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VYUŽITÍ TECHNOLOGIÍ V SOUČASNÉ KINEMATOGRAFII A JEJICH VLIV NA FILMOVÝ PRŮMYSL
TECHNOLOGY IN CONTEMPORARY CINEMA AND ITS IMPACT ON FILM PRODUCTION AND RECEPTION

BAKALÁŘSKÁ PRÁCE
BACHELOR'S THESIS

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Bakalářská práce

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NÁZEV TÉMATU:

Využití technologií v současné kinematografii a jejich vliv na filmový průmysl

POKYNY PRO VYPRACOVÁNÍ:

Cílem práce je podat stručný přehled technologií využívaných v současné kinematografii (případně v tomto ohledu srovnat Hollywoodskou a nezávislou filmovou produkci) a zjistit jaký vliv mají tyto technologie na filmovou tvorbu a vnímání filmu, jak na straně odborné veřejnosti, tak na straně diváků.

DOPORUČENÁ LITERATURA:

Fielding, Raymond. Techniques of Special Effects of Cinematography. 4th ed., Focal Press, 2013.

Foster, Jeff. The Green Screen Handbook: Real-World Production Techniques. 1st ed., Wiley Publishing, Inc., 2010.

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Abstrakt

Bakalářská práce se zaměřuje na techniky využívané v současném filmovém průmyslu. V první části se práce zabývá barevným klíčováním, snímáním pohybu a tvorbou animací. Druhá část práce je poté zaměřena na dopad těchto technik. Práce bere v úvahu nejen dopad na produkci filmu, ale také skutečnost, jak tyto techniky ovlivňují samotné přijetí filmu ze strany diváků.

Klíčová slova

Speciální efekty, vizuální efekty, zelené plátno, snímání pohybu, animace, produkce, problematika CGI

Abstract

The Bachelor thesis focuses on the contemporary utilised film techniques. The first part deals with a chroma key, motion capture, and computer-generated imagery. The second part of the thesis is focused on the impact those techniques have. The thesis deals not only with the impact on the production but also on the reception of the film.

Keywords

Special effects, visual effect, green screen, motion capture, animation, production, CGI problematics

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Prohlášení

Prohlašuji, že svou bakalářskou práci na téma Využití technologií v současné kinematografii a jejich vliv na filmový průmysl jsem vypracoval samostatně pod vedením vedoucího 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 …………………..   ……………………….

(podpis autora)

Poděkování

Rád bych poděkoval Mgr. Magdaleně Šedrlové za cenné rady, věcné připomínky a vstřícnost při konzultacích a vypracování bakalářské práce.

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<u>Introduction</u>

The film industry is one of the most profitable industries in the contemporary world. There exist many different approaches of how filmmakers can shoot their movies. Some filmmakers prefer to shoot scenes traditionally using real environments, premeditated action stunts, and thus attain the most realistic experience. In 2015 movie *The Revenant*, director Alejandro González Iñárritu decided to film the scenes only under the natural light. This decision meant that the shooting was restricted to an hour and a half a day (Masters, 2015). The result of this was that the production phase demanded more time than usually. For comparison, principal photography (part of the production during which scenes of a movie being filmed) of *Avengers: Age of Ultron (2015)* required approximately six months (*Avengers: Age of Ultron*). Whereas in the case of *The Revenant*, it was about eleven months (*The Revenant (2015 film)*).

Not every movie can be shot using the approach mentioned above. Not considering the time demand, a lot of current Hollywood blockbusters take place in imaginary worlds, in different realities, or they shape our world in a way of which we have never dreamt. It would be very expensive to arrange scenes with sceneries to achieve a required goal. Thus, different approaches have to be used.

Since the early days of cinematography, filmmakers have been striving to film scenes where a combination of a real environment and visual effects possesses such a quality that the audience is not able to determine what is real and what is the magic trickery. With everyday computer technology advancement, this moment gradually continues to become a reality.

Many people wonder how all this trickery is possible. The main goal of this bachelor thesis is to give an overview of contemporary utilised techniques and to provide a basis of the creation of the visual effects. The whole topic will be discussed in the chronological order of how different techniques are utilised during the production and post-production phase to ensure logical order and to avoid unnecessary confusion.

In the first chapter, the thesis will deal with a technique called chroma key, commonly referred as a green screen. The chapter will start with a brief history of different techniques used before and then it will proceed to a principle of operation of the chroma key. The whole chapter is ended by a discussion about the impact the chroma key has on the production due to its special requirements regarding the scene layout.

The second chapter of the thesis will be focused on a technique called motion capture, usually designated as a MoCap. A brief description of different types of the MoCap, likewise a principle of their operation will be explained. A significant section of the second chapter is devoted to an optical motion capture due to its wide variety of the contemporary usage, especially in the form of a facial motion capture.

The third chapter will be dedicated to a computer-generated imagery, abbreviated a CGI. At the beginning of the third chapter, there will be a brief overview of a history regarding the animations to give an idea from where the contemporary animations came. Afterwards, the thesis will proceed through individual steps every animator has to do in order to create a realistic animation.

The fourth chapter will deal with the impact the contemporary utilised techniques have on the film production. The whole chapter will start with a brief explanation of a term production and how it is divided into individual phases. The thesis will feature examples of how the techniques can affect each phase. Furthermore, the thesis will discuss the impact the techniques may have on the individual actors or whole passages of a movie.

The fifth chapter will demonstrate how the different production approaches result in different receptions by the film critics and audience by comparing two, at the first look very similar but at the second look different, movie trilogies.

Last but not least, the whole thesis will be ended with a conclusion where I will discuss and comment my opinion about the contemporary utilised techniques and the impacts they have.

1 Green screen technique

Before the beginning of the filming, it is essential to establish a scene. In the current film industry, the filmmakers often utilise a technique called a travelling matte or chroma key. The technique is most of the time interchanged with a term "green screen". From this designation, it is easy to estimate how the scenes look. Basically, the only thing the filmmakers have to do is to establish the green screen proportional to the scene. Even though this may seem like an easy task, in the following chapter the thesis will describe obstacles regarding the green screen and procedures how to solve them or prevent them altogether.

1.1 History

But first, the thesis will deal with a history of how the special effects were created without the green screen and modern computer technology.

1.1.1 First special effects (Matte shots)

George Méliès, French illusionist and film director, can be considered as a pioneer of the special effects. He was one of the first filmmakers who tried to create unordinary scenes by utilising different techniques. In his 1898 movie *The Four Troublesome Heads (Un Homme de Têtes)*, he used a technique which is similar to the technique utilised in the contemporary cinema, compositing. The compositing can be defined as a combination of different shots into one single image (*George Méliès*).

In his movie, Méliès put a glass with intentionally blacked spots in front of a camera lens. The black spots on the glass prevented the light from reaching a film, and thus the specific spots on the film did not get exposed. Méliès then rewound the film. For the second shot, he blacked out all the parts which were already filmed and previously hidden spots were this time exposed. He repeated this procedure many times always with different exposed and blacked out spots. The resulting film combined different camera shots into one frame, and due to it, Méliès was able to create an illusion of himself removing his head and putting it on a table (*Hollywood's History of Faking It | The Evolution of Green Screen Compositing*) (Fig. 1).

1.1.2 Glass shot

At the beginning of 20th century, a technique similar to Méliès trick was used. Fielding (2013) describes this technique as a glass shot. Glass with painted elements was placed between the scene and the camera lens (Fig. 2). The problem with the glass shot technique was that the painting had to be done before the filming of the scene. This problem was later solved by Norman Dawn who combined his experience with the glass and matte shots. He decided to paint sections of the glass black. The film was then transferred to a second, stationary camera. This method gave matte artists time necessary for creating a painting which exactly matched the live action. The technique was rather progressive at that time; thus, it is no surprise the technique had been used throughout almost a century (*Norman Dawn*).

1.1.3 Black matte process

The problem with the techniques mentioned above was that any movement with the camera would spoil the entire shot. A new technique was required to fulfil new demands of the directors and audience. Therefore, a travelling matte technique was developed and patented by Frank Williams in 1918. The technique was then first utilised in F.W. Murnau's 1927 movie *Sunrise* (Fig. 3). Foster (2010) describes the technique as follows:

> The process required the foreground actor to be evenly lit in front of a black background and then copied to high-contrast films, back and forth, until a clear background and a black silhouette were all that was left on the film. Using a contact print with the silhouette matte film and the intended background footage together, a composite could be created. (p. 4)

Another movie where this technique was extensively utilised was John P. Fulton's 1933 movie *The Invisible Man*. The lead actor Claude Rains wore a full black suit. As he was standing against a pure black background, the black matting process created an illusion of invisibility (Foster, 2010, p. 4). The Williams's process had disadvantages. The most important one was that during the black matting process any shadows on the subject were removed. This fact can be noticed, for example, in one of the scenes from *Sunrise*. The observant spectators can notice that the passing cars do not cause any shadows across the main protagonists (*Hollywood's History of Faking It | The Evolution of Green Screen Compositing*).

