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VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

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ÚSTAV JAZYKŮ

SPECIAL EFFECTS IN CINEMATOGRAPHY
SPECIÁLNÍ EFEKTY V KINEMATOGRAFIÍ

BACHELOR'S THESIS
BAKALÁŘSKÁ PRÁCE

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VEDOUCÍ PRÁCE

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Bakalářská práce

bakalářský studijní obor **Angličtina v elektrotechnice a informatice**

Ústav jazyků

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NÁZEV TÉMATU:

Speciální efekty v kinematografii

POKYNY PRO VYPRACOVÁNÍ:

Vymezte koncepci speciálních efektů v kinematografii z historického hlediska a popište technologii návrhu speciálních efektů. Analyzujte a srovnejte návrh a využití speciálních efektů ve vybraných filmech.

DOPORUČENÁ LITERATURA:

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Abstract

The aim of this bachelor's thesis is to frame the concept of special effects in cinematography, provide basic information about special effects at the theoretical and practical level, divide special effects into categories and subcategories including the detailed description of special effects mentioned in the thesis and the historical background. The thesis also deals with the design of special effects and their limitations, applications in the film industry and other industries where applicable. At the beginning, the study examines the history of cinematography. Furthermore, this study first draws attention to the description of visual effects used at the early stages of cinematography, while it concludes with the modern effects that are being used currently. Subsequently, the description of practical effects is discussed to conclude the theoretical part. In the last part, the knowledge of the concept of special effects acquired in the theoretical part is reflected and applied in an analysis of movies awarded by the Academy Award for Best Visual Effects.

Key words

cinematography, filmmaker, film production, practical effects, scene, special effects, the Academy Award, visual effects

Abstrakt

Cílem této bakalářské práce je vymezit pojem speciální efekty v kinematografii, poskytnout základní informace o speciálních efektech v teoretické a praktické rovině, rozdělit speciální efekty do kategorií a podkategorií včetně podrobného popisu speciálních efektů uvedených v práci a historického pozadí. Práce se také zabývá návrhem speciálních efektů a jejich omezeními, aplikacemi ve filmovém průmyslu a případně v dalších průmyslových odvětvích. V první fázi je stručně zmíněna historie kinematografie. Tato studie se dále zaměřuje na popis vizuálních efektů používaných v raných stádiích kinematografie, zatímco na závěr se věnuje moderním efektům, které se v současnosti používají. Následně zkoumá popis praktických efektů, čímž uzavírá teoretickou část. V poslední části se znalosti konceptu speciálních efektů získaných v teoretické části promítají a aplikují při analýze filmů, kterým byla udělena Cena Akademie v kategorií nejlepší vizuální efekty.

Klíčová slova

kinematografie, filmař, filmová produkce, praktické efekty, scéna, speciální efekty, Cena Akademie, vizuální efekty

Rozšířený abstrakt

Bakalářská práce *Special Effects in Cinematography* se zabývá problematikou speciálních efektů v kinematografii. Cílem práce je vymezit koncept speciálních efektů, jejich klasifikaci, design a výrobní proces spolu s jejich využitím ve filmovém průmyslu. Bakalářská práce je rozdělena na dvě hlavní části, teoretickou a praktickou. Cílem teoretické části je poskytnout historické pozadí kinematografie spolu s následným kategorizováním vizuálních a praktických efektů a podrobněji jednotlivé efekty charakterizovat. Praktická část přímo navazuje na teoretickou část a jejím cílem je analyzovat speciální efekty ve vybraných filmech.

Práce začíná krátkým úvodem do řešené problematiky včetně motivačních faktorů, které vedly k výběru daného tématu. Teoretická část práce je rozdělena na tři hlavní kapitoly. První kapitola představuje historický úvod do řešené problematiky, ve kterém detailně popisuje vývoj kinematografie včetně jejích charakteristických rysů v jednotlivých dekádách dvacátého století. Po úvodní kapitole následuje kapitola zabývající se postupnou proměnou koncepce vizuálních efektů od nejranějších fází jejich vývoje až po současné vizuální efekty. Poslední kapitola zaměřující se na praktické efekty uzavírá celou teoretickou část bakalářské práce. Součástí teoretické části je i doplňkový materiál ve formě obrázků, které slouží k vizualizaci daného efektu. Teoretická část práce je zpracována formou literární rešerše dostupných publikací, které se zabývají daným tématem. Text teoretické části práce je zpracován prostřednictvím komparativní metody s důrazem na pohled různých autorů na danou problematiku.

Po vymezení hlavních konceptů a klíčové terminologie z oblasti speciálních efektů v kinematografii, jsou tyto znalosti aplikovány v praktické části diplomové práce ve formě analýzy speciálních efektů ve vybraných filmech, které obdržely Cenu Akademie v kategorií nejlepší vizuální efekty. Jedním z kritérií pro výběr analyzovaných filmů bylo časové rozmezí od roku 2010 až po rok 2020. Analýza v praktické části se z důvodu komplexnosti a dlouhé stopáži filmů zaměřuje pouze na vybrané sekvence z filmů, které obsahují speciální efekty vytvořené za pomoci nové technologie nebo metody, případně metodami, které byly do určité míry modifikované a inovované. Každá kapitola zaměřující se na analyzovaný film obsahuje základní informace o filmu, režisérovi, filmovém studiu odpovědném za tvorbu efektů, distribuci filmu a supervizorech, kteří na tvorbu speciálních efektů dohlíželi. Kapitoly také obsahují zkrácenou verzi příběhu, který se ve filmech

odehrává. Po základních informacích o filmu následuje samotná analýza vybraných sekvencí z filmů s důrazem na technologii tvorby daného efektu včetně použitých materiálů a prostředků. Analýza filmů je rovněž doplněna o ilustrativní obrazový materiál. Praktickou část práce doplňují rešerše různých zdrojů zabývající se danou problematikou. Internetové zdroje jsou formou rozhovorů s různými supervizory, kteří na zpracování konkrétních efektů v daném filmu dohlíželi, případně s režiséry filmu. Veškeré rozhovory, ze kterých praktická část práce čerpá, poskytují zákulisní informace z tvorby efektů a jejich vliv na vytvoření celkového dojmu z filmu. Kromě rozhovorů jsou dalším zdrojem informací použitých v praktické části této práci také videa dostupná na internetu, která vysvětlují metody a technologie použité při tvorbě efektů.

Porovnáním koncepce speciálních efektů ve filmech, které byly oceněny Cenou Akademie, je možné dospět k závěru, že klíčovým elementem k dosažení tohoto úspěchu je vytvoření unikátních a revolučních záběrů, ať už z hlediska technologie nebo použitých prostředků, které přinesly do světa kinematografie něco nového a unikátní. Lidé podílející se na natáčení filmu posouvali hranice svých možností na novou úroveň. Všechny filmy zmíněné v praktické části sdílejí stejnou metodiku a přístup. Režiséři filmů trvali na vytvoření co nejvíce praktických efektů, které byly později v postprodukci vylepšené vizuálními efekty. Kombinace praktických efektů a vizuálních efektů se zdá být prospěšná, protože publikum v podstatě nerozezná, co je vytvořeno v reálném světě a co je vytvořeno v jeho digitální podobě. V takových filmech jsou sekvence natočeny s minimálním použitím zelené plochy a počítačem generovanou grafikou. Vytvoření sekvencí analyzovaných v praktické části práce mnohdy představovalo výzvu pro tvůrce filmu. Produkce filmu je proces, jehož složitost a časová náročnost přímo úměrně odpovídá nárokům režiséra. Čím větší nároky a ambice režisér na film má, tím je celá produkce filmu náročnější. Ty nejlepší filmy jsou každoročně nominovány na Cenu Akademie v kategorii nejlepší vizuální efekty.

FRKÁŇ, L. (2020). *Speciální efekty v kinematografií*. Brno: Vysoké učení technické v Brně, Fakulta elektrotechniky a komunikačních technologií. 2020. s 61.
Vedoucí bakalářské práce: Mgr. Ing. Eva Ellederová.

Prohlášení

Prohlašuji, že bakalářskou práci na téma *Speciální efekty v kinematografií* jsem vypracoval samostatně pod vedením vedoucí bakalářské práce a s použitím odborné literatury a dalších informačních zdrojů, které jsou všechny citovány v práci a uvedeny v seznamu literatury na konci práce.

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V Brně dne ....

Lukáš Frkáň

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1 Introduction

With each advent of new technology, the perception of the world changes and brings advances in every industry including entertainment and cinematography. As a result, special effects have become an important and necessary part of film production. The advancement of technology is constantly moving forward, thus generating a greater demand for the film industry, whether it concerns film production, viewership or profit.

The definition of the term *special effect* is quite ambiguous, as the definition varies depending on people providing it. Many times, it is not possible to determine what type of the effect it is, so they are all referred to as special effects. Special effects, notwithstanding, are divided into two main categories: visual effects and practical effects (commonly labelled as special or mechanical). These categories have several subcategories and frequently overlap. In most cases, it is necessary to use a combination of different effects to produce a box office success – a blockbuster. The aim of this bachelor's thesis is to provide a detailed description of the special effects in terms of historical development and to frame its use in cinema.

The bachelor's thesis is divided into two main parts, namely into a theoretical part and a practical part. The theoretical part of this thesis addresses a brief introductory history of cinematography, followed by the chapter concerning visual effects and concludes in the chapter dealing with practical effects. The history of cinematography is focused on the 20th century. Visual effects altogether with special effects are further divided into subcategories containing a detailed description of their design and usage. Moreover, visual effects are prior divided into two fundamental groups according to the time of their development: early visual effects and modern visual effects. The practical part of this thesis scrutinizes an analysis of production of special effects and their subsequent use in the movie awarded by the Academy Award for Best Visual Effects. The analysis of special effects is aimed at selected sequences comprising of special effects which are produced mainly by new technology or the technique is ground-breaking. Throughout the whole thesis, complementary material in the form of several illustrations can be found.

I found the inspiration for the topic of my thesis while visiting one of the greatest and the most famous theme parks in Hollywood – Universal Studios. The theme park also serves as a full-fledged film studio since many movies are still filmed here. One of the attractions

is the “Special Effects Show” which provides a behind-the-scenes glimpse of movie making. Seeing stunt doubles prepare to perform fire stunts just to entertain viewers, I realized that all these people are not given proper recognition, and quite often they are not considered as major players in the movie; often performing with little credit. The same applies for the visual artists who are responsible for creating and editing all special effects. Not every viewer is aware of the hard work that is needed to create a genuine cinematic experience. In this thesis, I would like to point out how extensive filmmaking can be.

