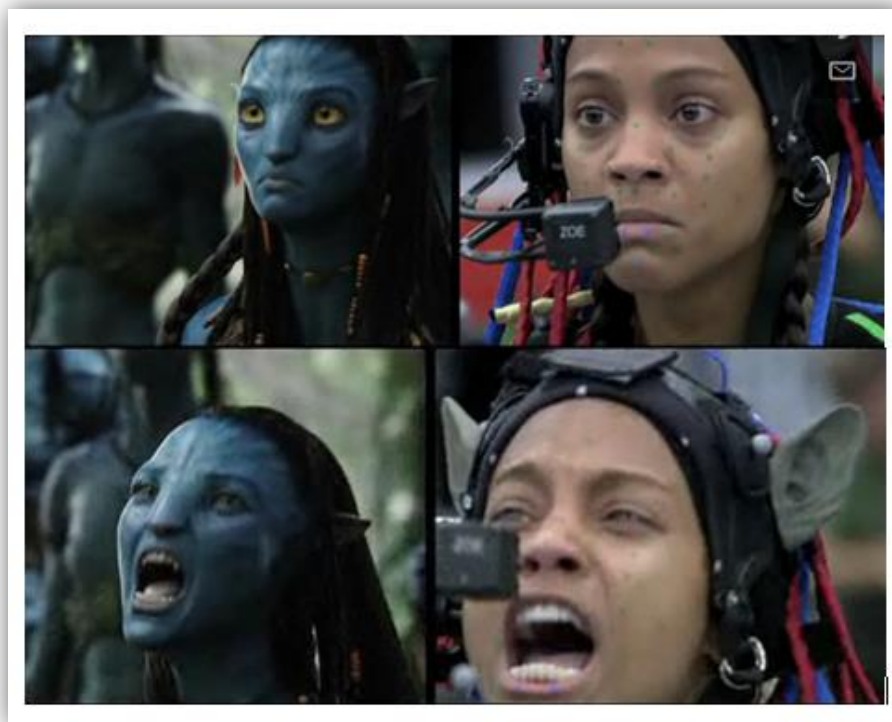

Figure 2. 3D compositing. "Rig helmet" is on the left top and bottom side. [8]

After describing all these benefits which CG brought to the creation of the VFX industry, it is worth concluding that "Avatar" managed to become the movie of a new era. It was mentioned before that "Titanic" was the leader of the box-office for 13 years and now is the time to say that exactly "Avatar" was the one which replaced the first most popular child (Titanic) of James Cameron. It seems impossible and curious that both

movies are the work of one person. However at the same time it can be explained by his deep devotion precisely to the work with CG. He developed himself in this field like no one did and found a pot of gold by that, because everything that is incredible always attracts most people, like lots of incredible scenes which he created in "Titanic" and each scene in "Avatar". [7]

Contemporary filmmaking is an interesting mixture of old and new techniques that can be named as "hybrid" of old traditional and digital methods. Almost every film, whether it is science-fiction, adventure, fantasy, or any commercial video contains CGI or VFX. Moreover, even in the production of dramatic or comedy films it is common to use digital visual effects, for example actors or any objects can be shot in front of the green or blue screen and then can be composited, by using editing software, into background footage. This post-production / visual effect technique is called chroma key compositing, which is widely used in modern filmmaking. [14, 2-3]

The new digital era has strongly changed in comparison with traditional production methods of films or advertising videos, bringing new possibilities and potentials to the industry of cinematography. For instance, now when the digital opportunities are highly improved, studios are able to send out a very small crew anywhere in the world without a single actor to make a video footage of background scenes for the films or commercials. In the result studio may get the filmed footage and then layer it with live actors by using visual effects. [14, 4]

2.3   Business and its aspects in the field of VFX industry

What is this all about? Try to look deeper into the phenomenon of steadily growing computer generated imagery and then answer the question - what is the real reason of all this to happen? The CG in motion picture is not only to entertain usual viewer and to make everything happen on the screen, but also it is developing to make money out of that. Money in this case, is one of the most important levers for improvements since animation became a big moneymaking business. The interest to computer graphics, visual effects and 3D visualizations is constantly going on the rise for all types of people of all generations starting from youngsters and up to old age spectators. In addition, the growing interest consequently causes higher demand for wealthier technologies, more variable methods of creating visual effects, more complex moves of the camera and so on; it means that in order to continue satisfying humans' desire for entertain-

ment and new eyeful, money should undoubtedly be invested into development of these technologies. What is even more pleasant is that for moviemakers/investors it is 90% successful investment, even if the storyline is very primitive, because movies which were made using high technologies used to recompense themselves. [2] [3] [6]

As "Avatar" was already discussed in the previous chapter, it is logical to analyse it once more to show what can be earned from the film with the help of the computer. Thus, here are some numbers: the budget of "Avatar" was 237 million dollars, the sum seems to be quite big and risky for the creators not to offset movie, especially comparing it with the other successful movie of the same year 2009 in which computer graphics were not used that much - "500 Days of Summer" where the budget reached 7.5 million. However, now it is interesting to look at the more important data – gross revenue. In the "500 Days of Summer" the revenue made 60 million dollars and it is supposed to be a good work and so it is, but what about "Avatar"? The work is not simply good; the gross revenue tells that the work was really great, incomparable with any other, because the result for now is almost 3 billion. 60 million starts sounding funny in comparison with the second amount. Of course, the "Avatar" was not completely a fair example, because the film is unique itself, but, in any case, the aim was to show how the CG multiplies its own expenditures, which rarely happens in usual feature films. [6] [7]

Whatever the case, there is still a thing which is very important to mention concerning the money factor and it is a movie ticket's price. Comparing gross revenues of the popular movies which were made - let's say - 15 years ago (does not really matter if the computer graphics were to some extent used there or not) and gross revenues of the nowadays movies, the current result will always be higher and the reason for that is not only in high-grade development of cinematography, but also movie ticket prices influenced on that. It is known all around, that it took 40 weeks for "Titanic" to reach a concrete amount of money, which was achieved by "Avatar" in 6 weeks after the release and, frankly speaking, influenced not only graphics; if the cinemas' tickets' price were the same as 13 years ago, it would still take longer for "Avatar" to earn merited 3 billion. [6] [7]

On the other hand, all above mentioned business advantages are mostly for those major industry enterprisers who successfully broker and invest into these films and commercial videos as well as for actors and production teams, merely excluding the stand-

alone visual effects companies that always play a significant role in the final result of the postproduction. When the actual film shooting is finished, at the point when future film has only raw videos (not edited), these industry enterprisers are contracting the work to creative VFX companies, making a big competition between them. The VFX companies, in their turn, are underbidding in order to get the opportunity to be involved into the great projects. At this stage, these companies are very assailable, lowering their pricing bids under the pressure of competition. Besides, sometimes big part of the work can be outsourced to the countries with smaller wages in order to achieve as good result, but with the lower funding. Generally speaking, the business strategy is structured to fit only these enterprise studios, and it makes this strategy faulty. [10]

The next dispute is related to the fact that the industry enterprises demand subsidies for projects of big sizes (like films) from national or governmental organizations around the world. Basically speaking, the subsidies, such enterprises are eligible to get, are issued using taxpayers' money. During the filming and post-production processes, the working place of VFX designers can be changed for up to several times, moving between countries around the globe, according to the subsidies sources and conditions, which may also shift. [10] [11]

Another issue that is present in the field of the cinematography is the lack of recognition of the CG artists. The amount of work and passion that contemporary professional VFX designers contribute is striking and the result of it is creative and also innovative in many cases. However, as it has been said once - "They are lucky if the credits mention them after the catering. I cannot think of a name of a worldwide VFX star in this industry – they are invisible." Though, everybody knows the names of at least few famous movie actors. [10]

Withal, these issues are becoming more and more crucial at the present time. In evidence, "The Life of Pi" (see Figure 13) Oscar-winning movie for the best visual effects of the year, which was released at the end of 2012, is a good sensational case. Rhythm & Hues, company who accomplished most of the special effects in postproduction of this movie, filed for bankruptcy. This caused many debates within the industry, and VFX artists started to consider that the business model of the field may lead to vulnerability and even result in some sort of exploitation. However, Rhythm & Hues Studios Inc. is going to return to the market, according to the latest news, be-

cause Prana Studios Inc. (another VFX company) acquired the R&H Studio on Bankruptcy Auction in the beginning of 2013. [11] [12]