1.1.4 Dunning Process

To better understand this technique it is important to define a bi-packing. It is a method of a combination of two separate films, one exposed and the other unexposed, into one. It was important for the films to touch each other. Consequently, both images from the exposed film and the camera lens were contact-printed onto the unexposed film during shooting (Fielding, 2013).

Now we can return to the special effects. A technique called Dunning process utilises the bi-packing method to create the travelling matte. Bazin (1997) describes the process thus:

> The foreground action is lighted with yellow light only in front of a uniform, strongly illuminated blue backing. Panchromatic negative film is used in the camera as the rear component of a bipack in which the front film is a positive yellow dye image of the background scene. This yellow dye image is exposed on the negative by the blue light from the backing areas, but the yellow light from the foreground passes through it and records an image of the foreground at the same time. (p. 76) (Fig. 4)

The Dunning Process was first used in Merian C. Cooper 1933 movie *King Kong*.

The previously mentioned techniques were able to work only for the black and white movies; therefore, the travelling matte technique needed an adjustment with an arrival of the colour film. Larry Butler, special effects' artist, came with a solution in his 1940 fantasy movie *The Thief of Baghdad*. Butler's movie was the first colour movie which used chroma key process and was widely admired for its special effects. Those special effects were achieved by using three strips of a film (red, blue, and green). Bialik (2012) describes in her article the process as follows:

> Butler could arrange the original negative and newly printed positive strips so that the blue negative and green positive strips would create a solid matte. This would be composited with new footage shot against a blue screen. All this was run through an optical printer so that the final film print would include the composited foreground and background (*Keyed Out, Coloured In: Chroma Chromatic Dreams).*

The disadvantage of the Dunning process was its time demand. Each shot had to be composite separately. It also featured an undesired thin blue line around the subject.

1.1.5 Sodium vapour process

This technique was developed in the 1950s as an alternative to the Dunning ("Blue" screen) process and widely used by The Walt Disney Company throughout the 1960s and 1970s. The process utilises a combination of the sodium vapour lights, sodium vapour prism, and three-strip technicolour camera. An actor, subject, is filmed in front of a white screen lit by the sodium vapour lights. The yellow light, emitted at a specific wavelength, is captured by the black and white film as the travelling matte (Foster, 2010, p. 8). "The lens in front captures the image, a prism deflects the sodium light frequency off at an angle onto the black and white film, and the colour information continues straight on through to the colour film" (Foster, 2010, p. 12) (Fig. 5).

Unlike the Dunning process, this technique did not have any problems with matting of hair, smoke, and motion blur. However, the Dunning process prevailed because only one sodium vapour prism was developed.

The sodium vapour process is responsible for the most advanced special effects at that time. Thus created effects can be seen in movies such as *The Parent Trap (1961), Pete's Dragon (1977),* and probably the most famously, *Mary Poppins (1964)* (Fig. 6).

1.1.6 The colour-difference process

Petro Vlahos was responsible for creating the only functional sodium vapour prism, which he sold to The Walt Disney Company, and he is also credited for an improvement of a blue screen (*Hollywood's History of Faking It | The Evolution of Green Screen Compositing*). In the late fifties, he developed a process known as a colour-difference system for the 1959 movie *Ben Hur*. The process works on a principle of how the black-and-white separation positives are printed from the camera colour negative. The blue screen is captured as black by the red record and as dark grey by the green record. The blue record captures the blue background as clear. Vlahos then used a complex combination of those records to create different mattes (Fielding, 2013). Together, twelve different film elements were required to get the final image (Fig. 7). This process was time-consuming. On the other hand, it immediately solved all the problems regarding the blue screen.

It was successful and laid the foundations for every subsequently developed green or blue screen technique. For example, the same process was employed by Richard Edlund for creating the memorable scenes from the 1980 movie *The Empire Strikes Back* with just an addition of a microprocessor for better accuracy and speed.

1.2 Contemporary utilised technique

1.2.1 Technique overview

"The chroma key process designates a single, very narrowly defined colour in one video image and electronically replaces that colour with a second image, leaving the rest of the picture untouched" (Stinson, 1998, *The Chromakey Genie*). The misconception arises from the fact that the green is the most often used colour for the background. However, the colour behind the filmed object is not limited to the green parts of the spectrum only.

In fact, any colour can be used for chroma keying. The only important factor is the contrast between the screen and an object which ensures seamless compositing during the post-production (Peters, 2013). Clear-cut scenarios are rare. Modern scenes have a wide colour spectrum, and it is an uneasy task to select the proper screen colour. However, a new generation of key programs provides one essential advantage. The programs do not rely only on the differences in the colour but also in luminance. Thus, the filmmakers can utilise the green screen even in scenarios where a lot of the green colour appears. The green screen is the most utilised as the result of several advantages it possesses.

1.2.2 Why green screen over the blue screen?

The first advantage is that the image sensors in the digital video cameras are more sensitive to the green. That is because the vast majority of current colour digital cameras utilise RGB (Bayer) filter. The filter consists of 3 sub-filters, each transmitting light of one wavelength – red, blue, or green. These sub-filters are arranged in a regular grid. A number of the elements transmitting green is twice as high as a number of the elements of the other colours. The greater number of the green elements reflects the characteristics of a human eye which is the most sensitive to this colour (Foster, 2010, p. 18) (Fig. 8). Due to this fact, the recording resolution of the green channel is double the resolution of the other channels. The green channel is also the cleanest channel in most currently used digital cameras. Additionally, the green channel has the highest luminance of all three digital channels, and thus the sensors deliver the least noise (Foster, 2010, p. 20) (Fig. 9).

Another advantage of utilising the green screen is its contrast with the human skin and clothes. It is not typical for the actors to wear bright green clothes; thus, it precedes issues with a replacement of undesired objects, such as jeans or actors' irises. However, this effect can be utilised in the scenes where the filmmakers want to achieve a partial or complete invisibility of an object. This effect was, for example, used during the filming of an invisibility cloak in the Harry Potter series.

In this case, the actor Daniel Radcliffe wore a cloak with a common obverse and green reverse (Fig. 10). When he was on the set wearing the cloak normally, nothing happened. However, when he put the cloak inside out, the green colour of the cloak was in the post-production keyed out and for the audience, it seemed as he turned invisible (*Harry Potter Invisible Cloak Tutorial: PopFX 006*).

1.2.3 Lighting

For utilising the technique perfectly, the aim is to light the scene as evenly as possible. Hours of the post-production can be saved by an appropriate arrangement of objects and lights.

Lighting process can be divided into two parts: the screen and the subject. Any variation in the lighting may result in a shadow and subsequently a darker colour to the camera. In the post-production, this colour might not be registered for the replacement during the keying. Even lighting can be achieved by a combination of the light sources, appropriate screen surface, and sufficient distance between the object and the screen (Foster, 2010, p. 72). An effective approach is to utilise softboxes. Their soft light beams cast evenly spread light; hence, the threat of creating undesired shadows is smaller.

The other important part of the lighting is to light the subject independently of the screen. A position of the object should be further from the screen to avoid casting shadows across the screen. Another advantage of the further positioning is that it prevents the reflection of the coloured light from the screen back onto the object. “Reflected spill light can rim your object in a tinted halo that can be difficult to discern with the naked eye” (Peters, 2013, *How does the green screen work?*). However, the reflected light can cause troubles during the post-production phase because the greenish objects may be keyed out.

1.2.4 Surface of the screen

The surface with the lowest reflection is required. Shiny materials are not appropriate because of their high reflection. A portion of the reflected light causes brighter and darker areas to the camera. There are several options from which the filmmakers can choose.

The first option is to paint the background of the scene using a chroma key paint. The disadvantage of the painting is that it is permanent, time-consuming, and labour intensive.

The second option is to hang the screen. There is a wide variety of materials from which the screen can be manufactured. The most commonly used material is the foam backed fabric because it possesses many advantages *(Hollywood's History of Faking It | The Evolution of Green Screen Compositing*).

It is composed of a three layer laminate design: foam core centre, nylon mesh backing, and chroma key diffusion face. The bottom two layers ensure durability, an ability to stretch, and also bounce back from wrinkles. The face layer is to evenly scatter the light, and thus eliminate the threat of hotspots (*Chroma Key Green Foam-backed screens*).

Another option is to use a foldable chroma key screen. This equipment is primarily utilised for small outdoor sets where building a large green screen would be a waste of resources. For example, it can be used in a situation when filmmakers want to achieve an illusion of a moving car (Fig. 11).

1.2.5 Motion tracking

In the living environment, there is plenty of trackable things. However, this can be a problem in the case of the green screen; therefore, a presence of tracking markers is inevitable. On account of their presence, software is able to track the movement, and thus create realistically looking moving scene (Foster, 2010, 179). Just the presence of the markers is insufficient. The tracking markers have to be parallax for the software to be able to recognise the movement. There are several important properties the markers should possess for utilising them in a sufficient way. Those properties are colour, shape, placement, and density (*How To Place Tracking Markers Part I*).