2 Theoretical part

2.1 Brief history of cinematography

Rickitt (2000) acknowledges that even simple *moving pictures* caused a wave of astonishment and amazement in the 1890s. As the themes of these pictures were quite basic, people started to desire more adventurous content which led to the development of *trick photography*. As a result, moon trips and flying cars were among the subjects that satisfied the audience. With every decade, viewer's demands had gradually changed, and the term *special effects* evolved proportionally. In the 1910s, Norman O. Dawn introduced his special effect technique called glass shots to the word. He is believed to be the first director who was interested in such effects. Regarding the film format and length, silent movies usually lasted no more than 15 minutes, movies with sound were a few minutes shorter. The term associated with movie length and its measurement is a *film reel*, which was usually 305 m long and 35 mm wide (Spottiswoode, 1963). Nevertheless, D.W. Griffith's movie called *Enoch and Arden* (1911) lasted approximately two reels, making it the first film presented in two parts. Later, *Queen Elizabeth* (1912) was produced in four reels and by the end of the decade, the movie length was around 90 minutes, which is the standard length the audience knows it to be currently. The 1920s marked the first credit of special effects in the movie *What Price Glory?* (1926) and arrival of a new technique called *matte painting* followed by the upsurge of *models* as a result of increasing movie budgets (Keil & Whissel, 2016).

As Ray (1985) continues, the importance of the years from 1930 until 1945 is quite significant, as these years are referred to as "the classic period". They marked a boom of classic movies from the major studios, namely Paramount, Twentieth Century Fox, Warner Brothers and Universal Studio, which had delivered their notoriously famous and profitable titles, for instance *The Wizard of Oz* (1939), *Gone with the Wind* (1939) and *Casablanca* (1942). Furthermore, Hark (2007) claims that some studios were deliberately focused on a certain genre, creating studio's signature in a way. For instance, Warner Brothers produced many gangster movies and Universal Studios produced many horror movies. However, it is the horror genre which is the most characteristic for these decades and resulted in delivering one of the Universal's most revolutionary titles, *Frankenstein* (1931), *Dracula* (1931), *The Mummy* (1932) and *King Kong* (1933). It is also believed that *Dracula* (1931) launched the production of movies which were referred to as *monster*

movies or *Universal Classis Monsters.* Universal Studios is aware that these monster movies were once profitable and is currently trying to produce modern remakes of these hits as part of the plan to expand their movie universe (Weaver, Brunas, & Brunas, 2007). As far as the technological innovations are concerned, Ray (1985) and Cole et al. (2003) acknowledge that sound and colour were integrated into an image as the newest innovations. After the introduction of sounds, movies having spoken dialogues became popular in a short period of time. As for the newly developed technology called *Technicolor*, it was quite expensive, therefore majority of the movies remained black-and-white. Cinematography was also heavily affected by external conditions, mainly by the fallout of World War II. Moving to the next decade, Rogers (2013) and Beach (2015) agree that at the beginning of the 1950s, Hollywood had to compete with the latest invention of that time – television. As opposed to the cinema, the quality of images in television were not remarkable. Hollywood focused on this issue, which led to a series of innovations – widescreen production. The first was a system called *Cinerama*, which combined the world of cinematography with panoramic views. This was accomplished by utilizing three synchronized projectors and projecting images at a rate of 26 fps. This system required investments in terms of screens and projectors, resulting in only 22 theatres being equipped for Cinerama by the end of the 1950s. Rosenberg (2011) concludes that the last major innovation of this decade was three-dimensional (3D) technology, which is "any stereoscope projection system that produces a three-dimensional effect" (p. 66). The boom of 3D movies did not last for long, as the audience was bothered with the glasses which are essential for this kind of movie.

Rickitt (2000) explains, that the movies from the 1960s started to be more violent and action based because of the positive reaction to airing a Paramount Pictures movie, *Psycho* (1960), and an introductory James Bond movie, *Dr. No* (1962). During this decade they relied heavily on on-set special effects referred to as practical effects, and shooting real locations, which were previously filmed predominantly with the use of models and mattes. Entering the 1970s, the term *event movie* was introduced, meaning movie release is a major cinematographic event of the year. The very first event movie was delivered by Steven Spielberg in 1975 as he directed *Jaws.* Utilizing a mechanical shark enhanced the scenes, but this resulted in time-consuming filming and budget related issues. Along with releasing movies of all genres, the studio's primary focus was finding the themes for other event movies. The 1980s focused more on the young audience. which was found as the key

audience of that decade. Production of future commercially successful movies called *blockbusters* was planned for approximately one hundred movies although these movies were quite expensive. As for the movie genres, sci-fi and fantasy was on the rise which is related to the key audience. Approaching the end of the 20th century, movies such as *Terminator: Judgment Day* (1991) directed by Steven Spielberg and *Jurassic Park* (1993) directed by James Cameron left the audience speechless. Both titles were delivered in a distinct way with unique characters; one is an inanimate robot having possibility of turning itself into any object, and the other is a group of long extinct dinosaurs which were brought back to life by genetic engineering. All the magic was created with revolutionary digital effects, mostly achieved by CGI technology. Advancement of CGI also led to safety improvements in terms of executing practical effects, predominantly stunts. In 1997, James Cameron delivered a spectacular movie, *Titanic*, to the world, thus concluding the 1990s as the highest-grossing movie in cinematographic history. The movie had been holding this record until 2009, when it was dethroned by another Cameron's movie *Avatar* (2009), and the last year's blockbuster Avengers: Endgame (2019) then took first place.

Chapter 2.1 dealt with the development of cinematography since 1890, followed by a brief description of the 20th century in terms of cinematography, techniques, features and films that are typical of various decades. In the next chapter, the development of visual effect will be scrutinized.

2.2 Visual effects (VFX)

Back in the days without computers, the art of visual effects was regarded as a special photographic effect because the work was attained photographically on a film and it depended on special optical cameras. Nearly every visual effect was later made in postproduction. In 2010, these effects were simply referred to as visual effects. Nevertheless, determining a visual effect is rather unclear.

Since the first time a cinematographer started to shoot with a wooden camera, a visual effect has been one of the essential implements helping a filmmaker to produce original movies of that time.

In 1895 a film called *The Execution of Mary, Queen of Scots* (1895) was introduced leaving views of that era in amazement. An executioner came to the victim with an axe in his hand and executed her by cutting her head off. As described by Finance and Zwerman, (2010), the trick was that the executioner placed his axe very close above the victim's neck and then the camera was stopped. An actress was replaced with the replica of a human being and the camera was resumed resulting in the victim's head rolling on the ground. Viewers had no idea about any visual trickery or jump cuts.

As already indicated, the definition of a visual effect is not as uncompromising as it might seem. Okun and Zwerman (2010, p.2) imply that "visual effect is the term used to describe any imagery created, altered, or enhanced for a film or other moving media that cannot be accomplished during live-action shooting". Yet, it seems everyone has a different definition which supports the difficulty to define the term. When the Visual Effects Society (VES) was asked about the issue, they could not provide a satisfactory definition. Before the computer era began John C. Dykstra[1] stated that a visual effect was a combination of more components of film into a single element (a film shot). This statement was quite acceptable given the time. Finance and Zwerman (2010) point out that most of the insiders in the industry would probably agree about the general statement that a visual effect is kind of manipulation with images and film shots. A more precise concept of a visual effect given the era we are living in will be framed in the chapter discussing modern visual effects.

[1] John C. Dykstra (b. 1947) is an American visual effect supervisor, pioneer in the development of the use of computers in filmmaking and recipient of three Academy Awards.

2.2.1 Early visual effects

One of the earlies visual effects the filmmakers developed are stop motion, glass shots and successor of glass shots named matte painting. Some of these techniques are still used in the film industry. Even though they are nowadays known as “old-school effects”, they were quite revolutionary at the time when they were introduced. Early visual effects deceived many viewers wondering how the filmmakers did the magic and prepared the ground for their successors.

2.2.1.1 Stop motion

Netzley (2000) explains that the process of animation by which a model is filmed frame by frame is called *stop motion*. This process is done entirely without computer intervention. On every frame the model is a bit moved by the filmmaker’s hand, thus camera must be stopped and resumed after the object is moved. As the result of this, in the film played with the conventional speed of 24 frames per second the object is smoothly and continuously moving. The term stop motion is derived from the process of making a stop motion film. The contrastive method of this is called a *go-motion process*.

According to Sawicki (2007), a stop motion method has been a great asset to the computer graphic methods developed at the beginning of the computer era. Another possibility of creating the moving object is traditional drawn animation. The difference between these two methods is basically in the dimension of the model. In traditional drawn animation the animator works with a two-dimensional (2D) object on a piece of paper, but in stop motion animation the object is three-dimensional (3D). The main advantage of the traditional drawn animations lies in the distribution of the tasks between several artists, whereas in the stop motion animation the distribution is not possible. This means that traditional drawn animation is the work of many hands involved in the project and it can be edited, tested or replaced with better ones. However, as Sawicki (2007) remarks, stop motion animation, however, is based only on the one animator. Since every shot is unique, a model can be placed only one time in that same position and mistakes cannot be corrected. The animator is aware of this limitation and considers the shots as final. A similarity to this can be found in the live performing in the theatre or on the stage.

Sawicki (2007) further reports that the work of the animator Willis H. O' Brien has been beneficial to the industry. As one of the many he belonged to the pioneers in this field. O'Brien is well known for animation of dinosaur models in his movie *The Lost World* (1925) where he combined stop motion with live action. Still, the interaction between an actor and models had to be limited so that the scene could look real. A few years later, in 1933 O'Brien became the man who created the famous monster King Kong. Additionally, he managed to improve his methods by using even more sophisticated models, miniatures and glass shots, a rear projection technique and others. Therefore, the result looked more real than ever before.

Netzley (2000, p. 206) concludes that "computer animation has largely replaced the stop-motion model animation in modern films, although the latter is still used to animate certain aspects of miniatures and models".

2.2.1.2 Glass shots

Sawicki (2007) states that the art of visual effects has been greatly influenced by many pioneers in the industry. Norman Dawn is believed to be among one of these early innovators. In 1905 Dawn started working for the Thorpe Engraving Company as a photographer. While photographing a building that had a light pole in front of it, a fellow colleague suggested that Dawn might remove the pole by putting a piece of glass with a painting of a tree between the building and the pole. The result of this trick was that the pole was covered by a full-sized tree which was more aesthetically pleasing. As the camera is unable to provide depth perception, the tree on the glass was enlarged and looked natural. The same trick works if a person closes one eye, holds a thumb and forefinger forward, and tries to cover an object in the distance. In this moment, the finger looks much bigger than it is. With one eye closed, the illusion is sustained; once both eyes are opened a person soon realizes it is normal-sized hand placed few centimetres from the head. Relationship between fingers and an object is the key feature of this illusion.

In a movie called *California Missions* or *Missions of California* (1907), Dawn used the same glass shot technique so that he could improve the appearance of the historic buildings he wanted to use in his movie. Live action was later filmed trough a piece of glass and roofs looked like a new one.

Netzley (2000, p. 91) explains “a glass shot is created by placing a piece of glass in front of a stationary camera. An artist then paints background scenery on the glass, leaving certain areas clear for live-action filming. When the camera films through the glass, it appears as though the action is taking place amidst the painted scenery”.