Figure 3. Life of Pi. Oscar-winning movie in 2012. [13]

Nevertheless, all earlier mentioned circumstances have led to the formation of organization that name is VFX Solidarity International. The purpose of this organization is to unite VFX professionals and the digital artists worldwide for fair and rightful international business standards and practices. In addition to that, this organization started an act among many professional digital artists and visual effect designers around the globe. Within this act the organization encouraged them to replace their profile pictures on Facebook and Twitter with a familiar green key colour to increase awareness about what is going on in the industry. Indeed, without all these VFX professionals most of the Hollywood movies would not achieve recognition. Removing CGI from movies would mean that there would be only green/blue key (screen) and actors. "Titanic" without a boat, "Hulk" without Hulk himself, "Hobbit" without its creatures, or "Avatar" without everything. All these and many other movies would not exist without VFX. [11]

2.4   CGI in VFX

Generally in the production of films or commercials VFX are planned along with all the other development stages. The most significant VFX scenes and CG characters are usually illustrated in vibrant colours. This helps to define the best views for the scene. [14, 59]

Customary visual effects in production of movies or commercial videos used to involve practical properties like explosions, fire, rain, waterfall, wind, etc. which were made manually from the raw materials and with the help of mechanisms by a crew of specialists in studios or in particular outside locations. In the modern digital world VFX is all about computer generated imagery that is created by 2D, 3D environments and particle systems, or by CG dynamic forces that can be applied to hard or soft body objects and particles. [14, 60]

One of the varieties that VFX provide is dynamic effects. This type of effects is produced to add realism to the movie scenes. Dynamic effects simulate real physical reactions, such as collisions and impact distortions. Moreover, this technique gives the ability to the character to interact with the environment in any action scenes giving a complete filling of realism. [14, 60]

Just think about how fast things changed. For example, some years ago Walt Disney artists drew by hand using a pencil. Now, if you think, in the last couple of years Walt Disney together with Pixar produces mostly animated movies. Why is it so? There is a list of reasons, for example one of the main motives is that animated movies look more attractive and interactive than hand drawn cartoons. The next reason is that 3D graphics provide more detailed image, which means that you can see every particle of a character starting from hair spring up to its wrinkle. Nevertheless, let's look what are the essential steps of production of 3D animation in the movies are:

1. Modelling: Includes structuring and making shapes of a model.
2. Texturing: Includes applying materials and textures to the model. Furthermore, it includes setting up and adjusting material properties like reflection, glossiness and light consumption.
3. Rigging: Includes setting up the invisible bones to the model and rigging points.
4. Lighting: Includes the installation of light sources in the modelled environment.
5. Animation: Includes the adjustment of rigging points and setting the key frames into a sequence.

In addition, it is important to mention that back then artists drew every single move for a character. Let's now count up again, one step of Mickey Mouse longs for about two seconds in old original cartoon and one second takes several frames (drawings), it means that one step is double the amount of frames of one second. Just imagine how many frames the artists had to draw to produce a proper cartoon. However, nowadays

all that CG artists have to do is to create a character and give him a birth, in other words, give expressions, emotions and make a movement of a character in a way you want it to move. [2] [7]

Once animators had tried the magic of digital graphics, they never wanted to go back to old-school pencil drawing. Nevertheless, even now computer graphics artists face a lot of complications. Modern technologies - high qualified hardware and comprehensive software are just tools in the hands of artists who play a role of a Gods creating and animating all kinds of animals, fantastic creatures, people, plants, buildings, natural disasters, robots and planets. It is all about the artists' skills, knowledge, creativity and imagination. Sometimes it takes a really long time to model and animate a character for an artist because before starting modelling an object they study a character, for example if it is an animal, they follow the animals' movement, and sometimes they even try to imitate and copy an animal by themselves because it helps to understand how to animate an object, its reactions and emotions in the way that viewers understand for sure what kind of creature it is. [7]

Usually when we watch a movie, we do not even think about the background of the movie, about how the CG artists reach one or another effect or how they modelled and animated the particular objects. We are constantly saying: "It is incredible how the technologies had improved!", but we should not forget that without skilful animators and VFX designers no one would be able to experience and witness these improvements.

Hypothetically, it is possible to create absolutely everything that a human mind can think of using CGI, but the other question is – is the CG artist skilled enough to achieve the desirable result.

Nevertheless, it also should be pointed out that there are common requirements for successful CG effects in the movie that most of digital studios follow:

- Idea-Creativity-Script. That is where the imagination plays the main role.
- Powerful computer hardware and massive render farms for a fast rendering time and better result.
- Variety of platforms in which the actual creation of digital effects are done. Diversity of platforms gives broader abilities for the result.

The implementation of desirable results with professional approach needs skills, knowledge and experience of CG artists.

3   Empirical part

3.1   Research Method

The most appropriate way to obtain necessary information about the software use from the companies is using the qualitative and quantitative methods. Features of both types of the research are present in the current work, and therefore it is not possible to define the method uniquely.

On the one hand, quantitative research approach suits best for gaining generalized information about what software companies use for production of VFX and all kinds of other motion graphics. The number of companies researched, in its turn, gives the opportunity to accept the respondents as a sample of the entire VFX and motion graphics industry. Basically speaking, the sample of twenty eight surveyed studios, which contributed to the research, are a reasonable illustration and may provide a reliable and validate picture on the existing trend of software preference among many production studios in Finland and abroad.

Finally, the open-question survey format leaves the place for further discussion with the respondents what makes the research approach also qualitative, which is good for in-depth study of the question from various unplanned perspectives.

3.2   Data collection

The empirical part of the work is dedicated to software research. All the information that is in the tables below is the result of consequential survey and investigational study. The process of obtaining the information included various steps:

- Direct emailing to the company representatives or VFX designers
- Phone calling to the company representatives
- Online searching of the software that selected companies are using

The criteria by which the companies were chosen for the study were grounded on the fact that they are involved in production of computer generated motion graphics or VFX, particularly in some of the following activities:

- Creation of commercial videos
- Creation of 2D animated films

- Creation of 3D animated films
- Video colour correction and editing
- VFX for movies
- Brand, company or product video presentation
- Motion graphics introduction videos for TV shows or series
- Compositing of 3D computer graphics into video footage
- etc.

3.3   Outcome from the Finnish-based companies

In the table below Finnish-based companies that are engaged with the industry of VFX and motion graphics are listed. Most of these companies are located in Helsinki.

Table 1. Finnish Studios.

Company Name	Specialization and Activities	Software	Projects	Official Website
UNDO	Commercials, VFX Movie, Animation	Lightwave, Nuke,Messiah, Modo, Houdini, Real Flow	Eckerö Line, VR, Axe, Nokia, MTV,Ghost Town, etc.	undo.fi
Shader	Commercials, Animation,Company/Brand Presentation, TV	Lightwave, Cinema4D, Modo, 3Ds Max, After Effects, Premiere Pro	iLOQ, Nokia Play 360, Nokia N9, Olala Sangria, etc.	shader.fi
Piñata	Commercials, Animation, Motion Graphics	3Ds Max, After Effects, Fusion, Mental Ray, V-Ray	Paulig, Arnolds Donuts, Jaffa, Up-cider, Ingman, Tupla, Bilar, K-Market, etc.	pinata.fi
Talvi Digital	Commercials, VFX Movie, Animation, Virtual reality, TV	ZBrush, Softimage, Renderman, Lightwave, Cinema4D, Modo, Maya, Houdini, Fusion, After Effects, Solid Angle Arnold, Final Cut Pro	Gilette,Sokos, Audi Quatro, Nokia NSeries, Finnair,Fazer, Priest of Evil, The Painting Sellers, etc.	talvi.com
Monte Gusto	Commercials, Animation, Motion Graphic	After Effects, 3Ds Max, Premiere Pro	DocPoint, Elivo Omega3, etc.	montegusto.fi
Anima Vitae	Animation Movie,	Maya, Nuke, Sony	Niko, Niko2, The	anima.fi