1.2.5.1 Colour

The most appropriate colour for the software would be white or black due to its high contrast with the green screen. However, white and black markers would be complicated to key out during the compositing; thus, another colour has to be selected. The filmmakers can use the blue colour and key out both colours gradually. However, usage of two chroma colours may result in a situation where markers remain visible even after the keying process (Fig. 12).

The second approach is to use the markers with the same colour as the screen but with a different shade. If the shade is a one-half level above or below the shade of the screen, the software should not have any problem to key the markers out during one keying process (*How To Place Tracking Markers Part I*).

1.2.5.2 Shape

It is necessary for the markers to possess a corner with a pointing end. The software is then able to track the zooming and rotations. Dots, for example, are unusable since they are rotationally independent and while they are zoomed, there is no visible steady point the tracker could stick to. However, these properties are utilised in the motion capture of the body movement, facial expressions, or other subjects. This topic is discussed later in the thesis. None of the marker's shape is considered to be the ultimate. The shape and placement of the markers depend on the scene layout or filmmaker's preferences.

When the camera moves a lot, the angle from which the scene is shot continuously changes. Triangles with an inverted triangle inside are the most common option because of their low dependency on the angular change (*How To Place Tracking Markers Part I*).

1.2.5.3 Placement

Some filmmakers prefer a method of an even marker placement. It can be defined as the placement of same shaped markers in a regular grid (Fig. 13). The others can use a combination of the grid and a random placement. The grid layout is important for a scale of the scene. The scale determinates a ratio between the green screen scene and the post-productively added background. The space between the grid markers is filled with the randomly shaped markers (*How To Place Tracking Markers Part II) (Fig. 14*).

1.2.5.4 Density

For the sufficient motion tracking, at least seven markers have to be visible on each shot. Thus, it is apparent the wide shot requires a smaller number of markers than the close shot. The seven markers rule can be sometimes hard to achieve, especially in the scenes where details of the subject are being filmed. In such cases, part of the subject, for example, mouth corner can be used as the tracking marker (*How To Place Tracking Markers Part II*).

2 Motion capture technique (MoCap)

The chroma key results in the creation of magnificent backgrounds, magnificent sceneries. However, the pivotal point of every movie is not the environment, but the characters and the story around them. The actors play human beings in the vast majority of the movies. However, if the filmmakers want to bring fantasy or sci-fi creatures to life and make them seem believable, they need to use the motion capture technique to give those creatures human traits, and thus help the audience to better identify with those creatures. Being able to see the creature with human mimic helps the audience to understand its motives and decisions. When Andy Serkis, most famously known for his Gollum role in *The Lord of the Rings* series, was asked in the interview with *The Guardian* to share his opinion about the motion capture technique he said:

> Performance-capture technology is really the only way that we could bring these characters to life. It is the way that Gollum was brought to life, and King Kong, and the Na'vi in *Avatar* and so on and it is really another way of capturing an actor's performance. That is all it is, digital make-up (*Andy Serkis: why won't Oscars go ape over motion-capture acting?*).

From the designation, it is easy to determine the main purpose of this technique. Menache (2011) describes the motion capture as follows:

> Motion capture is the process of recording a live motion event and translating it into usable mathematical terms by tracking a number of key point in space over time and combining them to obtain a single three-dimensional (3D) representation of the performance (p. 2).

The motion capture is often referred to as the "MoCap" within the film industry.

The variability of the captured objects is wide. Basically, anything that moves can be tracked and captured. Naturally, actors, whose body movement likewise facial expressions are captured, are the prime target. There exist different methods of how the motion can be captured.

2.1 Types of MoCap and overview of their operation

The MoCap can be divided into three main groups. Groups' designation varies. Kitagawa and Windsor (2008) designate the groups according to devices every particular type utilises as magnetic, mechanical, and optical systems. Whereas, Menache (2011) designates the groups according to the position of those devices as inside-out, inside-in, and outside-in systems.

An outside-in (optical) system uses sources directly placed on the object. The transmitted data are received by external sensors. The most common example of this system is camera-based tracking devices.

An inside-out (magnetic) system uses a reverse procedure. The sensors are placed directly on the body and receive data from the external sources. This type utilises transmitters and receivers.

An inside-in (mechanical) system has both capture sensors and sources placed on the body. This type of the MoCap uses a specially designed mechanical device often referred to as an exoskeleton.

2.1.1 Magnetic motion capture systems

The magnetic motion capture systems utilise a combination of the orthogonal coils and sensors. The sensors are placed on the subject, most commonly on the joints, and capture a low-frequency magnetic field created by the coils. The sensors and coils are connected to an electronic control unit which is able to calculate position and rotation of each particular sensor. The electronic control unit is interconnected with a computer which runs a software driver to represent the sensors in 3D (*Magnetic Motion Capture*) (Fig. 15).

The major advantage of the magnetic systems is an ability to display the results of the motion capture in real time. Even though the magnetic motion capture systems are cheaper compared to the optical systems, their disadvantages hugely exceed the advantages.

Firstly, the sensors have to be supplied by electricity, either by wiring or batteries. Both types of the power supply may lead to movement restrictions.

Secondly, even though the sensors of the magnetic system cannot be occluded by the subject or another non-metal object, the system can be affected by magnetic and electrical interferences caused by the metal objects and electronics in the surrounding environment. Those interferences may lead to the distorted result.

Thirdly, the magnetic system may have problems in the situations, where more captured objects appear close to each other. The signals transmitted by the sensors may interfere with each other. This may lead to another distorted result (Kitagawa & Windsor, 2008, p. 11).

2.1.2 Mechanical motion capture

The previously mentioned designation exoskeleton is derived from a specially designed device utilised by this system. The device consists of straight rods and potentiometers. "Straight rods are linked with potentiometers at the joints of the body, designed to measure joint angles as the captured subject moves" (Kitagawa & Windsor, 2008, p. 11) (Fig. 16). Apart from the exoskeleton, this motion capture system may also utilise data gloves and digital armatures.

The mechanical system possesses many advantages, such as the real-time display and low costs. It is also free of the occlusion, free from magnetic or electrical interferences, and highly portable. In the case of a wireless mechanical system, they even produce large capture volumes. On the other hand, the mechanical system features two major disadvantages.

It does not contribute well in a situation where the actor moves a lot alongside a vertical axis. If the actor jumps up or walks up the stairs, the real-time projection will show no or slight change in the movement. An increase in the number of the magnetic sensors can solve this problem.

Another disadvantage lies in the movement restrictions. Mechanical joints are not flexible. Thus, some moves can be hard to perform, and in some cases, the captured movement may seem unnatural. Also, the durability of the device does not enable shooting of some action scenes.

2.1.3 Optical Motion Capture Systems

As was mentioned above, the optical systems combine the markers (sources) placed directly on the captured subject and the digital cameras (sensors). There are different methods how the optical motion system can capture the markers' motion. The difference in those methods lies in the utilised markers. Kitagawa and Windsor (2008) divide optical systems into two subgroups: passive and active. However, in the contemporary cinema, a new type of a markerless motion capture starts to be used.

2.1.3.1 Passive

A reflective material forms a surface of the passive markers. Infrared diodes are attached near the camera lens (Fig. 17). The markers then reflect the light emitted by the diodes, and thus the motion of the markers is captured. The most utilised shape for the passive marker is a ball of an average size from 2 cm to 3 mm because of its rotational independence. The ball shape also possesses sufficient reflection from different angles (Fig. 18). The passive markers can be adherent directly on the subject or velcroed to a spandex or lycra suit designed specifically for the motion capture. The advantage of the passive optical system lies in the camera adjustment which enables to sample only the reflective markers. It is then less complicated to create a skeleton of the subject which is better for CGI (computer-generated imagery) modulations (Kitagawa and Windsor, 2008, p. 8).

2.1.3.2 Active

In the active marker systems, the markers themselves are LEDs. Rather than reflecting light back to the camera, the markers emit own light which can increase the volume and distance for capture (Fig. 19). The markers placed on the subjects can either emit the light of the same colour or different depending on the fact if the filmmakers want to distinguish between them. The different colours enable the cameras to identify each marker by its relative position. The active marker system is used in situations when the passive marker system is not able to produce sufficient amount of high-quality data. The active marker system proved to be essential for the outdoor filming because the intensity of LEDs can be remotely controlled. Thus, the filmmakers are able to acquire high-quality data even in the environments where the light conditions change rapidly (Kitagawa & Winsor, 2008, p. 8).

2.1.3.3 Markerless

The markerless motion capture system is a recently developed method. This system does not require a presence of any markers. Instead, the markerless system relies on a specially developed software to track the motion of the subject (*What is motion capture?*). There is a couple of advantages this system has. No calibration is needed because there are no markers to track and also no occurrence of an occlusion is possible. The actors do not need to wear the specially designed suit which can cause them to feel uncomfortable, and thus can affect their performance in front of the camera (*Markerless motion capture*) (Fig. 20). However, the passive or active optical systems are currently more preferred by a vast majority of the filmmakers because of their accuracy. On the other hand, the rapid development of the markerless method nearly assures that problems regarding this system will be solved, and thus the markerless technique will become superior in the near future.