Sawicki (2007) further states that the glass shot has drawbacks which need to be taken into consideration. Although a theoretical background may seem complex, the execution is not that uncomplicated. Artistic skilfulness is one of the essential requirements to execute a suitable shot. The filmmaker must also face constantly changing light conditions as it is usually filmed outdoors. On the one hand, artificially painted shadows only match the specific moment in the time. On the other hand, a viewer will not realize that shadows do not match exactly if the intensity is relatively stable. The time window is usually 30 minutes to an hour until these undesirable effects start to appear. In the case of unsatisfactory shots, the filmmakers will have to continue filming on the next day which can be tedious due to the need to move their equipment. As a solution to this problem, Sawicki (2007) suggests leaving a tripod and a glass frame at the location and removing only valuable items such as camera and glass painting.

Another option includes working with a 3D model to form a foreground miniature shot. The significant advantage of using this approach is that while shooting outdoor scenes, filmmakers do not have to deal with matching lighting and painting. Despite the real environment and the real model, the sun rays do not affect the model when it is recorded on the camera. Accordingly, filmmakers do not have to be dependent on the very specific time of the day when shooting. The drawback of this method lies within the limitation of the physicality. In other words, it is not as flexible as using glass shots and filmmakers use it mainly for buildings and terrain alteration.

2.2.1.3 Matte painting

As Sawicki (2007) affirms that a matte process had a significant impact in the development of visual effects. This process uses matte painting which leaves a certain portion of the frame unexposed so that new imaginary elements can be added or replaced later in postproduction. In comparison with miniatures or glass shots where everything had to be filmed simultaneously, the ability to divide compositing elements throughout the time is what made matte paintings so important in the development of visual effects.

Additionally, Finance and Zwerman (2010) support that matte paintings were important in the film industry in the 20th century, as it added elements which would have been either too expensive or impossible to shoot. If all elements and shots were composited skilfully, a viewer could not recognize the painting from live-action scenes in the movie. As mentioned earlier, glass shots were not that effective, yet they prepared the ground for their successor in the 1920s when optical printers were introduced. A major advantage of using matte painting is that they can be completed in the studio and live action footage can be filmed outside, independently of each other.

According to Sawicki (2007), the idea of this process lies in the fact that video records black or so-called zero elements, whereas photographic film "records" black areas. The film in this area can be exposed to light and processed afterwards. A black silhouette on the film is commonly referred to as matte. The combination of two exposures with light and dark areas will result in dominance of light areas. The result is called the superimposition effect which is widely used in production of ghost scenes or fog especially in the atmosphere. In order to give a slightly transparent effect, matte painting with 50% density is required, thus allowing a half of light to penetrate the scene. The partially transparent scene is used in combination with fire or smoke effects which are by nature slightly translucent. Although film cameras are no longer in common use and digital cameras cannot re-expose, mattes are still in use in postproduction. In the world of the digital cameras they are also known as an alpha channel or key. As Netzley (2000, p. 144) further affirms "one of the most extensive uses of the digital matte paintings in recent years has been for the movie *The Fifth Element* (1997), which also features advanced miniatures".

2.2.2 Modern visual effects

As the technology had been constantly developing, the visual effects started to proportionally develop as well. The newest visual effects techniques involved computer technology as the main source of visual effects. Post-production phase of movies heavily relied and still rely on the power of computers.

2.2.2.1 Keying

According to Rickitt (2000), mattes can be digitally produced, and this process is called in general *keying*, although the term often refers to the process of "pulling a matte". There are many ways how to pull a matte from a screen. Actors, whether real people or inanimate objects, are filmed in front of the coloured screens so that an image can be easily processed into the foreground and background images (see Figure 1).

Figure 1. Illustration of utilizing green screen in a shot from the movie *Godzilla* (2014). Reprinted from https://twistedsifter.com/2014/06/before-and-after-shots-of-visual-effects-in-film/.

The screen needs to have a uniform and distinct colour. The preferred colours of the screens are blue and green, but black and red can be used as a backdrop as well. Blue and green are used more frequently because they are the most opposite colour in relation to the human skin. Green screens are more effectively illuminated than blue screens because they require less light, and digital cameras respond more effectively to the higher luminance values of green. Additionally, the use of the green screen is more prevalent when shooting outdoors because of the high contrast against the sky. After shooting, the operator simply

removes the colour screen from the image and the computer software produces a matte. In the odd chance of having elements in foreground which contain blue or green causing them to disappear, a simple rendering technique is used to keep them in the scene. When preparing a shot, it is not vital to have the specific shades and balance the backing colours. As long as the item and the screen are not of the same exact colour, the computer algorithm is able to render the scene as needed. This technique of using colours as a background is also referred to as *chroma keying*, *chroma-key* or *colour-keying*.

When shooting of the footage is completed, the data are stored in *colour channels*, such as red, green, and blue channels. Moreover, there is one more channel, a quite unique one, which is called the *alpha channel*. The alpha channel manages the transparency of the colour channel. The colour range can be later specified by the compositor and may result in reducing or removing transparency of the colour channel. After specifying the colour range, the composition of a separate piece of footage with the coloured-keyed shot can be performed.

Luma-key is a method which deals with luminance, a measure of the brightness of a colour. This method can be utilized in production of a matte for an explosion. Explosions can emit a wide range of various colours, which is the reason why using chroma-key is considered rather difficult in this case. The high brightness of an explosion can therefore be taken advantage of while separating the explosion from its background.

Byrne (2009) indicates that in case of having colour keys too difficult to process, the use of *garbage mattes* is often necessary. Garbage mattes most often refer to the process of marking the area that will have a reduced transparency or will be reduced completely. The term *garbage* suggests that it is usually a part of another technique involved or it is just temporary, depending on the situation. In the case this is not employed as a temporary or a supportive procedure, the compositing material is said to be *masking*. Colour keying is used more often as this method requires frame-to-frame adjustment. Processing footage made from garbage mattes is called *rotoscoping*, which is a process of modifying mattes; it can be used to describe a shot treated with frame-to-frame adjustment. An example of the inappropriate use of this method can be represented in TV commercials. TV commercials are shot in 30 frames-per-second (fps), whereas a movie is filmed with 24 fps. Even if the commercial is 20 seconds long, there would be approximately 600 separate images that a

rotoscoper must pay attention to, which is massive considering we live in a quick changeover entertainment environment.

Rickitt (2000) suggests that measuring the visual information in a scene can be employed in a combination of different keying techniques in order to produce a perfect matte. For example, it is not always possible or practical to use chroma-keying behind an object. Nevertheless, *difference matting* can be used instead. Difference matting requires having two versions of a shot – one with the element that needs to be separated from a shot, and one without the element. Computer software later compares these two shots with each other and automatically recognizes the differences between the shots and produces a final matte based on the detected changes. This technique is commonly used when a large number of people are filmed in a busy location and need to be removed from its background and placed in a new environment. Another example is that a busy city centre can be reformed into a deserted location. Since people and vehicles are moving in the scene, the computer detects the changes and assembles a matte containing only the elements that remain motionless, such as roads and buildings.

2.2.2.2 Compositing

Byrne (2009, p. 3) introduces that "compositing is the act of combining two different imagery sources". Digital compositing emerged in the late 1980s. Until this point, the process had been done on an optical printer. Currently, compositing is done by computers which provide precise control of composition.

As Rickitt (2000) states, the final scene can be composited as soon as the mattes for each of the elements in a shot are extracted. To build up a new scene, the operator unveils the elements of a shot one by one, starting with blank spaces. When the final film returns from the processing laboratory, the role of an operator is to observe, whether a composite is successful or not. If a mistake is present, the entire process of developing a movie must be repeated. On the other hand, it is a non-linear process, which means an element that is needed to be added, removed or repaired can be accessed at any stage of the process. Therefore, compositing is the building of layers on each other, providing a chance to repair mistakes effectively. If the operator wants to test different versions of a shot, one can be saved while another one is being tested. Only when the visual effects supervisor and the director of the movie are satisfied, is the movie recorded on media. To prevent any

unpleasant surprises, computer monitors in the laboratory are calibrated ahead on the highest resolution possible to examine how it is going to be viewed during the projection.

2.2.2.3 3D models

Byrne (2009) claims that the beginning of wide usage of the CGI is estimated to have occurred in the early 1990s. The acronym CGI stands for computer-generated imagery, which refers to a creation of characters, scenery or whatever that cannot be filmed directly. The creating of CGI is often used in combination with compositing to solve most of the visual effect issues. The result of this is the building of 2D or 3D digital models that can be easily edited or transformed to attain the desired final scene (see Figure 2).

Figure 2. Process of creating a 3D model of transformers in the movie *Transformers* (2007). Reprinted from https://digitalsynopsis.com/design/movies-before-after-green-screen-cgi/.

The year 1993, marked the arrival of the first CGI characters, more precisely dinosaurs in the cult movie *Jurassic Park* (1993). It was also the first interaction of the CGI character with live actors. Currently, this is not a rarity, rather the norm. The traditional hand-drawn animated characters have been replaced with 3D models. Movies such as *The Lord of the Ring* (2001-2003) trilogy, *Star Wars: Episode III* (2005), *Sin City* (2005), and *300* (2006) had 3D rendered sets replacing the green and blue screen backgrounds. The ability to move freely these objects within the scene and the endless possibilities of creating objects are the reasons this form is preferred over classical scale models. In some cases, scale models are used by the production teams while 3D graphics designers are present to intensify the final look of the model. It is not only the characters that can be generated digitally, but also the natural phenomena such as dust, fire, smoke or even flowing water. To create such complex images that appear to respond to the laws of physics, *particle systems*[2] are employed (see Figure 3).

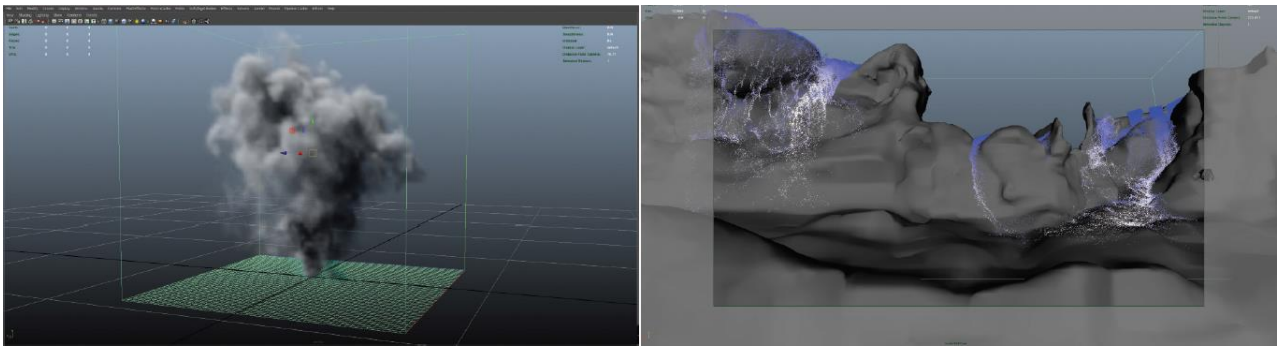

Figure 3. Simulations of gas (left picture) and fluid (right picture) utilized in Maya software. Reprinted from Dinur (2017, pp. 100–101).