	Commercials	Vegas, Final Cut Pro	Magic Crystal, Taf-felCruncheez, MTV3, etc.	
Fake Graphics	Commercials, VFX Movie, motion graphics	Real Flow, Light-wave, Cinema4D, Modo, 3Ds Max, Fusion, V-Ray, Mental Ray, After Effects	IKEA, Fazer, Nokia Lumia 920, Sub, Keiju, Satu ry, Yle News, etc.	fake-graphics.com
Rinki Pro-ductions	Commercials, VFX Movie, TV, Animation	Softimage, Real Flow, Mudbox, After Effects, 3Ds Max, V-Ray, Final Cut Pro	Plus TV, The Gnome, Hok-Elanto, Ingman Creamy, VR 150 Years, Master Chef Suomi, Veges Trailer, etc.	rinki.fi
Anima Bou-tique	Commercials, Animation, VFX	Cinema4D, After Effects, TVPaint, Final Cut Pro	Valio, Domino, Kopparberg Exotic, Elisa, ABB, Heinz, Pure Rush Energy, etc.	anima-boutique.fi
Twisted Films	Commercials, Animations, VFX Movies	Cinema 4D, Blend-er, After Effects, Premiere Pro	Marli:Vital, Sonera, Metripizza, BMW, Senno, etc.	twistedfilms.fi

Some of the studios listed in the table above were familiar to the author before the work on the bachelor's thesis was started, and most of them were found online. For exam-ple, official website of Finnanimation, non-profitable association, which was formed by Finnish animation producers, was a reliable source of motion graphics studios that headquartered in Finland. Another directory that was helpful in the process of finding the visual FX studios in Finland was CG Studio Map, which stores a giant list of indus-try studios around the world together with map locations and even some preliminary software-usage information. [15] [16]

About eighteen Finnish companies were surveyed by email, and only 8 companies re-plied to it, answering the question in full about the software they are using. One com-pany got surveyed by phone, and the information about the rest companies' software was found online on the website, which was mentioned earlier.

However, there are only ten Finnish studios in the table. Most of these studios are focused only on Finnish clients, but some of these companies, like Talvi Digital and Anima, are aimed also at international customers.

According to the Table 1, it is evident that projects that are related to commercial videos with visual FX and animations are predominant in this type of studios. Some of the major projects that studios participated in are listed in the table.100% of all mentioned studios had at least one project that was related to promotional content of some product, service, brand or company in some way or another. Nevertheless, such studios as Anima Vitae, Anima Boutique and UNDO are companies that do also productions of animated movies. For example, such animated movies like Niko and The Magic Crystal, which were shown in many countries around the world, were produced by Anima Vitae. [17] Ghost Town, animated TV-series created for Finnish audience, was produced by UNDO Studio. As regards the actual feature film productions, Talvi Digital participated in post-production and colour correction of Finnish movies like Harjunpää ja Pahan Pappi (Priest of Evil) and Taulukauppiaat (The Painting Sellers). Likewise, several other companies listed in the Table 1 do position themselves as being are able to produce VFX and post-production for the movies, as well.

As concerns the main research purpose about the software, it can be clearly seen that Finnish-based companies are tend to use many different software. However, it should be taken into consideration that software indicated in the Table 1 could not be the only ones that are used by these studios for production of VFX and motion graphics, though they are a reliable source, and deductions about the software will be based on the ones that are listed in the table.

It is important to know that, in addition to the indication of the software used, most of the respondents have also mentioned the purpose of using particular programs. This has led to the creation of categorizing of the software:
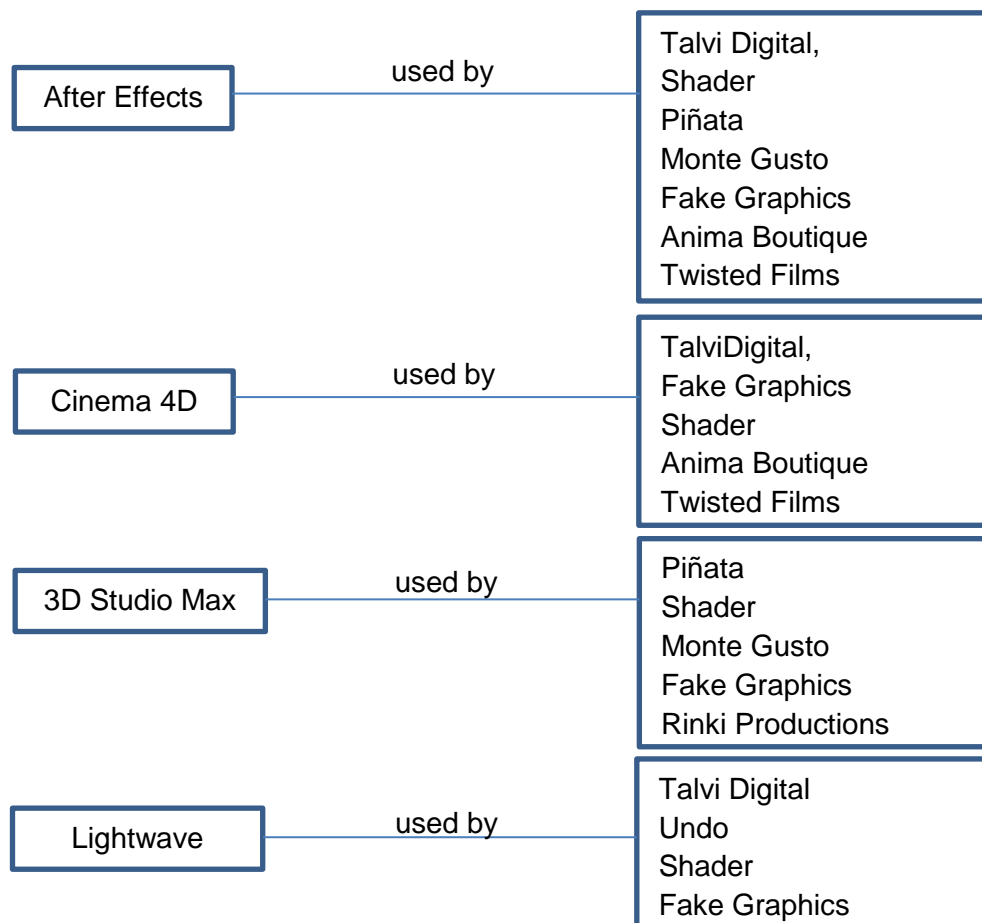
- For 3D animation and modelling (including sculpting, rigging, UV mapping lighting and rendering) and visual effects (such as particle systems, dynamic, fluid simulations, atmospheric, morphing, etc.):
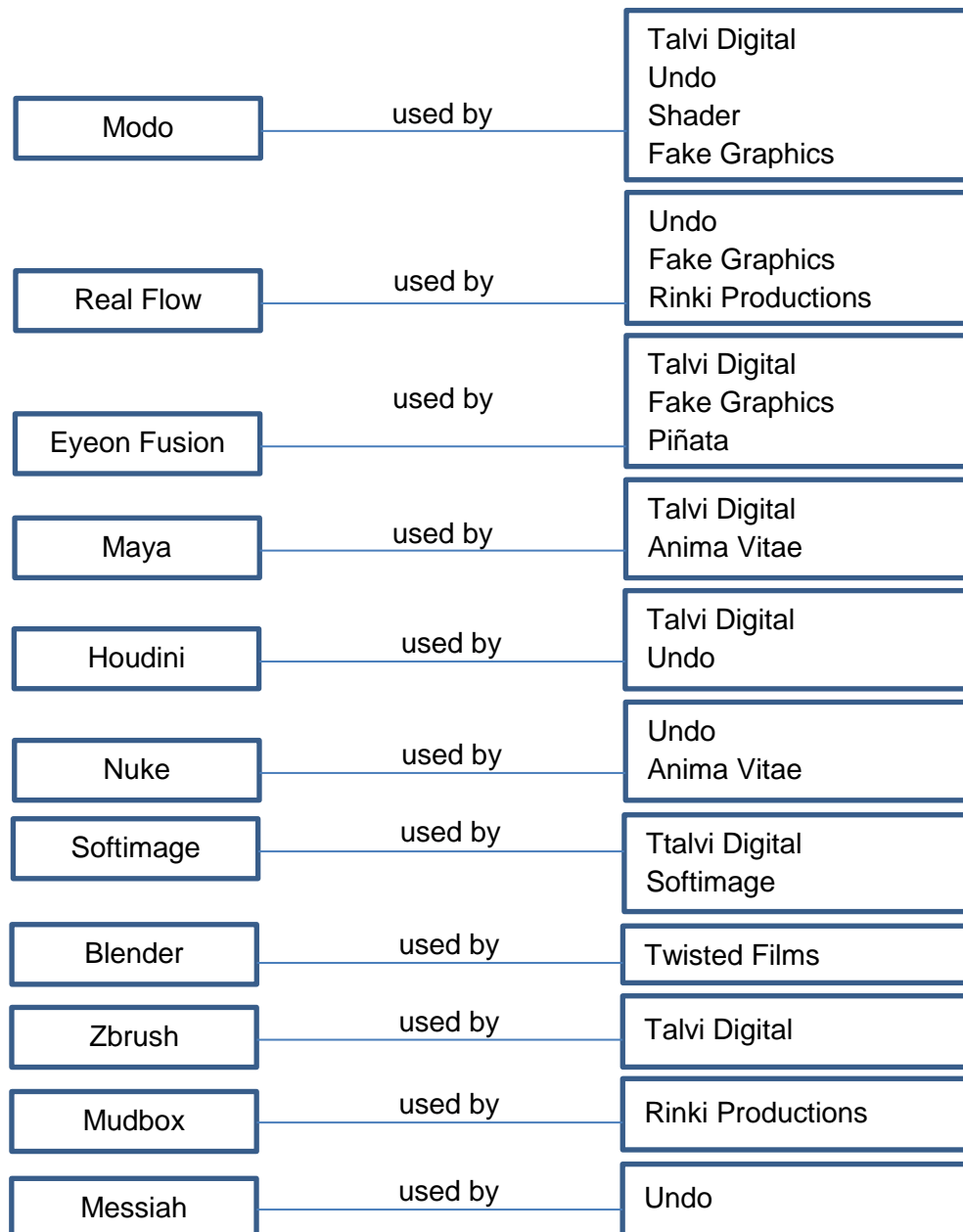 *3D Studio Max, Maya, Softimage, Cinema 4D, Blender, Lightwave 3D, Messiah, Luxology Modo, Houdini, Real Flow, Pixologic Zbrush, Mudbox*