2.1.4 Facial motion capture

Bringing the most believable characters to life requires proper capture of the facial expressions. The data then has to be transferred into a graphic system as accurately as possible. Techniques used for those purposes are based on the optical motion capture but present a greater challenge. Even the smallest facial movements of eyelids, lips, and brows have to be captured. Both marker and markerless tracking systems can be utilised. However, the marker systems are preferred due to the better accuracy as was mentioned above.

The marker-based facial motion capture utilises the same procedure as the optical motion capture of the body. Instead of having dozens of the markers on the body, the actor has to have up to hundreds of the markers directly on the face (Fig. 21). The markers are small dots, large approximately from 2 to 3 mm, either glued to the face or painted by a specially developed make-up. As in the case of the body motion capture, the markers can be passive or active (Kitagawa & Winsor, 2008, p. 154). All markers are in most cases captured by one high-resolution camera which is attached to a helmet. The helmet is specially designed for the motion capture purposes, and thus it does not restrict or cover any facial movement (*ProHD Headcam System*).

3 Computer-generated imagery (CGI)

Computer-generated imagery is an inseparable part of the contemporary cinema. Almost every blockbuster has at least one scene modulated by a computer.

In the first part, the thesis will briefly discuss a history of the CGI in order to make the discussed topic more familiar to readers.

In the following part, the thesis will deal with a contemporary used animation software and will briefly discuss individual steps of the animation process.

3.1 History

It is not an easy task to mark the origin of the CGI due to the rapid technical development throughout the 20th century. The history is closely connected with the history of the computer itself. Hence, the first mentions about a computer graphics date back to the 1960s.

Computers had already been in development, but in 1963, a radical new concept was presented by the mathematicians at Massachusetts Institute of Technology (MIT). Today, this concept is known as interactivity and is considered to be a massive breakthrough since which the computer development escalated.

The interactivity was achieved due to the innovative program called Sketchpad. Sketchpad was developed as a design tool. In a nutshell, the computer had a pre-programmed set of rules. By applying those rules on a basic sketch drawn by an animator, the computer was able to figure out the rest of the image. In the late sixties, varieties of Sketchpad were widely used in the automotive industry. These programs were able to achieve much more sophisticated images but the main restriction was that they were able to work only in 2D (*History of Computer Animation – P1)*.

3.1.1 Nineteen-seventies

The 1970s were a huge leap for the computer graphic. Firstly, tools necessary for three-dimensional animation were invented; hence, completely new possibilities how to animate the images and how to modulate them appeared. The advantage was that the computer was able to do both processes. This meant that instead of drawing every single image independently, as in the case of the cel animation which was slow because every image had to be drawn by hand, the animation could be done much faster and the images were indistinguishable one from another.

Secondly, as I mentioned above, the history of the CGI is closely connected with the history of the computer, and thus the animators and filmmakers were limited by the memory capacity. This situation changed completely in 1971 when Intel launched sales of its new revolutionary microprocessor which meant a video output for the animations (*History of Computer Animation – P1*).

3.1.2 Utah teapot

Behind the 3D animation tools, there is a story which took place at the University of Utah in the late 1970s. A computer graphics researcher Martin Newell was with the help of his team determined to find a way how to recreate a simple object in a computer environment. The goal was to create a three-dimensional representation of an object which would appear to be completely realistic. The chosen object was a teapot and as it turned out, it was the best choice they could have made.

This was due to the fact that the teapot has lots of different types of shapes. "It is round, contains saddle points, has a genus greater than zero because of the hole in the handle, can project a shadow on itself, and looks reasonable when displayed without a complex surface texture" (*Utah teapot*).

The first step was to recreate the teapot as a wireframe in a 3D vector graph. The procedure continued by removing vector lines which would be obscured by the teapot surface in the case that the teapot was real. Further, a process called faceted shading had to be applied to simulate how the light reflects off surfaces. The faceted shading was essential for the research because the light turned out to be the key to making an object to appear more realistic. The facets were smoothed over to make the shading look continuous. Next, the computer was used to calculate the position and brightness of highlights distributed across the teapot surface with respect to the light source. Then the researchers developed texture mapping, and thus were able to change the colour of the teapot. Once the texture mapping was in place, Newell's team was able to use a technique called bump mapping to create bumps and wrinkles across the teapot surface (*History of Computer Animation – P1*).

They programmed a sophisticated mathematical algorithm. The resulting teapot was almost indistinguishable from real one. This research laid fundamentals of the CGI we know nowadays.

3.1.3 Evolution of animations after the 1970s

Advertising agencies were the first who saw the potential in the CGI. In the beginning, the aim was to animate the whole scenes but later on a new concept was introduced. In the late 1980s, the directors discovered the potential of combining the computer-generated images with real-life shots to create lifelike images. This method required utilisations of the green screen and motion capture techniques which are both discussed earlier in the thesis.

The Walt Disney Studios were the first which attempted to create a movie featuring the combination of the computer-generated imagery and real time action in the 1982 movie *Tron*. The production of the movie was enormous. The 17 million dollars spent on the movie; including 4 million dollars spent on the CGI alone, meant that *Tron* was one of the most expensive movies at that time.

The technological side of the movie was marvellous. However, the poor storytelling and plain characters were a source of the criticism. Even though *Tron* found its audience, many people were not interested and in the end, the movie was a box office disaster. The main criticism was that the CGI had no soul and that the computers were unable to create characters with whom audiences could have an emotional involvement.

After this unsuccessful debut, the Walt Disney Studios returned to the traditional 2D animation. However, other Hollywood studios saw a potential in their work, and thus many of them employed at least one person from the team which was responsible for the *Tron*'s CGI effects. All they needed back then was a new software that could enable a creation of more realistic, emotional characters which would prevent problems troubling *Tron* from happening again. The animators were fortunate because it was not long until one Canadian-based software company came up with an animation software that could produce the most realistic digital effects and helped to bring computer animation onto a completely different level (*History of Computer Animation – P2*).

3.1.4 Alias software

In the late 1980s, a new animation software called Alias was introduced and unlocked the possibility to create the most realistic digital effects. The unlocked potential could be firstly seen in 1991 blockbuster *Terminator 2*. The stunning CGI effects were well-received by the public and the *Terminator 2* won an Oscar for its visual effects in 1992.

Two years later in 1993, the updated version of the Alias was used during the production of *Jurassic Park*. This time, instead of the time-traveling killing robot, the CGI effects were used to bring dinosaurs back to life. *Jurassic Park* also won an Oscar for its visual effects (*History of Computer Animation – P2*).

3.1.5 Maya

All the movies utilising the CGI at that time had one thing in common; the combination of the CGI and real-time action. The reason for this is that there was no software which would be able to animate everything from an environment to characters. However, this changed with the introduction of a new animation software.

Maya, developed on the basis of the previously utilised Alias, was much more complex software. However, its user interface ensured an easier creation of animations and its updated versions are used in the contemporary cinema.

The first fully animated movie, which featured realistically looking humans, was 2001 movie *Shrek*. Three hundred animators worked for four years to create well over 1000 computer-generated images. There were attempts to create fully animated movie before, but *Shrek* was the first feature film with characters that were truly alive, characters that were able to speak dialogues and express complex emotions. It was important that the audience could experience the story with the characters, to sympathise with the characters, and to care what happens to them. To do such a movie was a big risk. The long production meant a lot of pressure and spending all the resources to create another box office disaster simply was not an option. Fortunately, all aspects worked out well and in the end, *Shrek* was a big hit. It was seen as a milestone in the development of the computer animation and laid the fundamentals of the CGI we know nowadays (*History of Computer Animation – P2*).

3.2 Computer-generated imagery today

Times, when the animator had to the use command line to create a cube are long gone, and nowadays all animations are created via modelling software. There is plenty of programs which are currently used and the choice depends only on animator's preferences. Probably the most recognised 3D modelling programs are Maya, Blender and ZBrush. The advantage of mentioned programs are built-in modelling tools and organised user interface. Theoretically, everyone who is interested in 3D modelling and has sufficient computer literacy is able to utilise such software and with its help create basic models and animations. This is due to the fact that the modelling and animation are classic examples of the Bushnell's law; thus, it is easy to learn but difficult to master. Hence, in a nutshell, everyone is able to create model after completing the basic tutorial. However, to create realistically looking animation which can be used in a movie requires years of practice and the animations itself requires hours and hours of work.

Regardless of the skill and experience, every animator has to go through individual steps in order to create good looking, or even realistic animation. Those steps are Modelling, UV Layout, Texturing, Lighting and Rendering, Rigging and Skinning, and finally Animation. Following part of the thesis will be divided according to the mentioned steps. Each step will be briefly described to explain its function in the 3D world.