As Finance and Zwerman (2010) comment, the creation of the entire object is very simultaneous. It may take a long time to build, but every single detail of the object such as shape, size, texture is then stored in a database in case of rework or additional modification of the object is required. Once the object is completed, the point of view or the angle can be changed without the need to completely alter the object as it was in case of using 2D drawing. Furthermore, the input information of the 3D object is carried from frame to frame. If the object is in movement, the computer adjusts the perspective of everything in

[2] Particle system is a 3D animation technique used to create dynamic simulations where the behaviour of large number of objects (particles) are pre-defined by set of rules. It is widely used to control how particles move.

each frame. The computer is also able to recalculate the position of the object and the camera angle at each point in time. This is made possible as the 3D objects allow us to perceive the depth of the object. In other words, it is the addition of the Z axis to the existing the X and the Y axes which forms the basis of 2D image perception. The Z axis is perpendicular to the surface which adds volume to objects. To create a digital image, it is necessary to build a model, texture and paint the model, animate the model, render the model and composite the model with other elements. Although it seems the most important part of 3D CGI lies in character animation, most of the important work is solved by utilizing a huge number of anonymous workstations spread over the filming industry.

2.2.2.4 Motion control

Fielding (2013) illustrates that very often there is a need for an occasional shot which requires the need to move the camera in a desirable way, such as a dolly movement, a tilt or move over all components of the composite image. Undoubtedly, this kind of shot would require precise, repeatable camera moves throughout filming and this requirement may be only fulfilled by using a special piece of equipment. In 1949, O.L. Dupy developed a machine known as a *repeater head*, sometimes called the *Dupy duplicator* which was essentially among the first motion control systems ever developed. The principle of this system is to mount the camera on a differentially geared head. The technology was quite sophisticated given the time it was created, electronic components available in 1949 were not that sophisticated. Dupy's system was extensively used during the filming *An American in Paris* (1951). On the one hand, motion control systems can be very elementary, allowing the camera to tilt by 25° per second and the distance of the camera move is limited as well. On the other hand, there are more complicated systems (see Figure 4) that are designed to move over longer distances, for example over the entire stage. The most significant components of these systems are most likely stepper motors, as they are attached to rotating shafts on the camera. Instructions are taken by the stepper motors via electrical pulses delivered from a computer. Every pulse is accompanied with the moves of one or more increments of the stepper motor. These motors also regulate infrequent movements of the camera, resulting in subsequent synchronizing of individual exposures and the movements of the camera. Another major feature is the ability to enter the total array of movements of the camera and the crane into the computer's memory.

Once the data are stored, these movements can be reconstructed repeatedly with considerable precision. Some systems have ability to repeat the predefined positions of the camera with accuracy to 1/40 of millimetre[3] at any point in time.

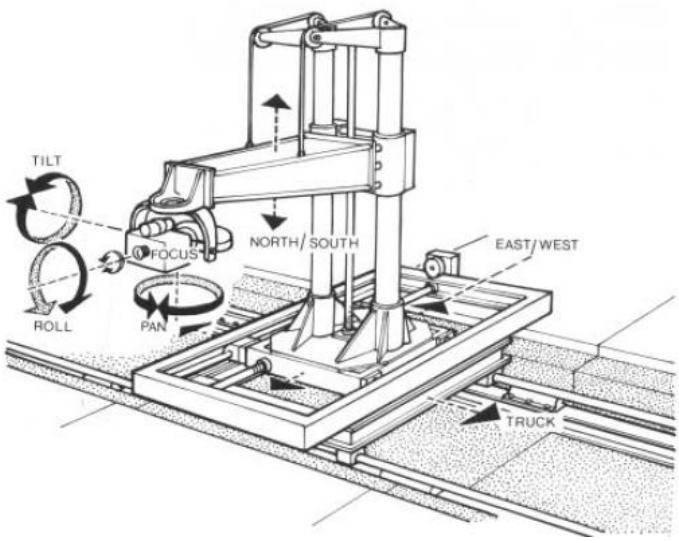

Figure 4. Motion control system called ACES (Automatic Camera Effects System) at Walt Disney Studios. Reprinted from Fielding (2013, p. 397).

Fielding (2013, p. 395) also adds that "motion control systems are used almost exclusively for the photography of inanimate art-work and miniatures". The miniature is motion controlled as it needs to be moved or twisted. Netzley (2000) supports the idea that this system is invaluable for scenes in which an actor is required to play more than one character with the identical look. It is widely used when the director wants to have twins in the movie. The illusion takes advantage of the motion control system, thus the actor plays one part of the screenplay as one character, and later with the help of repeating camera movements, the actor moves to a new position in a scene and plays the other part of the screenplay as a completely different character.

Okun and Zwerman (2010) further recognize different types of motion control systems. The basic division may include *live-action rigs* and *stop-motion rigs*. The main difference between these two categories is in the speed of recording. Live-action rigs are commonly used to film more than one transition within a shot. They are designed to collaborate with

[3] In international system of units, it is approximately 0,0254 millimetres and in imperial systems it is a thousandth of an inch.

live-action cameras, lenses and other accessories. Another type is a pan/tilt system which consists of shaft encoders[4] that allow a camera operator to digitally manipulate the pan/tilt head, control focus, zoom, and iris and/or adjust all the mentioned. Alternatively, the camera operator can program the whole sequence of camera moves by defining all those parameters stated above via the computer. To execute a true motion control shot, the head must be attached on a completely static device with zero degrees of freedom in terms of the scene. A remote control of the camera is also handy while shooting car stunts, since the camera operator's life might be put in jeopardy. A more complex type of the device may represent a pan/tilt head put on a track. This upgrade is usually done by combining a fixed rig and a dolly sled and its main asset lies in portability of the device. However, when it comes to filming miniatures and stop motion animation, stop motion rigs are preferred as they are capable of motion control and, moreover, the speed of recording is at very slow frame rate. Filming the scenes containing miniatures and models should involve a discussion with the VFX director about all the details needed to create a scene.

2.2.2.5 Motion capture

Menache (2000) contends that *motion capture* is a process whereby a live performance is translated into a digital performance. To translate the live motion performance into digital, several key points must be tracked over a period of time and combined to create a 3D simulation of the recorded performance. These key points are the pivot points between inflexible parts of a captured subject, and they serve as the areas which best represent the subject's motion. The captured subject can be literally anything that can make motion and exits in the real world such as humans, animals or even robots. The key points are being recognized according to their location with the help of one or more sensors-*markers* that are attached to the subject. The main collection device subsequently collects all the data and store them for further processing and postproduction.

The term motion capture, or shortened MoCap, is very often incorrectly replaced with the term *performance animation*, therefore Menache (2000) points out that the terms represents two different concepts of capturing motion and cannot be used interchangeably. MoCap relates to the technology used to record the movement, whereas performance

[4] A shaft encoder, also called a rotary encoder is an electro-mechanical device which use motion, under a variety of technologies, and translate it into an electrical signal.

animation pertains to the performance regardless of the technology used to record the process of bringing a character to life. Menache (2000, p.1) concludes that "motion capture is the collection of data that represents motion, whereas performance animation is the final product of a character driven by a performer."

The application of motion capture is not limited to use in entertainment industry, but applications can be found in medicine, sports, and law; which all benefit from MoCap technology. In addition, it is widely used while conducting safety tests in the automotive industry analysing the crash tests with dummies. In medicine, MoCap is called 3D biological measuring. This method is used to generate biomechanical data, examine a person's manner of walking, or to analyse the spine. These analyses are truly useful as any abnormalities or changes in conditions can be easily detected. In sport analyses, the data is used to improve the performance of sportsmen, mainly golf and tennis players, gymnasts and swimmers. Several MoCap studios are specialized in providing swing analysis for golfers. The aim of performance visualization is to find any problem areas that sportsmen may have. MoCap is extensively used in law to reconstruct videos, events or crime scenes. There reconstructions are an essential part of trails, as they can demonstrate the order of events seen by a witness. Moreover, this kind of evidence is more popular with jurors, as suggested by the study conducted by the American Bar Association. To create an adequate reconstructive video, the animation must comply with local and federal evidence laws so that it can be accepted in court, and it must be very simple; meaning no detailed models are allowed. Yet, this kind of evidence is very often required to be accompanied with supplementary testimony (Menache, 2000).

Kitagawa and Windsor (2012) further recognize that there are three types of MoCap: optical, magnetic, and mechanical systems. In addition to these three types, ultrasonic systems and inertial systems are also available, but they are used very rarely. The use of *optical mocap systems* is exclusively in medical practise. This system requires 4 to 32 cameras, a computer and a subject wearing passive or active markers. Passive markers are very reflective in terms of material and shape of the marker is usually spherical, semi-spherical or circular, and it depends on camera resolution. These markers are spread all over a subject's skin or on a special MoCap suit and illuminated by cameras equipped with light-emitting diodes (LEDs). This results in the markers reflecting the light emanating from LEDs cameras. On the contrary, the second group of markers are called active, because as the name suggest they are already quipped with LEDs. Adjustment of amplitude

and frequency of LED is quite convenient, and consequently, the identification of the marker is easier as well. Recent optical mocap systems do not require markers anymore, they are able to process the continuous skin surface without the markers on it making this system markerless. Instead, phosphorescent make-up is being applied to the skin and two sets of cameras are capturing the motion. Among the main advantages are accuracy, high capture rate, possibility of capturing multiple subjects and generation of skeletal data. The disadvantage is the expensive hardware requirements, extensive post-production and occlusion problems caused by hiding the marker. The second group of systems is also referred to as *magnetic trackers*. In *magnetic mocap systems*, post-production is not necessary and can be used for real-time application. The occlusion problems do not occur while hiding the sensor, as the sensors are captured based on the magnetic field and covering them does not cause interference with the collecting device. What causes interference are metal objects and electronics; as these objects generate their own magnetic field. In this situation, the output may be noisy and distorted. Magnetic systems are further divided into two subgroups: systems with direct current (DC) magnetic fields and system with alternating current (AC) magnetic fields. The advantages of magnetic mocap systems represents real-time feedbacks (therefore real-time application), they are less expensive compared to optical ones, and have multiple setups. On the other hand, the disadvantages are that configurations are harder to alter, and sampling rates are lower than in the case of optical systems. The last group is *mechanical mocap system*, which use a device that looks like an exo-skeleton. The purpose of the device is determining joints angles with the help of rods and potentiometers. These systems provide a few advantages as it is a real-time system just like magnetic systems, but without magnetic or electrical interferences, quite low-cost, and they are portable which also means that movement is only limited at the joins; otherwise the subject can move freely. The main issue with the mechanical systems is capturing of the jumps and walks up. The data cannot recognize this kind of movement; hence it looks like the subject is walking on the floor although the movement is in upward direction. Additionally, the exo-skeletons are quite fragile and breaks easily.