- For postproduction, compositing, 2D or 2.5D visual effects:
  Eyeon Fusion, After Effects and Nuke
- Video editing:
  Sony Vegas, Final Cut Pro, Premiere Pro
- Plug-in and renderers:
  Solid Angle Arnold, V-Ray, Renderman, Mental-Ray

It should be noticed that the outcome table cannot be the absolute reflection of software preference among production studios in Finland because there are still other bigger and smaller sized studios on the Finnish marked that provide similar service. Nonetheless, the most essential software for production of VFX and CGI in motion graphics are in "3D animation and modelling" and "post-production and compositing" categories mentioned above.

To sort out, which software are popular among Finnish studios for creation of visual FX, animation and motion graphics in general, refer to the Table 1. It can be clearly seen, which of the same software are used in different studios. In the chart below, the 3D platforms, compositing tools and motion graphics software preference is defined in descending order:

After Effects	used by	Talvi Digital, Shader Piñata Monte Gusto Fake Graphics Anima Boutique Twisted Films
Cinema 4D	used by	TalviDigital, Fake Graphics Shader Anima Boutique Twisted Films
3D Studio Max	used by	Piñata Shader Monte Gusto Fake Graphics Rinki Productions
Lightwave	used by	Talvi Digital Undo Shader Fake Graphics

Modo	used by	Talvi Digital Undo Shader Fake Graphics
Real Flow	used by	Undo Fake Graphics Rinki Productions
Eyeon Fusion	used by	Talvi Digital Fake Graphics Piñata
Maya	used by	Talvi Digital Anima Vitae
Houdini	used by	Talvi Digital Undo
Nuke	used by	Undo Anima Vitae
Softimage	used by	Ttalvi Digital Softimage
Blender	used by	Twisted Films
Zbrush	used by	Talvi Digital
Mudbox	used by	Rinki Productions
Messiah	used by	Undo

It is significant that such video editing software as Premiere, Final Cut Pro, Sony Vegas, and renderer plug-ins, like V-Ray, Renderman, Solid Angle Arnold, Mental Ray, which were mentioned by the representatives of the Finnish-based studios were excluded from the aforementioned chart because they are not playing an important role in production of VFX and motion graphics.

On the grounds of the gathered results from ten Finnish studios, out of a vast diversity of software available for creation of VFX and motion graphics, After Effects appeared to be the most preferable (constituting 70% of the sample) that is used mainly for 2D visual effects, motion graphics, colour correction and compositing. Though, as concerns

3D platforms used for production of more complex visual effects (such as 3D animations, particle systems, dynamic effects, etc.), only two different software showed the highest recognition among the studios participated in the research, which are Cinema 4D and 3D Studio Max. The next 3D software in the top of the most used among listed companies is Lightwave and Modo (both used in 4 different Finnish studios). Eyeon Fusion (used in 3 studios, according to the Table 1) is the next in the chart among software used for 2D visual effects, motion graphics and compositing, coming next to the After Effects.

As regards the least popular software among these ten organizations, Blender and Messiah (both are 3D platforms for animations and VFX), Zbrush and Mudbox (both are 3D platforms for modelling, sculpting and texturing) each are used only by one company.

3.4 Outcome from the worldwide studios

Studios from different countries around the world that are involved into the industry of VFX and computer generated motion graphics are listed in the table below. These studios are of a different scale and range, some organizations are international and some studios are smaller size, which are aimed only at local state customers.

Table 2. Studios from different countries.

Company Name	Country	Specialization and Activities	Software	Projects	Official Website
Tetsoo	Switzerland	Commercials, animations, Motion Graphics	Cinema 4D, Zbrush, After Effects, V-Ray	Anime Network, Helio, Hybrid Studio, Universal Studios, etc.	tetsoo.com
Transistor	Japan	VFX Movie, TV, Animation, Commercials	Houdini, Maya, Modo, Lightwave, Z-brush, Nuke, After Effects, Premiere	Amazarashi, Sony, NHK, etc.	transistorstudio.co.jp
Plastic Wax	Australia	VFX Movie,	3Ds Max, Ma-	Juiced, Bi-	plastic-

		Commercials, Virtual Reality	ya, Nuke	oshock, Borderlands, Fallout, etc	wax.com
Happy Ship	Netherlands	Commercials, VFX Movies, Motion Graphics	Cinema 4D, After Effects	Pardoes, Barslet,Spion Van Oranje, etc.	happyship.com
Mental Drive	Ukraine	Commercials, VFX Movie	Nuke, After Effects, Maya, Softimage, 3Ds Max, Houdini, Final Cur Pro, Premier, Avid	Actimel, Nescafe, Triora, Danissiomo	mentaldrivestutaldrivestudio.com
Aixponza	Germany	Commercials, VFX Movie, animations	Cinema 4D, Lightwave, Nuke, After Effects, V-Ray	Deep Silver, SEAT, Redbull, MTV, Burger King, etc.	aixponza.com
Park Road	New Zealand	VFX Movie, Animation Movie, Commercials	After Effects, Premiere, Maya, Nuke, Avid	Mr. Pip, Black Sheep, The Frighteners, etc.	parkroadpost.co.nz
3 Dart	USA	Commercials, Architecture Animations, VFX Movie	3Ds Max, Cinema 4D, Zbrush, After Effects, Premiere Pro	Amoroso's Baking, Swiss Farms, Tenbrook, In-House, etc	3-dart.net
Blue Bolt	United Kingdom	VFX Movie, TV	Maya, Nuke, Solid Angle Arnold	Skyfall, Sherlock Holmes, Pirates of The Caribbean, Prince of Persia, The Iron Lady, etc	blue-bolt.com
3 Bohemians	Czech Republic	Commercials, TV VFX	Maya, After Effects	Body Call, Hana&Hana, Botas, Last	3bohemians.eu