3.2.1 An idea, imagination, and research

Before any modelling can begin, it is essential for the animator to imagine how the animation should look like. Not only this helps to finalise the idea but the animator can also prevent possible obstacles regarding the animation he or she would otherwise find out later during modelling. Watkins (2012) in his book puts the greatest emphasis on a research part. He describes himself as a big fan of proper research and emphasises the importance of doing the hard conceptual work on paper before working digitally.

> There is simply no “Make Great Animation” pull-down menu. There are rarely happy accidents in 3D; every frame is a hard fought battle and is the result of many choices made along production pathways that culminate in the finished, rendered frame. (p. 4)

Drawing of sketches based on the proper research provides suitable fundamentals and ensures high-quality animations which invest time into every minor detail.

3.2.2 Modelling

Since every minor detail was considered and the sketch was drawn, the animator can proceed to the next step, modelling. Every animator has three options how to create the desired model.

The first option is via sketchpad. Even though the animators are able to create spectacular images with the usage of the sketchpad, this device is used primarily for 2D graphics. Therefore, it does not have much space in the contemporary film industry, since everything revolves around 3D these days.

The second option is to download the model from online 3D model libraries. This option is widely utilised nowadays due to the fact that the animator can skip almost whole modelling process and focus all of his or her time on texturing and animations.

The third option is to utilise modelling tools given by the software to create own unique model. Watkins (2012) describes this option as "the process of assembling the building block of 3D forms (called polygons) into shapes that define volume and shape" (p. 5). The result of such modelling process is a grey combination of polygons. The variety of shapes which the polygons can achieve is wide. From a simple object such as a tennis ball to complex one such as a character (Fig. 22). The whole process of modelling may sound simple, but the modelling is one of those processes where the difference between the beginner and skilled animator is significant. Even though the beginner may be able to create a similar object at first sight, the choice of polygon distribution will be certainly different. Poor choices regarding polygon distribution may affect the rest of the animation process. In some cases, the whole model can be discarded just only because it is not suitable. A proper number of polygons is essential to create an appropriate model which will function. A small number of polygons may result in a state where the model is not able to withstand higher resolutions whereas, a large number of polygons needs more time for animating and rendering (Watkins, 2012, p. 5).

3.2.3 Texture

"The basic idea is that texturing a model is the process of defining the surface attributes of that model" (Watkins, 2012, p. 7). The texturing is a process where the colours are assigned to the model and surface properties such as roughness or smoothness, for example, are defined (Fig. 23).

The texturing process can also be used to create surface deformities. Scars or bullet holes can be created with the usage of painted textures to avoid complex and time-consuming modelling.

3.2.4 Rigging and Skinning

"Rigging and skinning is the process of creating organization or deformation objects that allow a geometric form to be manipulated and animated" (Watkins, 2012, p. 7-8). The process is often used to create skeletal structure, and thus give the model, which has the appearance of a character, the ability to move the joints (Fig. 24). However, this process can also be used for non-organic things to enable rotations or any other kind of required movement.

In practice, data gathered via motion capture are used for mapping the skeletal structure. Usage of the motion capture provides realistically looking movements and gives the character weight. To create a character which appears to have weight is a challenge for every animator considering only pure animation.

3.2.5 Animation

The animation is probably most exciting and most difficult part which can last an unmeasurable amount of time. “When I am doing character animation, if I can get a good 2 or 3 seconds of acceptable finished animation done in a day, I feel pretty good about my progress,” wrote Watkins (2012, p. 8) when discussing the topic of the animation.

To bring the character to life and animate believable moves and emotions in a way that the audience is not able to determine whether it is an actual actor or just the pile of polygons is a hard task. This is the reason why 3D-animated feature films spent months even years in the production and post-production phase. The common frame rate of the movie is 24. This means that the animator has to go through 24 individual frames to fully animate one second of the movie. Every frame has to be precisely animated and the transition between the frames has to be smooth to prevent the animation from appearing to be staggering. The animator has to take into account every detail because that is the thing about animations (Fig. 25). If everything works out well, the audience may not even notice that what they have just seen were animations. However, one missed detail can result in spoiling the scene and in most cases it is the first thing which catches the viewer’s attention (Watkins, 2012, p. 9).

3.2.6 Lighting

As was mentioned in the chapter above when the thesis dealt with the history of the CGI, the lighting is the key component for the animation to appear realistic. Proper lighting, shadow and reflection ensure realistically looking animation which is hard to distinguish from the real object (Watkins, 2012, p. 9) (Fig. 26).

3.2.7 Rendering

It is a process when the computer calculates all the elements together; such as light, textures, and movement, to create the final image. It is only at this stage that the filmmakers see whether a sequence works or not. The more complex the shot, the longer it takes to render. The 86 minute long movie like *Shrek* took 100 million hours to render with 500 computer servers working around-the-clock (*History of Computer Animation – P2*).

Rendering is usually the last step after which is the animation transitioned to post-production and editing.

Even though the whole animation is a sequence of processes dependent one on another, it is important to mention that the animator can skip between them. For example, if the animator discovers during the animation process that the model is not able to perform desired poses, he or she can go back and edit the model structure or expand the model by additional manipulable points. The same holds for the texture changes. It can happen that in the post-production phase, the filmmakers decide it will be better for the animation to have different colours. The currently used software programs enable the filmmakers to change the colours without risking a loss of the already animated motion.

4 Impact of the contemporary utilised technologies on the film production

This chapter of the thesis will deal with the impact the technologies mentioned above have on the film production. The explanation of the film production will be provided because the term is wide and not everyone knows what it includes.

The film production includes everything from an initial idea, through casting and shooting to final editing and releasing. Since it is an extensive process, every production is separated into phases. The three main phases are pre-production, production and post-production. It is worth to mention that the film production also includes phases such as insurance of the property and staff or scheduling. However, those phases are either narrowly or not at all connected with the topic of film techniques; thus, the thesis will not deal with them.

4.1 Pre-production

When a filmmaker has an idea in his or her mind, one of the first things he or she has to do; assuming all necessary materials for the movie had been finished, most importantly a screenplay, is to find a producer who will raise finances. After raising a sufficient amount of finances the idea can be realised At that point, the pre-production phase starts. Eve Light Honthaner (2010) describes the pre-production in her book as "the period of time used to plan and prepare for the shooting and completion of your film" (p. 95). This phase includes everything from the casting to producing a final screenplay.

Finishing the screenplay is an important part of the pre-production phase because it gives a film crew possibility to create a shooting script. The shooting script can be imagined as a manual in which every scene is described in detail and is used as the main basis for shooting. Thus, the film crew can decide, for example, whether it will be better to shoot in the studio or outside. Since the visual effects are part of almost every contemporary produced movie, the film crew has to decide which techniques they will feature in the movie and which equipment they will require.

4.2 Production

The production of the movie is the period of time used for shooting. The biggest impact the contemporary used technologies have is in this phase. The whole sets have to be specially designed for the techniques to work appropriately and to avoid undesired complication in the post-production phase (Honthaner, 2010, p. 157). In this particular thesis, the production phase considers only chroma key and motion capture. The CGI animations are created mostly in the post-production phase.

4.2.1 Impact of the chroma key

The chroma key technique impacts the production in several ways. The filmmakers have to decide which colour of the screen will be the most sufficient for the upcoming scenes. Furthermore, they have to realise even illumination across the established screen and set up proper motion capture makers to enable graphical editing during the post-production phase.

Since the thesis has already dealt with this topic in the chapter focusing on the chroma key and its correct utilisation no further details will be provided.

4.2.2 Impact of the motion capture

When the filmmakers want to utilise the motion capture technique in the movie, the first thing they have to do is either build or rent a motion capture studio. Every studio is equipped with hundreds of cameras. The selection of the cameras, as well as other equipment, depends on the utilised type of the motion capture. The optical motion capture is the most utilised type of MoCap in the contemporary cinema. Before starting either type of optical motion capture, active or passive, it is essential to calibrate the optical system and determine if the placement of the cameras is sufficient with respect to the markers. Since the optical systems can utilise hundreds of the markers and cameras for the detailed scenes where the motion of the captured character needs to be as accurate as possible, it is crucial to have a placement where every marker is captured by at least two cameras for sufficient 3D capturing. Although, three or more are preferred for better accuracy of the system (Menache, 2011, p. 19).

The major disadvantage of the optical systems is that the markers can be occluded by different objects or by another captured subject. This situation can be fixed during the post-production; however, in cases where too many markers are occluded, or the period of an occlusion is too long, it is impossible to recover data, and the scene must be re-filmed (Kitagawa & Winsor, 2008, p. 9).

4.3 Post-production

The post-production phase assembles individual pieces such as sound effects, filmed shots, and dialogues together to create a final version of a movie. These days, one of the biggest parts of the post-production phase is keying out the colour of the screen and providing the shot with CGI animations. In a case of the movies which were filmed in the real environment, the post-production phase can last a couple of months because the images require just little adjustments and the director wants to achieve the most realistic experience. On the other hand, there are movies for which the combination of above-discussed techniques is the focal point and the post-production phase can last several months, even years.