Chapter 2.2 described the basic concepts associated with visual effects, their design, production and use in films. This chapter began with the early techniques and proceeded to the most modern ones. The following chapter will examine the importance of practical effects as the main representative of in-camera tricks.

2.3 Practical effects (SFX)

Dinur (2017, p. 160.) explains that “special effects are done practically on the set and in-camera”. Even though they are referred to be photoreal which gives reason to think that their production is unchallenging, creating them in the real world is sometimes a very arduous task, or they are very high-priced. Such a once-in-lifetime opportunity was given to filmmakers when they found themselves in the middle of genuine action happening on the set. While shooting the movie *Entebbe* (2018) about a plane hijacking, simultaneously a genuine hijacking of Libyan plane was happening at the Malta airport, which provided unique shots usable for the movie (BBC.com, 2017). Many times, there is a need to improve practical effects on set and that is when visual effects overlap with practical ones. Contrary to this, if a shot made with use of practical effects is for any reason imperfect, these effects should be skipped and instead only VFX should be used to create a shot. For instance, when artificial rain from sprinkles is poorly oriented in a frame, it is beneficial not to leave it for VFX to fix the imperfections. Deformation of Richard Harrow’s face in *Boardwalk Empire* (2010-2014) was initially planned as a practical effect using prosthetics and makeup and with further VFX finalization, this method had proved ineffective and concerns about the result and the time it would take to apply makeup on daily basis led to a decision to make the deformation fully in postproduction using CG mask.

As suggested in the book *How it Works: Science and Technology* by Horobin (2003), a range of practical effects or, commonly known as mechanical or special effects, differs based on the difficulty of the effect. It can be as easy as to make leaves fall by shaking branches to more complex ones such as demolition of an old building with explosions and it all depends on special effects supervisor and scriptwriter’s imagination. Practical effects are predominantly associated with scenes containing brutality, destruction, wounds, or explosions. One of the common practical effects used in action movies are wounds made by bullet hits. These are accomplished by placing a combination of a small explosive charge and a plastic bag filled with artificial blood. This small device is later placed underneath their clothes and detonated as needed by an actor or a crew member remotely. The other violence-related scenes in the movies may involve stabbings, which are done with the use of a collapsible knife. When the tip of the knife (or its side) is pressed against some surface, the blade is pulled back to the handle.

2.3.1 Miniatures and models

Netzley (2000) acknowledges that a replica of an object is called a *model*. There are two types of models; a full-size model generally referred to as *mock-up model* or a *miniature model*. Filmmakers have used both types of models since the very beginning of the film industry. A model of a ship in the movie *The Battle of Manilla Bay* (1899) is considered among one of the first ones to ever appear in a movie.

As Finance and Zwerman (2010) explain, a miniature or a model might represent something which does not exist in the real world or is too expensive for movies with low budget; or is simply inaccessible for any other reason. For example, it can be a city or a landscape on the Earth, an alien planet, a car, creatures, technology, or an animal. The only limitation is the imagination of the author. Like the techniques mentioned in the previous chapters, this technique is used in combination with live-action shots.

Netzley (2000) notes that the main feature of a miniature is in which scale the miniature is manufactured. In other words, how much bigger or smaller a miniature's size is compared to a full-sized equivalent. For instance, a miniature built in a scale of 1/150 has 1 meter for every 150 meters of the full-sized object. The same miniature built in a scale of 1/18 is far larger, with 1 meter for every 18 meters of the full-sized object. Subsequently, it means that miniatures built in large scales can be quite huge. As an example, the volcano miniature shown in *Dante' Park* (1997) was 9 meters tall and 33.5 meters at its base.

Finance and Zwerman (2010) comment that the size of a miniature is not the only key feature in how convincing it appears. The attention detail plays an important role and a miniature builder should be a very precise person. If this criterion is not considered, the audience will sooner or later realize that the object is not real. To spoil the illusion, it takes seconds, yet building a miniature may take hours or occasionally days if more complex. Some elements or full-sized events are very difficult or even impossible to miniaturize. Water, fire and explosions are suitable examples of such an obstacle because these obey certain physical laws.

Netzley (2000) observes that most of the miniatures used in the movies must be extremely durable because they must endure repetitive shooting over several months, most often under the intense heat produced by stage lights, or the extreme weather conditions, such as snow, wind, rain when shooting outside. When mentioning durability, miniature sets are often made of carved polystyrene with foam, onto which other scaled models can be

affixed such as trees, people or animals. Items that are supposed to represent vehicles, or other means of transport including spaceships, are composed from a metal framework hidden under a few layers of styrene, foam and/or plastic. These sets are rather complicated in terms of electronics and working lights, so it is necessary to include safety features such as internal air conditioning to prevent the overheating of electronics. Surface protection of the material is ensured by utilizing etched brass which gives a realistic look to vehicles and buildings. These techniques were widely used for building spacecrafts in *Stark Trek* movies (1994-1998), which resulted in the spacecrafts appearing very sleek. In 1972, Douglas Trumbull changed the recognized conception of spacecrafts with his introduction of the modelled spacecraft for *Silent Running*. Trumbull's miniatures had a hodgepodge of surface details manufactured from plastic model kits which are available in hobby shops. Moreover, this practice would be later used in movies *Star Wars* (1977), *Close Encounters of the Third Kind* (1977) and original *Blade Runner* (1982).

Netzley (2000) proposes that the model can be divided into three groups according their purpose. The first would be the *hero models*, as they represent the most detailed models used for closeup and are used as main *stars* of the movie. The second group would be the *background models* which are a bit less detailed as they are used in the background just to give a grander look of the scene. The final group would comprise of the *stunt models*. The stunt models are the most common and manufactured, as they are used for all the stunts that would include crashes, pyrotechnics, and other destructive work. Comparing all these models, they also differ in materials. The stunt models tend to be more durable than the corresponding hero models. For example, space stations used in the movie *Armageddon* (1998) were created as stunt and hero models. The hero version was made of Plexiglas and styrene, whereas the stunt version or pyrotechnics version was made of cardboard and epoxy resins and had a larger scale for the use of the special effect, such as blasts and impacts that were used inside the model.

Finance and Zwerman (2010) recognize the model according to its use. The *in-camera models* are stand-alone miniatures that are filmed as they are in the film. They are believed to be one of the "purest" and the most practical form of miniatures. These models often involve getting destructed when shooting a building or vehicle which are supposed to be shattered into tiny fragments. Natural phenomena such as explosions, winds or flowing water are rather unpredictable and have their own minds, which tends to lead to the destruction of the miniature at any time. Afterwards, the miniatures will have to be restored

and the shot will have to be repeated several times. It is essential that production teams are aware of this fact, as it impacts the budget and schedule of the movie. The common solution to this problem is to plan on three repetitions of the shot. The *hanging models* are also referred to as foreground miniatures in combination with live action. This is a technique where a miniature is blended with a live action background, therefore it is built close to the camera. This technique can be a very effective and relatively inexpensive means of creating a marvellous set or a fictional environment. The idea behind this technique is the same as matte paintings, with the difference being that these objects are 3D and more realistic in appearance. Another key difference is that the production team can easily shoot the setting during daylight or night-time; whereas a painting requires lengthy redesign to change the setting. The directors do encounter a few limitations such as they must decide on the camera angle before filming. At this time the miniature must be built and lined up perfectly with the background with respect to the scale, colour and perspective. Additionally, the camera moves are considerably limited or in case of the use of a dolly and crane shots are impossible to make. To make tilt effects the camera's lens must be used on a *nodal point*[5]. The *models with composited elements* are the one of the most widely used techniques, since it is a combination of a miniature with either live action, a matte painting, or a glass shot. Compositing elements were extensively used while filming *The Lord of the Rings* (2001-2003) trilogy and *Harry Potter* (2001-2011) in order to intensify the overall look of the scenes.

2.3.2 Stunts

As Lane (2015) claims, one of the most essential categories of "movie trickery" happening on the screen is believed to be stunts. The main objective of action movies is to excite a viewer's imagination and to experience a high-octane ride. The laws of physics do not work in these movies and the viewer enters the world where almost everything is possible. These fantasies and high-octane action portrayed in the movie is very often part of physical action performed in real-life and not made by computer with the help of CGI. To deliver these sequences, special skills are required. These stunts, nevertheless, are not solely used in the film industry, but also in TV series, advertisements, documentaries or even in theme parks as a part of entertainment show.

[5] The nodal point is the point of an optical system for which an incoming light ray, directed at a nodal point, leaves the system with the same direction. It is the point at which the light rays converge.

Virkki (2015) explains that stunts are performed by stunt artists who are specialists in this field. In movies with storyline set in the Wild West, stunt artists are the ones who start fights in saloons, gunfires, jumping through windows, ride horses, or even falling off them. Modern movie stunts include car chase scenes, jumping from one high building to another, hanging on cliffs or even riding a motorcycle without helmet on the streets of Paris. Stuntmen and woman are very often referred as to record breakers, fearless heroes of the movies and daredevils. Their job is to perform a dangerous and risky scene in order to entertain the audience.

Subsequently, Lane (2015, p. 5) provides a more precise definition of a stunt: "A stunt is a physical action described in a script that must be performed by a person other than the actor required by the story, to dramatize that moment". This moment takes the storyline forward and is characterized by the lack of words that can precisely describe what is happening and the action itself is the storyteller. The viewer is capable of "feeling" the adrenaline from it. It is essential to make these scenes like illusions and persuade the whole audience that was seen on screen really happened. They cannot be aware of the fact that the actor was replaced with a trained professional if they take a close look at the action. Stuntmen and women replacing the actor are called stunt doubles. The same concept of unawareness of ongoing replacement applies to a place that action occurred and any mechanical devices that helped to build the scene, whether they are wires, safety nets or rods. Safety-related devices, which are used quite extensively considering the fact they are meant to prevent accidents and injuries, should be erased with the help of computers or just simply placed out of sight of the camera to create the perfect illusion. Without using safety devices, stunt artists might sustain minor injuries, severe injuries with permanent disabilities, or in the worst case, fatal injuries. During the last decade, three stunt doubles did not return home from filming. Kun Lieu was fatally injured while filming a scene with controlled explosion on a boat in the movie *The Expendables 2* (2012) and his fellow colleague Nuo Sun was severely injured (Movieweb.com, 2011). Five years later, shooting of *Deadpool 2* (2017) took another life. Joi Harris, riding a motorcycle without a helmet, lost control over a vehicle and crashed into the Shaw Tower in downtown Vancouver (Desta, 2017). In the same year, while filming the eighth season of popular American horror TV series *The Walking Dead (2017)*, John Bernecker missed a safety net by a few centimetres when he fell from a balcony, which was 6 meters high, onto concrete (Otterson, 2017).

Virkki (2015) recognizes three types of stunts. The first type would be *basic stunts*, which focus on performance in terms of athletic abilities. The number of the crew members do not need to be as numerous as in the case of other two types of stunts. Instances of scenes containing basic stunts can be smashing a window, falling off a motorcycle, or as simple as collision of a pedestrian and cyclist. These scenes do not require any additional camera trickery and do not require specific camera angle, even though camera angle might contribute to the overall look of a scene and mask any safety equipment if present. A fall, as one of the basic stunts, is not as simple as it may seem and requires training and skills to some extent and can ensure performer's injuries if not done properly. To reduce injury-related consequences of falls, various safety equipment is used such as air bags, box rigs, stunt pits or landing pads.