				Shot, etc	
Dexter Digital	South Korea	VFX Movies	Maya, Nuke, Final Cut Pro	Mr. Go 3D, The Berlin File, Haeundae, etc	dexterstudios.com
Images & Sound	New Zealand	VFX Movie, Commercials, TV	Maya, Flame, After Effects, Nuke, Real Flow	Johnson & Johnson, Flying Fish, Demon Energy, etc	imagesand-sound.co.nz
Animatic Media	USA	Commercials, TV	Maya, After Effects	Persil, Pepsi Max, BMW, Nature Sweet, etc.	animaticmedia.com
RTT	Japan	Commercials	Maya, Nuke, RTT Deltagen	Citroen, Audi, Toyota, Mazda, Opel, Adidas, etc.	rtt.ag
Absolutely Cuckoo	United Kingdom	Animation, Commercials	Lightwave, After Effects, Zbrush, Synthesis, Modo	BBC, Walker, Dhx Media, Zodiak Kids, Vectone Mobile,	absolutelycucklutelycuckoo.com
Mosfilm	Russia	VFX Movies, TV	Nuke, Houdini, Solid Angle Arnold, 3Ds Max	Hunting for a princess, Hissar Carpet, Silent Hill (adaptation), etc	mosfilm.ru/eng
Boogie Monster	Australia	Commercials, Movie VFX	Maya, Avid, Smoke&Flame, Nuke, After Effects, Premiere, FCP	LiveLighter, ECU, Two Worlds, Happy Haven, etc.	boogiemonster.com.au
Huhu	New Zealand	Animation Movie	Maya, Nuke, Final Cut Pro	Noah, Slingshot, The Ten Commandments, Awaken, etc.	huhustudios.com

Most of the studios from the table 2 were unknown to the author prior the study was conducted. The lack of initial knowledge of studios headquartered in different parts of the globe made the general process of finding VFX and motion graphics studios challenging. Though, Russian studio Mosfilm and British studio Blue Bolt were known before the thesis research was started, as they are big international companies in the area of movie making, and luckily these studios participated in the survey about software preference. However, many well-known international companies ignored the questionnaire, and some studios did not desired to tell information about software usage because of confidentiality.

About sixty companies from around the world (except Finnish companies) were interviewed by email, and only eighteen representatives replied, answering the question in full. It also should be noticed that the questionnaire was send to only fourteen countries, and twelve of them contributed to the research. Few studios were picked from each country to make sure that at least one studio responds as a representative of a country. Nevertheless, there were no special criteria by which the VFX studios were selected from particular countries.

All the projects that are listed in the Table 2 were found from the official studio websites. Each studio that is listed in the Table 2 has a rich amount of projects it participated in or produced from scratch. These projects are all of a different type from animated movies, 3D compositing and motion graphics to advertising videos, VFX movies and TV series, depending on the companies' activities. Studios like Park Road (New Zealand) or Mental Drive (Ukraine) and many other companies from the Table 2 participated in different range of projects like implementing VFX in movie post-production and producing a commercial video (brand or product promotion). Even though, almost all studios are able to produce contents for different kind of projects (like VFX movie and commercials), not all of them had a chance to do so.

As outlined above, all the studios that are listed are of the same industry, but their activities and finished projects completely differs from each other. Blue Bolt (UK), RTT (Japan) and Huhu (New Zealand) can be taken for the comparison:

- Blue Bolt Studio mainly participated in creation of VFX for movies like Sherlock Holmes, Skyfall, Prince of Persia, etc. that were in the cinemas all around the world.

- RTT Studio mainly is focused on the promotional VFX content. Most of their projects were related to production of the vehicle commercials for such car makes as Citroen, Audi, Toyota, Opel, etc.
- Huhu Studio is a big animation studio and their main spectrum is animated movies like Noah, Slingshot, The Ten Commandments, Veggietales and many more.

It is a great example, which shows how diversified can be one big industry (i. e. CG and VFX) in terms of the possible output it can provide to the customers and the end-user – the audience.

It should be taken into consideration that some of the interviewed studios, while giving a list of software, also mentioned which software they use in priority and for particular situations, because many listed companies have several software of the same type. For example, Oleksandr Kucherov from Mental Drive Studio (Ukraine) stated in his e-mail that for 3D visual. However, 70% of 3D and VFX content they produce is mainly done in Maya. As regards the compositing tools both Nuke and After Effects are used equally in Mental Drive Studio production. [18]

Nevertheless, the results that are stated in the Table2 do not define a deep reflection of software popularity among studios around the globe, because there are hundreds and hundreds of studios that might use different software in preference. Though, Table2 is a good source of information, which can help to understand apparent tendencies of software in particular field of visual effects and 3D animation among diverse organiza-tions.

To clarify the software preference among registered studios from the Table 2 and find out, which software is mostly used, two tables are provided below.

Table 3. Software that are used for creation VFX, animations and 3D based content.

3D Platforms (Software)	Number of studios (from Table2)
Cinema 4D	4
3D Studio Max	4
Modo	2
Softimage	1
Maya	12

<u>Houdini</u>	3
<u>Lightwave</u>	3

Table 4. Software that are used for compositing, motion graphics and colour correction.

3D Platforms (Software)	Number of studios (from Table2)
After Effects	12
Avid	2
Nuke	12

According to the Table 3 the most common 3D software among listed studios in the Table 2 is Autodesk Maya. Next software in preference are 3Ds Max and Cinema 4D. As regards the compositing software, both After Effects and Nuke are used in 12 different studios. Some companies combine the workflow between After Effects and Nuke software.

3.5   Overall analysis of software preference

This chapter will summarize the information about software preference that is used in Finnish based studios and studios from different countries. In total there were about eighty studios to which an e-mail was send with the questionnaire. Finnish studios were more responsive to the survey than studios from abroad, which helped to get a better image of software popularity among studios in Finland.

However, relying on the information of both Table1 and Table2 it can be clearly seen that the software preferences differ dramatically. As to take 3D platforms, for example, in Finland the most popular software are Cinema 4D and 3Ds Max, while from the Table2 Autodesk Maya is one the first choice. According to the compositing tools, Table1 and Table2 shows that After Effects is one of the most desirable for motion graphics and other VFX productions, except Nuke software is also as much appreciated as After Effects in other countries (except Finland). Though, in the Table 2 appears another compositing software – Avid, which was not noticed by studios from Finland (Table 1).

It is a good way to rely on projects from Table1 and Table 2 to find out, which software suits best for particular purpose. For instance, these studios that mostly aimed for animated movies like Anima Vitae (Finland),Huhu Studios (New Zealand), etc.or commer-

cials that have character animation in studios like Talvi Digital (Finland), 3 Dart (USA), Plastic Wax (Australia) and Anima Boutique (Finland) are mostly using Maya, or Cinema 4D. Though, most of the 3D software that were mentioned above are capable for animation.

Exploring the software from the stated tables in this thesis, it can be found that some software are preferably used in Europe and another software are used in another parts of the world. From the Table 1 and Table 2, for example, it can be deducted that Cinema 4D is mostly using in European countries. European studios that are specified from Germany, Switzerland, Netherlands and Finland are likely prefer using Cinema 4D, except one case of small studio in United States, which is 3 Dart and is also using this software.

Besides, some studios pointed out in their responses that they are going to integrate or swop from one main production software to another one. For instance, the biggest Finnish animation studio Anima Vitae is planning to shift from Autodesk Maya to Houdini, according to e-mail from the studio producer Sini Lindberg-Soininen. Another Russian VFX department from Mosfilm studio is going to integrate new software and plug-in renderer into the production processes – Modo and Arnold Renderer, while Houdini stays as their main software. [21] [22]

One of the additional sub plans in current research was to contact any of the big online renderfarms, because these cloud based organizations are able to give information on which software do customers request to render their animations. Renderfarms are getting more popular nowadays, because it is a faster and cheaper way to render big size projects without using your own hardware for rendering. Basically, renderfarm is a set of interlinked computers united together to work as a one computer. That is why cloud rendering is capable to compute large and complicated renderings in contrary to regular stand-alone computer. [19]

In addition to all the response I got from the companies, luckily, I also got a reply from one of the biggest cloud render organizations in the industry – FOX Renderfarm. The question that was addressed to FOX Renderfarm's manager Sophia Suen and it was aimed at revealing what software are the most popular for using their service. According to the e-mail dated 10th of April, 2013, and their official web page, the organization

supports the following list of software: Blender, 3Ds Max, Maya, Softimage, Cinema 4D. [19] [20]

It was of a high importance for the current research to address to such organization that deals with cloud rendering, because they are capable on providing the information regarding the popularity of software from the different perspective, as service providers for the studios of such type that were mainly researched in the actual work.