4.3.1 Impact of the CGI

Apart from already discussed procedures regarding CGI, almost every contemporary filmed movie utilises part of the CGI technique called colour grading. The colour grading is the process during which the animators digitally alter and enhance the colours to stress the image; thus subconsciously arouse different feelings in the audience. The colours can be, for example, brightened to achieve warmer and more pleasant feelings or darkened to cause mysteriosity or fear (Fig. 27). The animators can also alter only some parts of the image to highlight them, and thus subconsciously tell the audience where to look.

The colour grading is not used only for these purposes. During the outside shooting, the changes in sun position and weather conditions may result in different shades of colours. The digital colour grading brings consistency and helps to balance the colours in order to prevent problems which may occur during the scene cutting.

4.4 Impact green screen have on actor(s)

Hitherto, the thesis dealt primarily with the impact the utilised techniques have on the scenes. However, another important factor to consider is the impact the techniques have on the actors themselves. Sometimes, the actors are forced into a situation when they have to imagine they are under attack by some creature. Sometimes, they have to pretend seeing something unrealistic and impossible. But, there are situations which go far beyond that. In some movies, the actor is forced to imagine everything, the environment around him and most importantly the characters he or she is supposed to be talking to. The thesis will further provide an example of how stressful the acting in front of the green screen can be. The example is focused on the comparison between production phases of *The Lord of the Rings* trilogy and the newest adaptation of the Tolkien work, *The Hobbit*.

<u>4.4.1 Production of *The Lord of the Rings: Fellowship of the Ring (2001)*</u>

During the production of *The Lord of the Rings*, the filmmakers had to find out how to solve the height difference, the scale, between characters. The film crew tried many various techniques in pursuit of the best one. In the end, the problem with the scale was solved by a combination of body doubles, different sized sets, and forced perspective. “Every book in the bookshelf of Baggins, every piece of parchment, every prop had to be built perfectly to replicate two different sizes” (Jackson, 2001, *The Lord of the Rings: The Fellowship of the Ring Appendices*).

The forced perspective technique works on a principle that if one of the objects, both having the same size, is further from the camera, it appears to be smaller. The problem with the forced perspective is that it is suitable only for scenes with a static camera, and thus it allows only pan and tilt movement. Any movement with the camera would result in cancelling the illusion of different scale (Jackson, 2001).

The film crew invented a new technique which enabled camera movement around the horizontal axis to get the camera alive. They called it moving forced perspective shots and it included sophisticated props and precisely calculated camera movements to not spoil the illusion even during camera movement (Fig. 28). The whole technique is based on an idea that one actor is on a moving platform, the platform then moves relatively to the camera, and thus the illusion persists. This technique is challenging for the scene setups because it requires specially designed props and sceneries. However, both actors are on the scene at the same time, and thus the dialogues seem natural (Rygiel & Van’t Hul, 2001).

<u>4.4.2 Production of *The Hobbit: An Unexpected Journey (2012)*</u>

Since *The Hobbit* trilogy is approximately ten years younger and all the techniques advanced throughout the decade, Peter Jackson has decided that the scale difference will be solved via usage of the chroma key and CGI this time. This meant that Ian McKellen, who portrayed Gandalf in both *The Hobbit* and *The Lord of the Rings*, had to film almost all scenes alone. Every time in the movie when Gandalf and dwarfs appear side by side on the scene, he was standing there alone talking to no one during the shooting. After two days, Ian McKellen was mentally broke and was thinking about leaving the cast (Fig. 29). In the interview with *The Guardian*, he shared his feelings and said: “It was so distressing and off-putting and difficult that 'I thought I do not want to make this film if this is what I am going to have to do.' It is not what I do for a living. I act with other people, I do not act on my own" (McKellen, 2013, *The Hobbit's Gandalf almost proved a greenscreen too far for Ian McKellen*). From this expression, it is not hard to determine how big impact the contemporary used technique may have on the actors.

On the other hand, it should be mentioned that the impact the shooting in front of the green screen may have is rather individual. Ian McKellen belongs to the older generation of actors and is more used to the traditional acting.

From my point of view, if the actor is accustomed to acting in front of the green screen and does it for several years, the feeling is probably different.

4.5 Impact of the motion capture and to it connected CGI

Because the first impact was connected mostly with the green screen and how it can affect the actor psychologically, the thesis will feature another example. This part will be about the impact the techniques, and to its connected technologies, may have on the actor's further work and how the actor is perceived and recognised by the audience. Once again the featured example is based on *The Lord of the Rings* trilogy in order to follow the same template.

The lead cast members of *The Lord of the Ring* turned into superstars almost immediately after the premiere of the first film. It is more than likely the actors will be associated with those roles forever. This is a result of one simple fact. The actor and portrayed character resemble each other. Even though the character has costume and make-up, Legolas still looks like Orlando Bloom and Aragorn like Viggo Mortensen. However, there is one actor who appeared in all three films; yet, his name is not as recognised. The actor is Andy Serkis, and the reason behind is that even though people know the character, the difference between the appearance of the character and Serkis differ to such an extent they are not able to connect the character and its protagonist together. Andy Serkis did an excellent job in bringing the Gollum to life, and his performance is often hidden behind the motion capture and stunningly looking CGI animation.

It may seem this impact is also negative and speaks against the usage of the modern techniques and technologies; however, the opposite is true. For Serkis, the role of Gollum had changed everything. Even though he is not world-recognised as others, the roles utilising motion capture completely absorbed him. He played, for example, the leading role of chimpanzee César in the remakes of *Planet of Apes* and he also landed himself a role in the last and upcoming *Star Wars* movies.

Serkis enjoys playing characters with the usage of motion capture to such an extent that he currently owns a motion capture studio and works on own projects. Namely, the release of a new *Jungle Book*, which he directs and plays in, is set for 2018. During his interview with *The Guardian* was Serkis (2015) asked about his new project and how the other actors, who collaborate with him, enjoy motion capture technology:

> [For the actors] it's like being on stage or like being in rehearsal. They say the same thing: that there's no limit. Once they've got used to the technology, they feel they can do anything. The key to the new technology is its fidelity to the actor's performance, to the character. It's not a question of the actor being smothered by special effects. The exciting thing is that it liberates them, creatively (*Andy Serkis and the marvel of 'performance capture'*).

5 Impact of contemporary utilised technologies on the reception

The last part of the thesis will deal with the impact the contemporary utilised technologies may have on the audience. The impact will be once again mostly demonstrated on the difference between *The Lord of the Rings* and *The Hobbit* trilogies. However, another example will be included to demonstrate that the over-reliance on visual effect is not a problem regarding *The Hobbit* trilogy only. As materials for this chapter, the thesis will use reviews and articles from *The Guardian*. The reviews are written exclusively by the film critics. As another source, the thesis will feature reviews from websites *Rottentomatoes.com* and *Metacritic.com* to give a contrast between critics' and users' scores.

The trilogies will be used as a whole because the films are similar to each other more than it may seem at first look. Both trilogies were directed by Peter Jackson, took place in the same world, featured similar characters and were ended by a spectacularly looking battle. Despite the all stated facts how both trilogies are similar, the reception of both trilogies differs quite a lot.

The Lord of the Rings trilogy is one of the most successful movie series of all time. It was hit not only for the mainstream audience but also well-received by the critics. Each movie of the trilogy exceeds 90 % at *rottentomatoes.com* based on critics. According to the critics of *metacritic.com*, the films also deserve approximately 90 out of 100. In both cases, the critics' scores are almost identical to the users'.

The Hobbit trilogy tried to replicate the success of the original Middle-earth adventure. It took similar visuals and put them into a story which is not far from the original trilogy. Even though it may seem the filmmakers did everything correctly during the production of *The Hobbit*, it was not a big box office hit as was expected. All movies of the trilogy received mixed reviews. At the *rottentomatoes.com*, critics' scores are between 59 and 74 % which is above average, but the expectations were way higher. *Metacritic.com* features similar results. However, in the case of *The Hobbit*, there is a difference between scores based on critics and users. Still, a comparison of the third films' reviews shows that there are 106 negative and 63 mixed opposing to 2,045 positive reviews in the case of *The Return of the King (2003)*. In the case of *The Battle of the Five Armies (2014)*, there are 127 negative and 257 mixed opposing to 695 positive reviews. There are two main reasons behind this decline.

The first one is storytelling itself. Whereas the story of *The Lord of the Rings* is spread well over 1000 pages, *The Hobbit* is based on a single book approximately 300 pages long. The director Peter Jackson expanded the script with additional plots and characters to make it epic and give it a darker tone. However, the problem is that the original book is meant for children and the darker tone does not suit the story.

5.1 Exaggerated usage of CGI

The second reason is the excessive usage of the visual effects resulting in exaggerated passages and scenes which seem over-the-top even in the fantasy movie. Both trilogies feature passages which are similar to each other. In the following section, the thesis will discuss one pair of similarly conceived scenes in details to point out the differences and to arrive at a conclusion, why something that had worked in *The Lord of the Rings* did not work in *The Hobbit*.