The second type would be *special equipment stunts* and these stunts, as suggested by the name, require the presence of on-set tools which are not commonly used when shooting every scene of a movie. Depending on the scenes, they either cannot be filmed without special equipment or, when using special equipment, scenes are made stunning. When filming a getaway scene involving running through a window, a special type of glass is used. This glass is widely known as breakaway glass and its properties prevent causing injuries to a performer when shattering it. Occasionally, special equipment is custom-built and very pricey. While shooting *Point Break* (2015), wingsuits were essential equipment in order to perform a base jump and to film unique, dynamic, and breathtaking shots in the first person combined with shots made by co-jumper/cameraman having camera mounted on the helmet. Another instance of special equipment is a hydrogel providing thermal protection necessary to execute fire-related stunts. This life-saving hydrogel produces a cooling effect which prevents skin burns. To execute one of most dangerous stunts, a performer applies a layer of hydrogel on exposed skin, puts on special fire-resistant clothes, which is sometimes accompanied by a protective mask, and applies final layer made of a pyrogel, which after igniting produce real-looking flames at a low temperature.

The last type would be *vehicle stunts*, where the key roles are played by different types of vehicles and advanced driving skills are required to perform this type of stunt. Almost every action movie contains at least one scene involving a car, bicycle, motorcycle, bus, truck, van, boat, or helicopter. These vehicles are subsequently used in sequences which were carefully planned and well prepared according to a special stunt script. Car chases, illegal street races, jumps of one vehicle over another vehicle, car flips, single or multiple

vehicle collision sequences are likely to be common representatives of vehicle stunts. Virtually any motion produced by some vehicle is a foundation for creating an authentic action scene.

2.3.3 Pyrotechnics

According to Rickitt (2000), to create one of the most spectacular movie effects, filmmakers should employ fire and explosions, which are referred to as pyrotechnics. This half-art half-science industry is engaged in producing a dangerous-looking effect in scenes. Although these effects should only look dangerous and should not present an imminent danger to those performing them, life-threatening situations are still real. For this reason, only trained and skilled professionals are permitted to perform these stunts, as they must utilize dangerous and highly explosive materials.

Regarding an explosive material, Netzley (2000) explains that one of the commonly used explosive materials is black powder. Black powder is a substance which can be commercially purchased or handmade and is formed as a mixture of carbon residue called charcoal and potassium nitrate (commonly known as saltpeter) acting as fuels, and sulfur acting as oxidizer. To make a smokeless effect, nitrocellulose is used instead. There are many substances which can be used to create explosions and they are used with respect to what type of effect filmmakers want to achieve. For instance, naphthalene is suitable for large-scale explosions, chain reaction-like explosion is made by detonating cord (shortened Det cord or detacord), which is filled with small charge of explosive material such as pentaerythritol tetranitrate (PENT) or trinitrotoluene (TNT).

Rickitt (2000) adds that the use of explosive material and performing explosions is governed by laws, which vary in every country and state. Every pyrotechnician is required to obtain a license, which gives them permission to buy, store and manipulate these materials. Prior to granting the license, they are required to demonstrate that they had acquired the knowledge necessary for this industry in terms of safe operation with explosives. Like other licenses, it has various degrees and with years of experience comes a higher degree along with greater responsibility. As there is no room for mistakes and hesitation when performing detonation, rigorous planning and testing present a major role in this process. In terms of testing, this involves how much of explosive material is used, what type of explosive is preferable, which detonation devices is suitable for detonation or

what the temperature of the flames are for a given distance. Afterwards, a risk assessment document is written, which is intended for a cast, a crew, or the emergency services on standby. This document contains safety precautions and detailed information about the upcoming explosion. Special effects supervisors are the ones with decision-making power and give the green light to execute the explosion. Without their approval, no explosion is happening as they are responsible for the consequences.

2.3.4 Makeup

As Nogueira and Namm (2014) state, an artist responsible for a character's look is called a makeup artist. This job does not include only the beauty features of a look, but ranges from fixing actors' hair, maintaining facial hair, creating cuts and bruises, and applying bald caps. If artists are capable of creating and applying more complex makeup, such as *prosthetics*, they are referred to as special effects makeup artist.

Delamar (2003) further points out that the job of makeup artist depends on makeup designers. The duties of makeup designers are sometimes more time-consuming and complex than it seems. The most significant duty is analysis of the script and its needs, such as creating wounds, bleedings, or scars for all characters involved. They also participate in proposing makeup budget which is later approved or further discussed with the director. The job of makeup designer is principally needed in pre-productional phase of the movie, whereas makeup artist starts in the production phase.

Netzley (2000) further recognizes three types of makeup. The first group would be *street makeup* which involves rudimentary processes to improve the actors' look in front of the cameras while using elementary cosmetics materials. The second group would be *character makeup* and as suggested by the name, it employs transforming actors into other characters they are required to play according to the script. The last group would be *special effects makeup* which includes the presence of mechanical or electronic components to create alien forms of life or monsters.

Regarding prosthetics, Rickitt (2000) explains in more detail the production process of prosthetics which are essential part of whole makeup department. This term refers to "the art of creating three-dimensional makeup which depends on producing artificial appliances that can be accurately, and invisibly, attached to the performer" (Rickitt, 2000, p. 215). The

first stage of production is to obtain live cast, which is a template of any part of body, most commonly the face. Prior to taking a cast, the head of the performer is covered with plastic wrap to prevent hair damage. The back of the skull is later covered with plaster bandage strips. To take a face cast, dental alginate is used, and it is the same material which dentists use to take teeth casts. Dental alginate is applied onto the performer's face as the first layer, then followed by a second layer consisting of plaster bandage strips. These strips are used to strengthen the cast. After approximately half an hour, the layers should harden, and the cast can be cut into two halves. This cast is still a 'negative' copy of a performer's face, hence additional copies must be obtained in the form of a 'positive' replica which is almost indistinguishable from the original. To make the final, 'positive' replica, the mould is filled with a gypsum plaster mix.

2.3.5 Puppetry

Finance and Zwerman (2010, p. 6) define puppets as "artificial creations that simulate a living creature, whether human or not". Then they explain that animation of the puppets can be done by hand, just like in the case of stop motion, or by wires, cables or, back in 2010, by animatronics. Animatronics is used to refer to puppets motorized by mechanical, hydraulic or similar device on the same basis. For clarification, if we talk about animatronics, we are interested in the question how the object is made to move.

Whenever an actor or living animal cannot be depicted, it seems reasonable to use puppets instead. Some puppets can be more advanced than their predecessors on strings, having realistic appearance for instance. Design of puppets depends on requirements of the scene. For example, in the movie *The Fly* (1958), a spider has realistic appearance and is powered simply by hand put inside the spider. To improve the result, footage of a real living spider was blended in. The classic puppets on strings that are moved with the help of a puppeteer are called marionettes. However, in the second half of 20th century a lightweight version on rods started to be more attractive for filmmakers than the classic ones. One of the advantages was easy manipulation and, moreover, rods could be painted with the colour of the background in order not to be made visible for a viewer. The main objective was to hide any auxiliary devices and to make the viewers think the puppet was moving on its own. Puppeteers often used more than just one auxiliary device to make illusion even more

realistic (Netzley,2000). Nowadays, this problem can be solved by using modern technologies.

Chapter 2.3 focused on practical effects that are widely used in all films, especially in those directed by ambitious directors who attempt to limit computer effects. The practical part of this thesis will examine what kind and to what extent acclaimed directors utilize special effects in their movies.

3 Practical part

The aim of this part is to examine special effects in selected movies. All selected movies are recipients of the Academy Award for Best Visual Effects and some of them even received awards in other categories. The movies are sorted by their release year from the oldest to the newest one. Every subchapter contains basic information about the movie, followed by a shortened version of the storyline and concludes with an analysis of the selected sequences containing special effects that stand out of the norm. The objective is to describe given sequences in terms of techniques and technology used to create effects, and an overall production process of special effects.

3.1 Analysis of special effects in movies awarded by the Academy Award for Best Visual Effects

3.1.1 *Inception* (2010)

While starting a new decade, in July 2010 Warner Bros. Pictures released a new sci-fi movie, *Inception*, which was rightly awarded in many categories at the 83rd Academy Awards ceremony; one of which, was the Best Visual Effects. A filmmaking veteran Christopher Nolan was sitting in the director's chair and Paul Franklin was responsible for visual effects. This was not the first collaboration of Paul Franklin with the director, as they collaborated on *Batman Begins* (2005), *The Dark Knight* (2008), and then *Inception* (2010) (Seymour, 2011; Imdb.com, n.d.).

3.1.1.1 Storyline

The main character of the movie is Dominic 'Dom' Cobb (played by Leonardo DiCaprio) who is an extraordinary thief, referred to as an extractor. Dom extracts information from the deep, subconscious parts of his target's mind – the world of dreams. While being an international fugitive, Dom is offered one last job which he hesitates to take, but eventually agrees when he is promised to have chance to go back to his children. This time, the job is not to extract information, but to implant and grow a new memory, which is called inception. No matter how careful their plan is, Dom and his team find are unable to outrun Dom's past and his demons (Imdb.com, n.d.).

3.1.1.2 The Paris café explosion

According to FandangoNOW Extras (2014), the Paris café explosion scene is a combination of outstanding VFX and in-camera elements. Christopher Nolan was trying to demonstrate the destructive power of dreamworld and how fragile the mind is when dreamers realizes it is a dream. Chris Corbould from Double Negative studio continues the process prior to shooting an actual scene. Many tests were completed, mainly to determine whether or not it was safe for DiCaprio and Page (playing Ariadne) to sit at the café while filming explosions. Despite the dissatisfied expressions of residents living close to the filming which was realized in the streets of Paris, Nolan insisted that the explosions needed to be done in front of the camera and in the presence of the protagonists Dom and Ariadne. He tried to film as many shots containing practical effects as possible.

Additionally, Corbould utilized a series of air cannons to film explosions of real objects, such as paper, boxes, and small turbulent debris as an illustration of dreamworld's physics being disintegrated. The scene also involved a flipping car and a motorcycle which was done with wires. The actors were in placed in the middle of the explosions, but safe a few meters behind the main action. Once the crew filmed all the footage with practical effects and real-world objects, they submitted the footage to a VFX team at Double Negative to enhance the scene and add extra layers of CGI particles to it. The VFX team created a fragmentation effect (see Figure 5), meaning that objects blasted from air cannons were further disintegrated in the air to appear as small pieces. Nolan further explains for FandangoNOW Extras that the aim of this effect is to portray "the potential of human mind to create infinite levels complexity within a dreamer, complexity in detail" (FandangoNOW Extras, 2014, 2:59).