3.6   Up to date price comparison of software

It is very beneficial for those who are starting up their business in the industry of visual effects, motion graphics and animation, or for those studios that are thinking to shift to another software, to be aware of the current software pricing. For many individuals price may become the decisive criteria and important factor in question whether to learn/obtain certain software or not. Those parties that are with lower financial abilities can substitute the desirable software with the similar, but cheaper, one without losing the main functionality, but lacking additional or advanced features. From the data pro-vided in the previous chapters it can be seen that different agencies are often using different software in order to do the same service. Variety of software provides a diver-sity of interfaces, different capabilities, some software has better rendering systems, other software has improved animation features, etc. Prices of the most frequently used software in studios from Table 1 and Table 2 are defined in the table below.

Table 5. Software up to date pricing 2013.

Software Name	Price	Main usage	Official website with pricelist
Autodesk 3D Studio Max 2013	3.900,00 €	Rendering, visualiza-tion, 3D modelling, simulation, visual ef-fects, and animation	store.autodesk.eu/store/adsk/en_IE/html/pbPage.All-Product-Listing_en_IE
Autodesk Maya 2013	3.900,00 €	Rendering, visualiza-tion, 3D modelling, simulation, visual ef-fects, and animation	store.autodesk.eu/store/adsk/en_IE/html/pbPage.All-Product-Listing_en_IE
Autodesk Mud-box 2013	825,00 €	Sculpting and Painting	store.autodesk.eu/store/adsk/en_IE/html/pbPage.All-Product-Listing_en_IE
Autodesk Soft-	3.300,00 €	Rendering, visualiza-	store.autodesk.eu/store/adsk/en_IE/ht

image 2013		tion, 3D modelling, simulation, visual effects, and animation	ml/pbPage.All-Product-Listing_en_IE
Lightwave	1.398,25 €	Rendering, visualization, 3D modelling, simulation, visual effects, and animation	shop.lightwave3d.com/878/purl-lightwave11
Blender	00,00 €	Rendering, visualization, 3D modelling, simulation, visual effects, and animation	____
Cinema 4D	995,00 $	Rendering, visualization, 3D modelling, simulation, visual effects, and animation	maxon-shop.com/us/ps/CINEMA%204D/1/s1/C100
Houdini FX	4.495,00 $	Rendering, visualization, 3D modelling, simulation, visual effects, and animation	sidefx.com/index.php?option=com_purchase&Itemid=234
Zbrush	699,00 $	Sculpting and Painting	pixologic.com/store/
Real Flow	2.995,00 €	Fluid and dynamic 3D simulator	realflow.com/pricing/
Adobe After Effects	999,00 $	Visual Effects, motion graphics, compositing	adobe.com/products/aftereffects/buying guide.html
Nuke	2.985,00 €	Visual Effects, motion graphics, compositing	http://www.thefoundry.co.uk/cart/item.php
Eyeon Fusion	2.370,00 $	Visual Effects, motion graphics, compositing	realflow.com/pricing/

Note: All the prices from the Table 5 are excluding VAT and are based on standard licenses.

These are the most common 3D and/or compositing tools in the Table 5. All the software prices are recorded in 2013. The general features of the software are mentioned in the "Main usage" section of the Table 5, excluding detailed or advanced tools of it. The most expensive 3D software from the Table 5 are Autodesk Maya and 3D Studio Max. Though, Blender is completely open source software, which also can be used for commercial purpose without any charges for licensing. As concerns the compositing

tools, Nuke is the most expensive 2D based tool, which costs 2.985,00 €, according to the official website. While After Effects costs only USD 999,00 $, which makes it the cheapest compositing software from the Table5.

4   The Project

4.1   3D Compositing

For the last chapter of the empirical part of the thesis a project was conducted in order to get a real practice of computer graphics VFX. The main goal of the practical part is to choose one contemporary motion graphics visual effect, which is used in post-production, and learn how to implement it in real practice. Technique that was chosen for the practical part is the compositing between 3D animation and real video footage.

There are a few types of compositing in the industry of visual effects. For instance, blue- and green-screen compositing were discussed earlier in the theoretical part of the thesis. For practical part I am going to use 3D compositing method. This technique is also very popular among industry studios for post-production of commercials and mov-ies. Generally speaking, 3D compositing is a technique that includes several elements, but mainly live action video footage and CGI (in this case 3D graphics). Both elements are composited and layered together into a single motion picture (video sequence). [23]

4.2   Process development

In order to create any motion graphics or VFX project, it is very important to plan it and think about what it is going to be in the project and how to implement all the steps, be-fore starting the actual production of it. In my case, I wanted to create a simple charac-ter animation and composite animated character into a filmed video footage. This will give a feeling that the character is a part of the video, which will simulate a realistic look.

The software that were used for 3D compositing project:

3Ds Max   - 3D Platform (Student Version)

Photoshop   - 2D Platform (Student Version)

Boujou   - Matchmoving and tracking software (Demo Version)

After Effects   - Compositing and colour correction (Student Version)

Other Equipment:

Canon 550D   - Camera

Canon 18-55mm   - Standard Kit Lens

Later in the text all the major steps, which were followed during the process development, will be described. Some of the stages were known to me before the thesis development started; some of the steps had to be learned from the very outset.

In order to create this project, the following stages were covered:
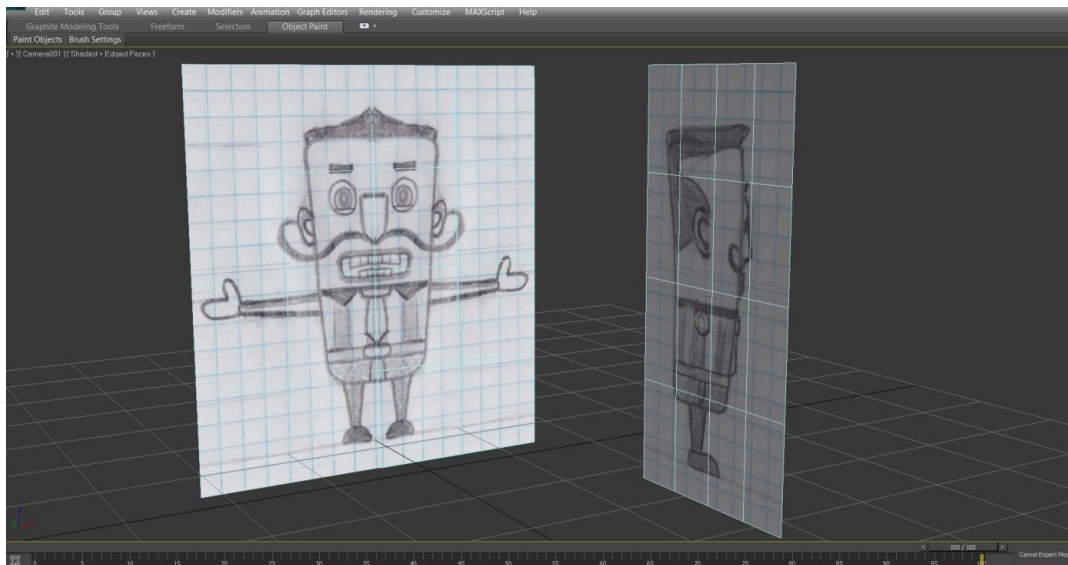
1. Character Sketch (drawing) and importing to 3Ds Max

Figure 4. Screenshot of imported drawings in 3Ds Max.

After the character sketches were drawn on paper, it was scanned and imported into 3Ds Max as a reference for further modelling. In order to make modelling more simple and the resulted model more precise, sketches were drawn in front and side view of a character.