For *The Lord of the Rings*, the filmmakers decided to realise the world with the usage of large-scale miniatures or bigatures. Shooting miniatures in 2D gave the filmmakers a possibility of cutting them out and use them for different camera positions. However, *The Hobbit* was meant to be shoot in stereo because of the 3D, and thus the usage of miniatures and bigatures was not possible. The cameras have to be locked down for stereo. This can be the problem during the post-production changes because the shots are not flexible. For the reasons of flexibility, the filmmakers decided to create everything digitally. This opened the possibility to manipulate with the scenes until the very last minute (Letteri, 2012).

The stereo also limits the filmmakers in the case of stunts. Since the perspective is apparent for the audience, the animators are not able to adjust just parts of the actor's movement, and thus the filmmakers were forced into the usage of digital doubles. "The scene may have started with the actor and as he is going through this incredible stunt you hand over to a digital double and hopefully the audience is not able to see the transition" (Letteri, 2012, *#163: The Hobbit: An Unexpected Journey*). For the usage of digital double, the animators had to create faithful models of actors with realistic texturing, geometry, and lighting which looks at least as the miniature. In the ideal case, the final animations are unrecognisable from the real protagonist.

In *The Lord of the Rings*, the Moria sequence works because the tension arises from simple action as jumping over a small distance without falling (Fig. 30). It is a simple goal with realistic and understandable threats. The scene gradually escalates as the conditions are becoming worse. The whole group is suddenly under fire from bowmen, the gap between stairs is becoming longer, and the group of heroes is under pressure of being killed by approaching horde of orcs. The orcs are rather hidden in the shadows than actually present on the screen, and the audience is aware of them due to the sound. That is something which works in the scene very well because the tension tends to be higher when the audience does not know what to fear.

In *The Hobbit*, the heroes find themselves in a similar situation. Previously kidnapped by orcs, the heroes are now escaping through Goblin-town which is a clutter of shoddy stairs and bridges. During the escaping passage, they are dispatching hordes of computer-generated orcs. (Fig. 31). The whole escaping passage ends with the scene when the heroes slide down the rock aboard of a wooden scaffolding and fall off a few meters high cliff. Instead of facing a realistic challenge, the whole action passage is exaggerated due to the excessive usage of the CGI. Therefore for the audience, it is difficult to feel the tension for the safety of heroes when the action scenes do not operate at any level of physics.

5.1.2 *Star Wars*

It is important to mention this problem does not relate to *The Hobbit* only. *Star Wars* trilogies are another good example of different production approaches. At the turn of the 70s and 80s the visual effects were limited, and thus George Lucas utilised practical effects for the original trilogies. Most of the alien characters were created using costumes and complex prosthetics. In cases of Jabba the Hutt or master Yoda, when the previously mentioned method was not possible to realise, the filmmakers had to create puppets and control them directly on the set. All ships, AT-ATs and AT-STs were models filmed against a blue screen, and every explosion was a practical effect (Fig. 32). The original trilogy was a huge success among the audience and the practical effects have a share in it.

For the prequels, George Lucas decided to abandon practical effects and rely on the CGI instead. The prequels were heavily criticised for over-relying on CGI (Fig. 33). The audience was not satisfied, and the animated character of Jar Jar Binks is probably the most hated persona in the *Star Wars* universe.

This is the reason why the fans were pleased to hear J.J. Abrams, director of the *Star Wars: The Force Awakens (2015)*, and Kathleen Kennedy, president of Lucasfilm, talking about their inspiration by the original trilogy and how they want to eschew CGI wherever possible. "We're looking at what the early *Star Wars* films did; they used real locations with special effects. So for [Episode VII] we're going to find some very cool locations, [and] we're going to end up using every single tool in the toolbox" (Abrams & Kennedy, 2013, *Star Wars: Episode VII to limit cheap CGI tricks and keep it real*). Later Kennedy (2013) added, "Using model makers, using real droids, taking advantage of the artwork that you can touch and feel – we want to do that in combination with CG effects" (*Star Wars: Episode VII to limit cheap CGI tricks and keep it real*).

Since these quotes are from 2013 and *The Force Awakens (2015)* has been released two years ago it is possible to discuss if those promises were fulfilled and how was the movie received in the end.

> There are obviously an enormous amount of CG effects in the film, and I can't wait for you to see the combination. But it was very important … that the film have a tangible, sort of authentic quality that you believed that these things were actually happening in a real space with real sunlight – if it was an exterior scene - or [that] we could build a big portion of a scene and not have anything be blue screen … (Abrams, 2015, *Is JJ Abrams headed to the CGI dark side for the Force Awakens?*).

Even though *The Force Awakens (2015)* featured a lot of CGI, a combination of digital and practical effects with a real environment ensured the visuals were not as debated and if so, mostly in a good (Fig. 34). However, the movie was criticised for its story which resembles the concept of *Star Wars: Episode IV – A New Hope (1977)*, and thus it was considered to be a safe bet.

5.2 How is the usage of CGI viewed by the audience

In this part, the thesis will compare actual reviews written by the film critics. It would be better to compare reviews written by the same critic since the reviews are a matter of individual opinion. However, the time period of ten years between releases proved to be an obstacle. Even though there are reviews written by the same critic, their content is focused rather on the characters and storytelling than visual effects.

As materials, the thesis will use reviews of *The Lord of the Rings: Return of the King (2003)* written by Roger Ebert, who became the first film critic to win the Pulitzer Prize for Criticism, and Peter Bradshaw, chief film critic at *The Guardian*. Regarding *The Hobbit*, the thesis will use a review of *The Battle of the Five Armies (2014)* written by Mark Kermode, chief film critic for *The Observer*, who also writes for *The Guardian*. Reviews of third movies are selected deliberately due to an amount of visual effects both feature.

The Lord of the Rings movies were one of the first to utilise CGI for the creation of stunningly looking environments and epic battles. The audience has never seen something like that before and reviews reflect this fact. Roger Ebert (2003) wrote: "Return of the King is such a crowning achievement, such a visionary use of all the tools of special effects, such a pure spectacle…" The end of his review is dedicated to, as he wrote, exhilarating visuals. According to his words, the final battle is kind of magnificent:

> We see men and even an army of the dead join battle against Orcs, flying dragons, and vast lumbering elephantine creatures that serve as moving platforms for machines of war. As a flaming battering-ram challenges the gates of the city, we feel the size and weight and convincing shudder of impacts that exist only in the imagination (*Lord of the Rings: The Return of the King*).

Throughout the review, Ebert seems amazed by what Peter Jackson and his team of animators were able to achieve with the usage of the CGI. The same can be said about Peter Bradshaw (2003) and his review in which he wrote:

> In Lord of the Rings, the computer-generated image technology found the perfect medium for the stunning new effects now possible. Technically it really is superb, with breathtaking landscape tableaux and setting, seamlessly meshing cyber-geography with the New Zealand locations (*The Lord of the Rings: The Return of the King*).

Bradshaw presents one important thought in this quote. Mark Kermode, in his review of *The Battle of the Five Armies*, stresses out exactly the same thought when he compares *The Lord of the Rings* with *The Hobbit*. About *The Lord of the Rings*, Kermode (2014) wrote following: "… Jackson was making game-changing use of computer graphics to blur the line between the "real" and the "imagined." Whereas in the case of *The Hobbit*:

> It doesn't help that Jackson shoots every meeting with a panoramic swirl which accentuates the virtual artifice; although once hailed as a potential successor to David Lean, Jackson's cinematic instincts are here singly overshadowed by a computer game aesthetic (*The Hobbit: The Battle of the Five Armies review – no more than a middling final from Middle-earth*).

In both quotes, the difference speaks for itself. Easily said, the combination of the real action and special effects will always seem more realistic than creating scene purely with the usage of the CGI.

Kermode also criticises the action scenes. Part of his review is devoted to a particular action scene which caused controversy even among the wide public. The controversy was once again due to the exaggerated usage of the special effects and how the CGI denies physical laws and creates rather ridiculously looking moments. The scene Kermode has in his mind is the one where Legolas leaps unfeasibly atop tumbling rocks. Firstly, he compares Legolas with Ezio from game Assassin’s Creed due to the weightless runny-jumpy-stabby style of combat and later he even exaggerates that by marking Legolas for Super Mario, “I half expected him to gather spinning gold coins en route” (Kermode, 2014, *The Hobbit: The Battle of the Five Armies review – no more than a middling final from Middle-earth*) (Fig. 35).

Fans and critics are not the only ones who see the difference between two trilogies. One of the former cast members, Viggo Mortensen, expressed his opinion about Jackson’s new movies and how they are overwhelmed by special effects. Here is a quote from his interview with *The Telegraph*:

> Peter was always a geek in terms of technology but, once he had the means to do it, and the evolution of the technology really took off, he never looked back. In the first movie, yes, there’s Rivendell, and Mordor, but there’s a sort of an organic quality to it, actors acting with each other, and real landscapes; it’s grittier. The second movie already started ballooning, for my taste, and then by the third one, there were a lot of special effects. It was grandiose, and all that, but whatever was subtle, in the first movie, gradually got lost in the second and third. Now with *The Hobbit*, one and two, it’s like that to the power of 10 (Mortensen, 2014, *Viggo Mortensen interview: Peter Jackson sacrificed subtlety for CGI*).