Figure 5. Illustration of fragmentation effect created by Double Negative in the movie *Inception* (2010). Reprinted from FandangoNOW Extras (2014).

3.1.1.3 The Fortress

Failes and Hunter (2010) describes the scene with the Fortress as another instance of combining practical and visual effects. The entire sequence was carefully planned prior shooting, including models, pyro effects, demolitions, and rehearsals. The Fortress, consisting of a main building and a tower, is a 1/6 scale model which was built based on a 3D model made in Rhino software. The mountain was made of eight shipping containers welded together to form a base of the mountain. The main building was designed as an inverted pyramid, was then attached to the mountain and the tower. After assembling all the parts together at the New Deal Studios' backlot, the tower was around 16 meters above the ground, which resulted in facing another challenge. Nolan wished to have an aerial shot from above the model, acting as helicopter-made shot. Commonly used technocranes was not an option, as the height of the tower was exceeding the possibilities of this equipment. Instead, a construction crane was borrowed to lift a platform on which a technocrane was mounted. To create snowy environment, snow flock used on Christmas trees and table salt cover the scale of the mountain and the Fortress. Ian Hunter from New Deal Studios then triggered the chain of explosions (see Figure 6). The explosion was filmed in two takes at 72 frames per second. The first take utilized five camera angles and the second was shot with adjusted timing and pyro. A scale model was not used as the only Fortress, another one was built in a ski resort in Calgary, Canada, but in bigger scale. Because of massiveness of a project, construction of the Fortress in Canada started in August, despite

filming the scene in November. The Fortress is not the only element which was filmed as practical effect. An avalanche in the sequence was a practical effect that triggered with the aid of a series of dynamite charges dropped at the top of the mountain.

Figure 6. Explosion of the Fortress in the movie *Inception* (2010).
Reprinted from Failes and Hunter (2010).

3.1.1.4 The Limbo City

The last sequence and the most challenging in terms of creativity was the Limbo City. Frei and Franklin (2010) analyse that Limbo City consists of two basic concepts. The concept is that the City represented Dom's current mental state, then it changed as his thoughts did. This included buildings from the 1920s, new-age architecture, and ultimate decay and collapse. This crumbled City is supposed to portray Dom's ongoing mental breakdown. Another concept is based on the breaking of a glacier. As the glacier cracks, a portion of glacier is severed and dropped into the sea. This process of natural disintegration was preferably chosen as reference materials over the process of building demolition. Nolan's idea was to apply these two straightforward concepts into his dream environment. The glacial model samples had to be created in Maya software from reference materials, while

the disintegration of the building on the shoreline was rendered based on the glacial samples in Houdini software. Although it may seem like simple process, the Double Negative's VFX crew struggled to execute Nolan's idea of Limbo City and render the City so that it matches the director's vision.

3.1.2 *Gravity* (2013)

The winner of the 86th Academy Award for Best Visual Effects was indisputably one of the greatest movies of year 2013 – *Gravity*. The sci-fi movie *Gravity* was released in American cinemas on October 4, 2013, and one month later in the United Kingdom where the entire production was located (Imdb, n.d.; Framestore, n.d.). The distribution rights belong to the Warner Bros. Pictures, although the director Alfonso Cuarón initially planned to direct the movie at Universal Pictures (Cohen & McNary, 2013). The greatest recognition belongs to the visual effects supervisor Tim Webber and the visual effects company Framestore. The close collaboration of Framestore, filmmakers, and the visual effects crew was crucial as the development of new techniques, alongside with utilizing existing ones is what made the movie stand out (Busch, 2014).

3.1.2.1 Storyline

The story is set in deep and cold space, leaving a veteran astronaut, Matt Kowalski (played by George Clooney), and a greenie, Dr. Ryan Stone (played by Sandra Bullock), at the mercy of dealing with the fate after the Space Shuttle Explorer is irretrievably destroyed by remnants of a Russian satellite that was hit by a missile. Their only chance of survival is an involuntary space adventure in the effort to reach another space station. The odds are against them as they are losing fuel and oxygen supplies (Imdb.com, n.d.).

3.1.2.2 Zero-gravity

Framestore (n.d.) acknowledges that most shots involved CGI, except for the actors, who are the only real 'elements'. Even the space suits are done with the aid of visual artists, as are space, the Earth, and the 30 million stars. Shots containing zero-gravity were initially produced using various types of rigs, especially a tilt rig. However, one of the first-rate inventions of that year called *the lightbox* (see Figure 7) claimed the responsibilities for

producing these shots instead of rigs. The lightbox is equipped with approximately 196 interior panels measuring 60x60 cm each containing 4 096 LED lights. The actors were filmed inside the lightbox where the background can be customized and adjusted according to the film's need. To create illusion of falling, actors do not necessarily have to move. Contrary to logic, if the actors remain still, a camera will move around them and then stop near their faces. Seymour, Webber and Clark (2013) additionally point out that the cameras are required to be highly precise as they race towards the actors' faces. Without the precision, there is potential for on-set injuries. IRIS, the most advanced robotic camera in year 2013 owned by Bot & Dolly, tackles these types of tasks perfectly, whereas the camera initially intended for this task was left broken the very first day of shooting. The director's style of filming contributed to the complexity by requiring the production of long, uninterrupted shots. Some of these continuous shots lasted nearly 17 minutes, with the opening scene marked at 13 minutes of on-screen time. This created an additional problem of how to make those long, continuous shots in a way that was impressive and kept the viewer's attention.

Figure 7. The lightbox with interior LED panels used to film scenes for *Gravity* (2013). Reprinted from Seymour, Webber and Clark (2013).

3.1.2.3 Re-entering the atmosphere

Seymour et al. (2013) further identify the scene with the capsule re-entering the atmosphere as ambitious. The essence of these scene was created by utilizing lower altitude shots. To acquire a reference material, Tony Clark from Rising Sun Pictures (RPS) contacted local balloon hobbyists that were launching balloons with GPS trackers and transmitters. They then developed advanced tracking software so that they may reclaim the footage. Clark's team utilized a hi-tech camera and sent it up to 36 kilometres above the ground in hope they would retrieve some satisfactory footage. The ground crew would later track the balloon's location and chase it for retrieval. Utilizing this technique ultimately led to the retrieval of some astonishing photographs and texture pieces which were later included in the movie. Clark notes for FxGuide (2013, para 43) that "real photography is never clean relating to the optical performance of the camera, the chip, the camera operator" in the context of trying to combine refence material and computer graphic renders which are believed to be noticeably clean. Additional authentic effects of minor lens deformations must be supplemented. The re-entry of the module sequence also involves flames and plasma effects around the module, which was achieved with series of simulations, mainly a particle simulation (a technique called the "particle system") and a pressure simulation.

3.1.3 *Interstellar* (2014)

In autumn 2014 Christopher Nolan delivered yet another spectacular movie named *Interstellar*, which was the sci-fi movie of the year having set a new IMAX[6] opening record ($20.5 million) (Imax.com, 2014). It was no surprise that Interstellar dominated the 87th Academy Awards ceremony in Best Visual Effects (Pederson, 2015). Due to the large scale of the movie, the distribution rights belong to two studios, namely Paramount Pictures (domestic distribution) and Warner Bros. Pictures (international distribution) (Finke, 2013). It was additionally co-financed by Legendary Pictures (Siegel & Galloway, 2013). VFX effects for the movie were produced by the team from Double Negative led by supervisor Paul Franklin and SFX effect by New Deal Studios led by a supervisor, Ian Hunter (Pederson, 2015).

[6] IMAX refers either to digital cameras having largest resolution format, projectors with brighter colours and specially designed theatres having large, curved screens.

3.1.3.1 Storyline

In the near future, the Earth decays and becomes inhabitable. Humankind is at the edge of extinction, decimated after series of natural disasters, droughts, famines. The last hope for saving humankind is courageous mission led by NASA sending a team of explorers on a quest into a deep space to search for new horizons. There are potentially three planets that have sustainable environments in the deepest parts of space. To reach this location, the explorers travel through a massive wormhole to find a new home (Imdb.com, n.d.).

3.1.3.2 The Endurance explosion

Failes and Hunter (2014) allege that Nolan's filmmaking style is predominantly based on shooting as many real objects as possible, mainly miniatures or full-scale models in real environment. For instance, New Deal Studios built a spaceship called the Ranger in full scale which was used for shooting in Iceland, as well as miniature versions having 1/5 and 1/15 scale. The Endurance space station was built as a miniature only, whether shooting outside or in studio interiors. The full-scale model was not built by production due to its massiveness. Even the 1/15 scale miniature was made to fit studio interiors as it had 12 pods and approximately 5 meters in diameter. Prior building the Endurance miniature, Double Negative provided with the previs[7] resulting in having 3D models built in MODO and Rhino software based on which New Deal Studios started production of the Endurance miniature. As far as the material is concerned, resin and foil were used as they are suitable due to their properties to shoot explosion sequences. For this sequence, filmmakers did not use the whole of the Endurance, only a quarter of it re-built in 1/5 scale. The debris caused by the explosion, was from using an air cannon that was vertically orientated. As for the explosion itself, filmmakers encountered a physics-related obstacle. The sequence was happening in space where there is no oxygen, and flames are dissipated very quickly. The presence of oxygen is always inevitable while filming on Earth, so filmmakers needed to achieve state of quick dissipation another way. Richard Helmer, responsible for explosion in the sequence, resolved this problem by utilizing highly flammable gas, known as butane. Its physical properties were sufficient to build the sequence.

[7] Previs is the term shortened from previsualization, which is preliminary visual design of the shot made in pre-production phase of the movie. It can be either produced digitally or in form of hand drown sketch.

3.1.3.3 Black hole

One of the reasons why *Interstellar* won the Academy Award was because of its very scientifically accurate and detailed depiction of the black hole named Gargantua. In contrary to other sequences in Nolan's movies, due to impossibility of making a black hole, it was done completely by CGI. Seymour and Franklin (2014) comment that the team from Double Negative was responsible for creating images of a black hole, alongside with the task "to have them accurate to not only quantum physics and relativistic laws, but also our best understanding (guess) of quantum gravity" (Seymour and Franklin, 2014, para 1). The team faced the challenge to create images of black holes which resulted in implementing a new render software called Double Negative General Relativity, shortened DnRG. Paul Franklin and other members of the team acquired knowledge of black hole's behaviour after a series of consultations with astrophysicist Kip Thorne, who provided them complex mathematical equations creating an algorithm to predict the trajectory of light rays, which was essential for developing DnRG. Rogers, Franklin and Thorne (2014) continue that prior designing Gargantua, the team produced a wormhole to see if the entered equations were working, which resulted in remarkable outcome in form of "a crystal ball reflecting the universe or a spherical hole in spacetime" (Rogers et al., 2014, para 12). Attempts were made to depict the black hole having the same approach, however this ended with the need to develop a new rendering software as the concept of these two objects are slightly different. As proposed by Einstein, gravity is not a force but rather effect of a distortion in space and time and is proportional to the mass of objects. For instance, massive objects such as black holes are due to its massiveness capable of bending the light and space-time, meaning that approaching the black hole would essentially result in changing of perception of space and time. Following this theory, the closer the person is to a black hole, the faster they perceive the time. Examining the theory more deeply, Thorne proposed that the central part of the black hole is called a singularity, from which there is no escape once drawn into. Around the singularity there is a glowing disc (known as accretion disk), which is made of gas clouds and dust, that significantly bends over the top and below the bottom (see Figure 8). Furthermore, it is a product of singularity's gravity. Seymour and Franklin (2014, para 6) conclude that the final design was inspired by concept suggesting that "the gravity being bent in space/time deviated the light around it producing this thing called the Einstein lens which is this gravitational lens around the black hole" (see Figure 9).