2. Character Modelling
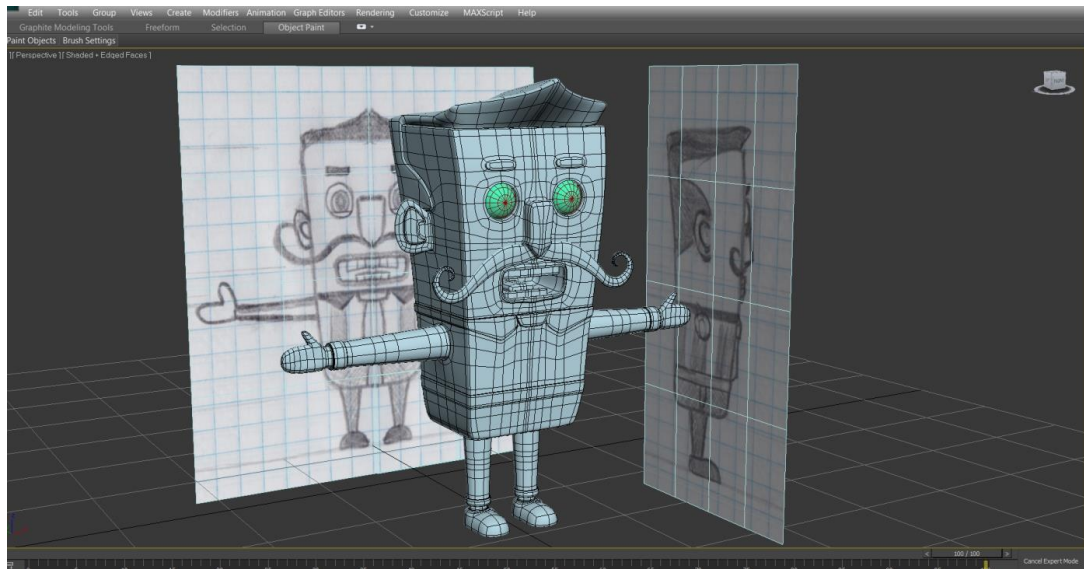
Figure 5. Screenshot of a modelled character (T-stance) in 3Ds Max.

The character was made as a low-polygon model (not very detailed) in order to ease the rendering time and animation process. The whole character was modelled as one object, except eyes that are separate spheres.

3. Character Texturing

The first step of texturing the model is UV mapping. This process projects a texture map onto 3D object, whereas texturing is a method for adding a colour or texture surface onto the 3D model.
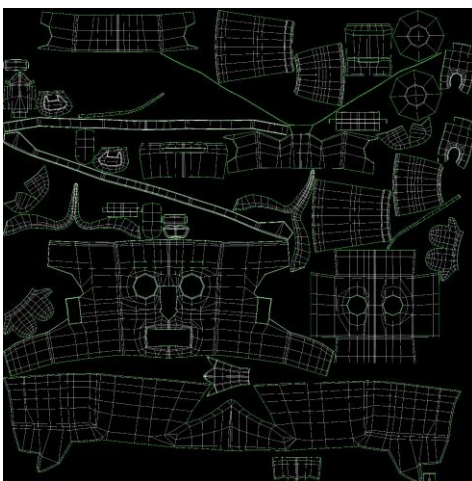
Figure 6. Unwrapped UV map.
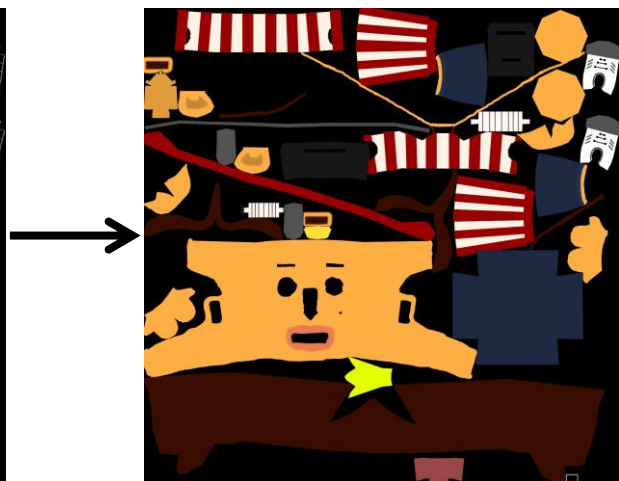
Figure 7. Painted UV map in Photoshop.

After the UV map is unwrapped (Figure 6), the next step was to paint UV map in Photoshop (Figure 7). Then I applied the painted bitmap back to the model.

Figure8. Screenshot of a textured character model.
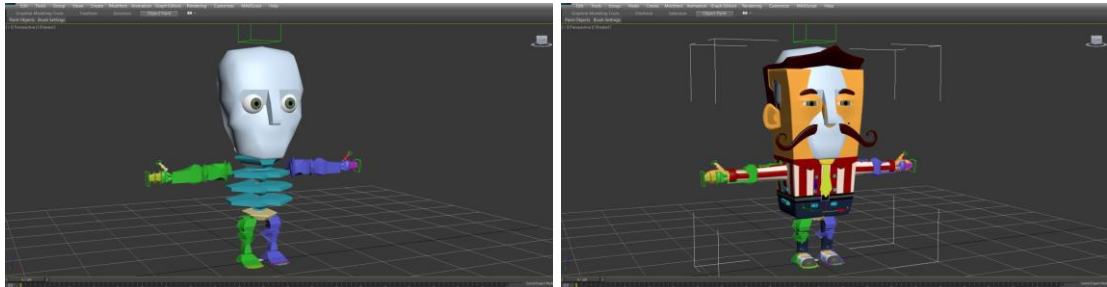
4. Character Rigging

Figure 9. Rig (skeleton) of the character on the left, rigged character on the right.

Before starting the animation, the character must be bound to a system of bones and joints. This helps to have a control over character movements.

5. Character Animation

Figure 10. Screenshot of a character animation.

Simple character animation was made for this project by moving the rig points and set-ting the key frames on timeline. With walk cycle, face expressions, head movements and waving arms were made as a base for the animation.
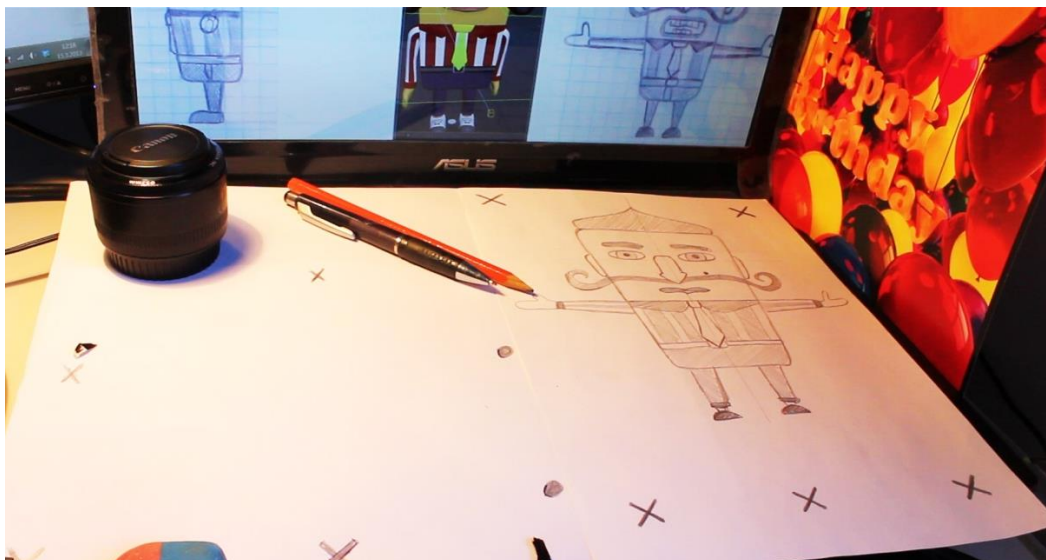
6. Video Shooting

Figure 11. Frame of a video footage.