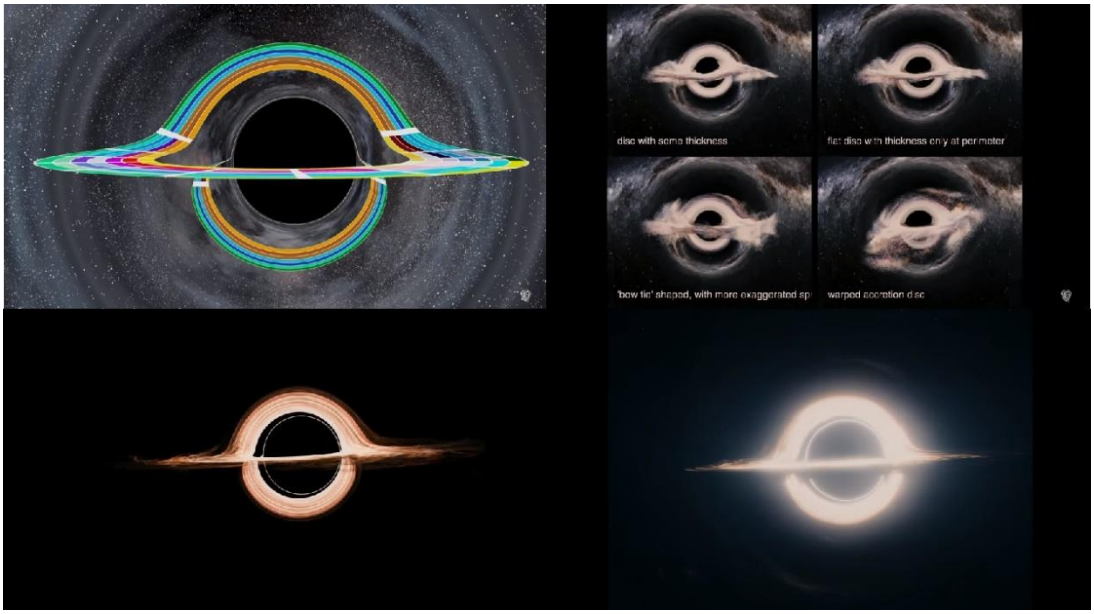

Figure 8. Illustration of simulations utilized to build black hole – Gargantua in the movie *Interstellar* (2014). Reprinted from Warner Bros. UK (2014). Available at https://www.youtube.com/watch?v=MfGfZwQ_qaY.

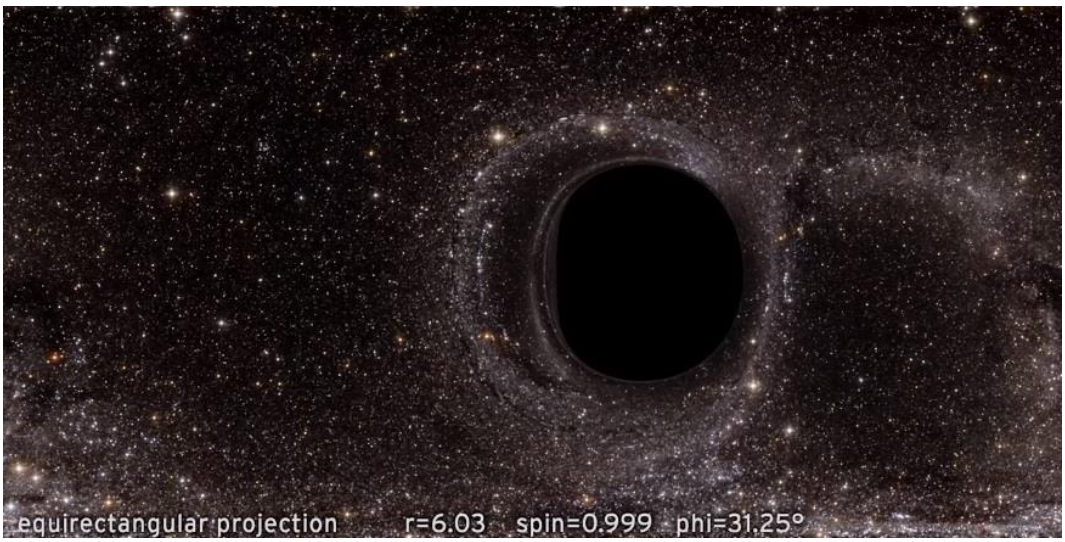

Figure 9. Simulation of influence of Einstein lens, known as gravitational lensing on starfield. Reprinted from Double Negative (2014). Available at https://www.youtube.com/watch?v=bmWs00JRXc0.

3.1.4 *Blade Runner 2049* (2017)

The highly anticipated sequel of the sci-fi movie *Blade Runner* (1982, directed by Ridley Scott) named *Blade Runner 2049* (2017) hit cinemas in October 2017, which was 35 years after the release of the first movie. This ambitious project was nominated for Best Visual Effects at the 90th Academy Awards. It did win, alongside with the award for Best Cinematography (Grobar, 2018). The director of the sequel movie is Denis Villeneuve. As for the distribution rights, Warner Bros. Pictures was responsible for distributing the movie in a domestic market; with Sony Pictures releasing internationally (Brueggemann, 2017). Despite celebrated success among the critics, the box office results did not live up to studios expectation (Bianco, 2017).

3.1.4.1 Storyline

The movie is set in year 2049 where bioengineered humans, known as replicants, are enslaved, and hunted by LAPD's officers, known as Blade Runners. Their task is to pursue and kill outdated Nexus-8 model replicant remnants. While performing his duty, officer K (played by Ryan Gosling) uncovers long-buried secret, which could cause chaos and lead to a war between humans and replicants. Determined to unearth the truth, K needs to locate former Blade Runner Rick Deckard (played by Harrison Ford) who appears to have all the answers. However, finding Deckard is not going to be easy as he has been missing for 30 years. K races against the clock to find Deckard before somebody else does (Imdb.com, n.d.).

3.1.4.2 Life-like hologram

Frei and Lambert (2017) emphasise that creating an AI character in form of hologram named Joi (played by Ana de Armas) was not as straightforward as one might assume. Although the idea seemed simple at first and was based on the simple visual effect, the execution was quite difficult. Villeneuve insisted on having Joi as sort of a hollow and transparent hologram, but at the same time with volume. His intention was to let the audience question themselves whether Joi is real or not. Prior to the production phase, many conventionally used holograms were tested but none of them seemed to be suitable for this movie. The VFX team proposed to use so called *black-shell effect*. Marshall and Nelson (2018) further observed that this effect might be explained using a transparent glass

bottle. Looking at front side of the glass bottle, an observer literally can see through the bottle to the back side of it and even the background if transparent enough. The same principle was applied to create Joi according to Villeneuve's vision. Frei and Lambert (2017) add that the scene consists of 2 layers creating a futuristic look of life. The first step required creating ordinary shots with de Armas and Gosling, which will serve as the reference shot. Secondly, de Armas was extensively scanned with several cameras under different angles. These later created the CG version of de Armas. The effect used vertical slicing into two 'shells', providing the front and back shells. The front shell was removed, and back shell was reversed so that it had the same effect of looking at a label on the glass bottle. From the reference shot, the extraction of live-action version of de Armas followed, leaving a clean background with Gosling in it. Joi's first layer, comprising of back-shell, was projected onto this clean background afterwards with the aid of Photoshop-like transfer function. To create Joi's final appearance, a second layer was added. This meant that de Armas' live-action version was partially composed over the first layer resulting in having this transparent, yet voluminous Joi (see composition in Figure 10). Regarding the transparency, Frei and Lambert (2017, para 17) conclude that "the transparency effect was weighted to when she was over bright lights or when bright lights would hit her back shell". Therefore, only bright lights showed the audience her true, holographic characteristics; otherwise, she looked very real.

Figure 10. Illustration of CG model (top picture) and composited layers consisting of back shell and live-action footage (lower picture) used to create hologram Joi in the movie *Blade Runner 2049* (2017). Reprinted from Frei & Lambert (2017).

The last chapter scrutinized the scenes from the selected movies that were awarded by Academy Award for Best Visual Effects. Some of the scenes are believed to be revolutionary, especially in terms of their production and final look. The directors took their limits to the next level to create these breath-taking scenes.

4 Conclusion

The aim of this bachelor's thesis was to analyse the necessary aspects of cinematography in terms of special effects and based on the available literary sources, to give definitions and descriptions of various visual effects, which were later used in the analysis of the movies. The objective of this study was also to provide a historical overview of cinematography alongside the special effects. The methodology used in the thesis is literary research into the books concerning the art of filmmaking complemented with online sources dealing with the sphere of cinematography.

The thesis featured an extensive theoretical part as it was one of its main objectives. The first chapter of the theoretical part provided the introduction to the topic in form of the historical overview of the special effects and cinematography. The second chapter comprised of fundamental definitions, categorization, and a detailed description of the visual effects, both early and modern ones. The third chapter placed its focus on defining practical effects, definitions associated with this term and the use of the effects.

The thesis also contained a practical part whose main objective was to provide the analysis of the movies recognized for Best Visual Effects by the Academy Award. Due to time constrains and complexity of the movies, only selected sequences from the movies were described.

As for the other constrains, a closer look at the hardware and software requirements was not present in this thesis, as the filmmakers mostly do not share these details with the public, therefore, there is a lack of this kind of information. However, some instances of software used in the filmmaking process were marginally mentioned in the practical part, as special effects supervisors had shared details of selected sequences from the movie they were working on.

To sum up, fully understanding the complex techniques utilized in the film industry to create the movies we take for granted can put the amount of demanding work into a broader perspective. Cinematography is art that should be understood and appreciated.

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6 List of figures

7 List of abbreviations

2D	Two-dimensional
3D	Three-dimensional
CGI	Computer Generated Image
DnRG	Double Negative General Relativity
fps	Frame-per-second
GPS	Global Positioning System
LAPD	Los Angeles Police Department
LED	Light Emitting Diode
MoCap	Motion Capture
MODO	3D modelling software
NASA	National Aeronautics and Space Administration
PENT	Pentaerythritol Tetranitrate
Rhino	3D modelling software
RSP	Rising Sun Pictures
SFX	Practical Effects (referred to as special effects)
TNT	Trinitrotoluene
TV	Television
VES	Visual Effects Society
VFX	Visual Effects