The video was shot on a Canon 550D with 18-55mm Standard Kit Lens at 720p and 30frames per second. The video footage has many standout points. In other words, these are spots of a high colour difference (contrast). Therefore, this will help to track and recognise the position of the paper on the video.
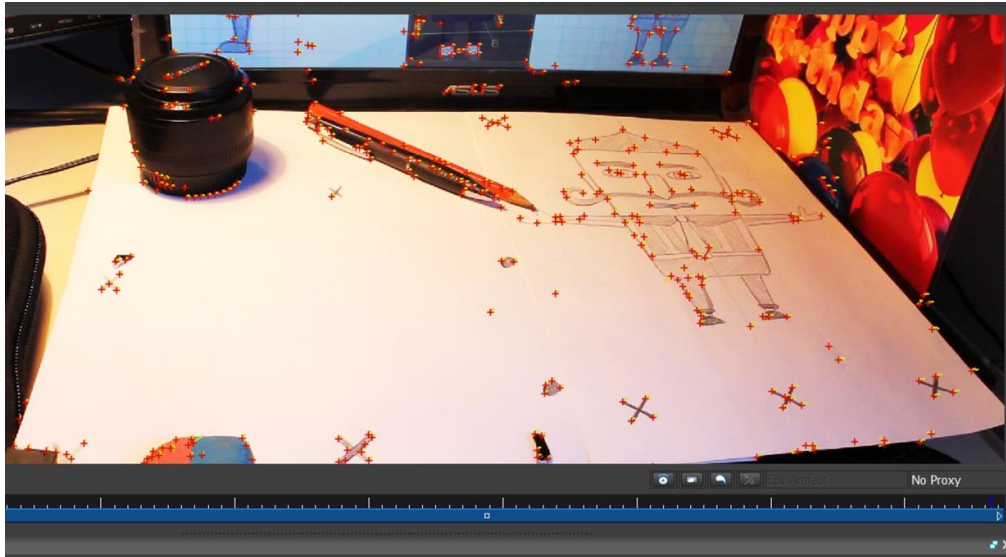
7. Tracking Points / Matchmoving Video

Figure 12.Screenshot of tracking points in Boujou.

After the video was shot, it was imported in Boujou for tracking the points. Consequently it helped for imitating the ground. Then the tracking points were exported into 3Ds Max for further steps.

2. From Bojou to 3Ds Max

Figure 13. Screenshot of merged track points in 3Ds Max.

Later, when the tracking points were imported in 3Ds max, I also imported a sequence of video frames on the background and placed the character to the suitable position (on top of the paper according to the background. See Figure13).

When everything was matched, the next step was to set the light source pointing from top left side above the character, in order to fir the direction of the shadow to the reference of another objects in the video footage (pen, pencil, camera lens, eraser etc.). The colour of the character shadow was matched to the colour of the other objects from video footage, to give a realistic look.

8. Rendering of animation (as an image sequence in .png or .tiff formats)

Figure 14. Rendered frame in .tiff format.

The animation was rendered in .tiff format (it also could be rendered in .png format) in order to composite both animation and the video.

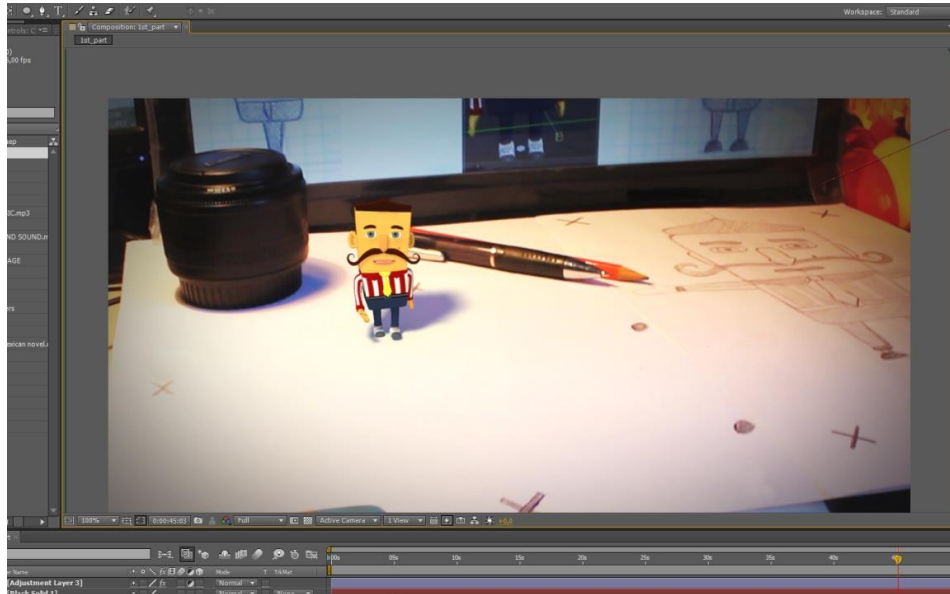9. Compositing video and animation in single video using After Effects

Figure 15. Rendered frame in .tiff format.

The final step was done in After Effects. Rendered animation of a character was layered on top of a filmed video. The color correction was applied after the 3D compositing was finished. The project was rendered in After Effects at 25 frames per second and 720p resolutions.

Project video URL: http://www.youtube.com/watch?v=TGII_aff-h0
(3D compositing starts from 0:44 sec.)

5 Discussions

To compile the data about the software research it should be pointed out that the results were considerably different to the ones I was expecting to get. For instance, I supposed that 3D software such as Blender would be more popular among advertising studios, or at least among small studios, because it is a completely free of charge platform, which also means that it can be used for commercial purpose and without having to pay for the license. In addition, Autodesk Maya also appeared to be unpopular in Finland, even though it is widely used in many countries abroad, especially in animation purpose, wether for animated movies of just VFX commercial purpose. It was surprising that Cinema 4D is so popular nowadays, especially in European countries. Finland also is not an exception; more than 50% of all surveyed Finnish studios are using Cinema 4D as a main tool and most of them are advertising related studios.

However, examining the recorded results from all the studios that responded to my investigation, I made an objective conclusion about the software use. From all the defined above software – 3D Studio Max, Cinema 4D, Lightwave, Softimage and Modo are mostly used for VFX or commercial advertising videos, as much as compositing tool, such as After Effects is also used for these purposes. On the other hand, Maya and Houdini is mostly used for animations, VFX in movie postproduction, and compositing tools like Nuke and Fusion are used in VFX movies. Obviously, these results are based only on the outcome from Table1 and Table2 and almost certainly a different mix of software is used globally in other studios.

Quite unexpectedly, a Finnish studio called Fake Graphics Oy got interested in my research about software and asked me to send them the final version of my thesis.

It was also interesting to find out that some studios are not 100% stable with their software. Sometimes digital designers are shifting from one main studio's software to another for various reasons, such as technical ones or a certain software can gave better features than another one. Finally, the reasons for choosing particular software can be financial. It can be cheaper to acquire another software that has all the necessary features, rather than updating all the other software the studio has.

3D compositing is very common method in the industry of VFX postproduction. That is why in my practical project I got acquainted with this technique and broke it down in gradual categories in the "Process Development" chapter. It was a new technique and experience to me. For instance, I had to learn the basic rules for shooting the video for further motion tracking and that is why I put crosses on a paper (see Figure11). This helped me to get the contrast between white color of the paper and dark cross for tracking the points. I also got familiar with new software called Boujou which is used for motion tracking. Also, I learned how to composite in After Effects between rendered 3D animation and the video footage. However, I had a good knowledge in modeling, texturing and animating the objects in 3Ds Max and I also used After Effects for different real life projects. Most of the steps in this project went without difficulties. However, I had to learn several things for applying the VFX method, because of a little previous experience.

To summarize, digital graphics and animation have left a huge mark in the field of entertainment and particularly in the industry of cinematography. I found out that there are no limits for creating desirable results in the movie industry, because of the opportunities provided by CGI and digital VFX.

In conclusion, contemporary industry of digital video with all its motion graphics, visual effects, real looking 3D and animations only has exceeding benefits. However, some critics state that modern technologies infiltrate flatness into the dialogs and the actual story line of the movie, because they are stuffed with special effects and CGI. With the advent of computer graphics and different kinds of visual effects the work of actors in some movies is slightly decreasing.

In my opinion the industry of digital videos in the near future will mostly be covered with computer generated imagery, most of the scenes will be done in studios using all modern technologies, software and VFX methods such as green/blue screen, 3D animations, morphing, motion tracking, compositing and many others. No doubt the digital industry of cinematography will continue improving, because people are interested in watching movies, commercials, animations and it is a very profitable way of entertainment. However, the digital nature of the visual effects is so different in comparison to the visual effects that were done previously that it is difficult to predict where computer graphics will lead in the future.

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