Conclusion

Many people these days share the opinion about practical effects being better. They criticise the contemporary film industry for not utilising them and instead relying on the CGI. Their opinion is that the computer-generated imagery looks artificial, and thus ruins the entire movie. However, there is one important thing to realise. The CGI is used almost in every contemporary movie, and the truth is that a lot of people does not even notice it. It is because good visual effects serve the story and characters. If the story is well written and the acting is good, the visual effects only enrich the whole movie. The way of getting great scenes has nothing to do with utilising only practical or digital effects. It is about understanding limits each technique have. The computers, for example, excel in rendering solid objects, such as furniture or buildings, whereas they have problems with the creation of human beings. On the other hand, it is expensive and time-consuming to build and consequently destroy cities, etc. The key is to understand the strength each technique has and supplement its weakness by other technique. The combination is, in most cases, the best possible result every filmmaker can achieve. This combination was mostly utilised in the original *Star Wars* trilogy as well as *The Lord of the Rings* trilogy and both came out on top due to the criticism of *The Hobbit* and prequels to over-rely on the visual effect.

However, there is one important thought. Are there any great movies with awful visual effects? Even in the older movies, where the practical and visual effects were far from perfect, the audience does not seem to mind. Maybe this is because people do not have much to complain about when it comes to a great movie. When the storytelling and acting are good, there is no need to complain about the bad visuals because the movie was still entertaining. Therefore, maybe the complaints about how the CGI ruins the contemporary film industry are not necessary a problem of the visual effects. Maybe it is just a problem with the movies themselves. The thesis already mentioned how Peter Jackson had to expand the original story of *The Hobbit* to make three films out of it. In the case of the *Star Wars*, almost every fan considers the *Episode I – The Phantom Menace (1999)* to be the worst movie in the series due to the storytelling and plain characters. The remaining two episodes are criticised for poor acting and ruining one of the most iconic villains, Darth Vader.

The thesis showcased that the visual effects have been part of the film industry since the beginning. The thing to realise is that the computers are just a tool which introduced new possibilities and it is up to filmmakers to use the tool wisely.

<u>Figures</u>

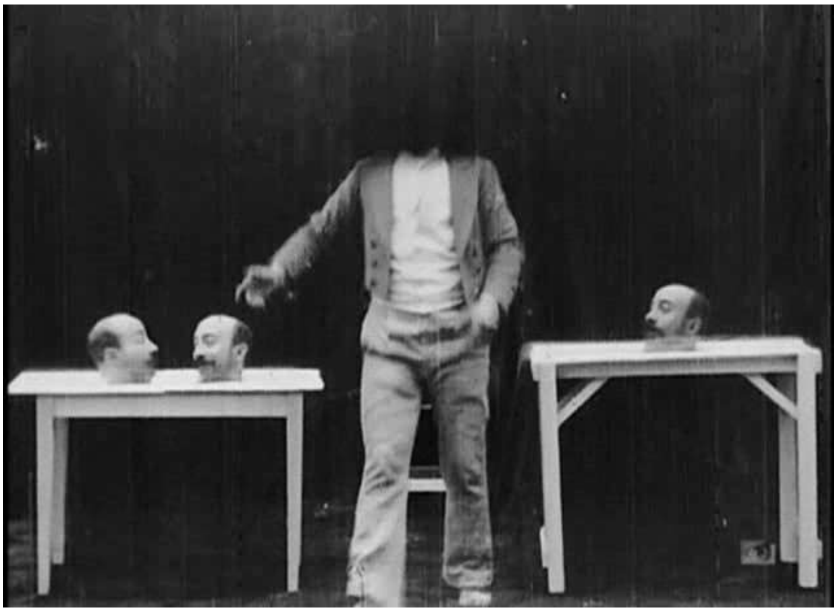

Fig. 1 The Four Troublesome Heads (1898)

Fig. 2 The Glass shot technique

Fig. 3 Sunrise (1927)

Fig. 4 Dunning Process

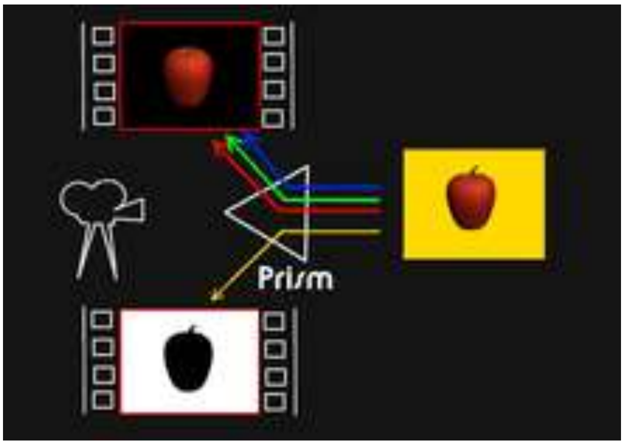

Fig. 5 Sodium Vapour Process

Fig. 6 Marry Poppins (1964)

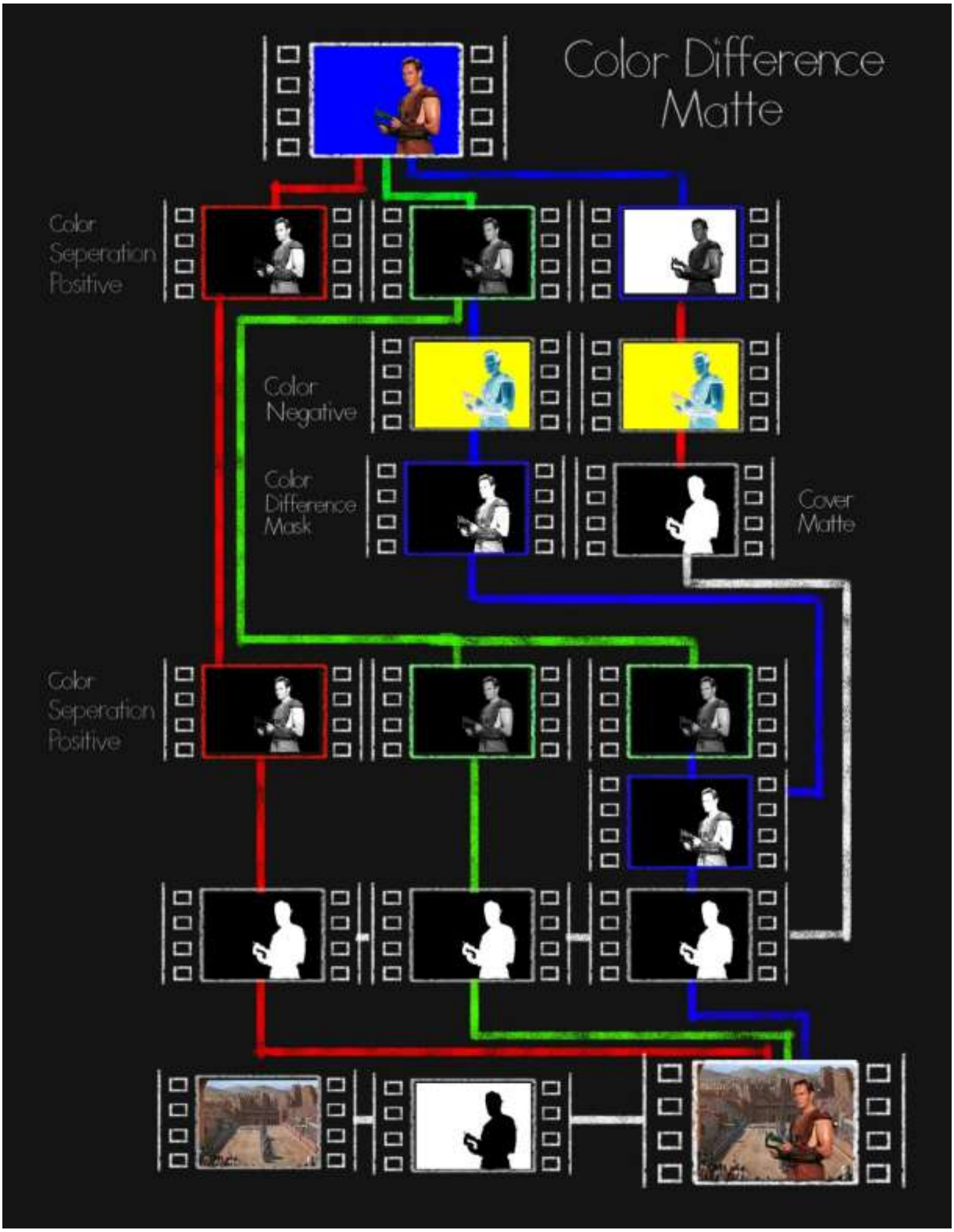

Fig. 7 Colour Difference System

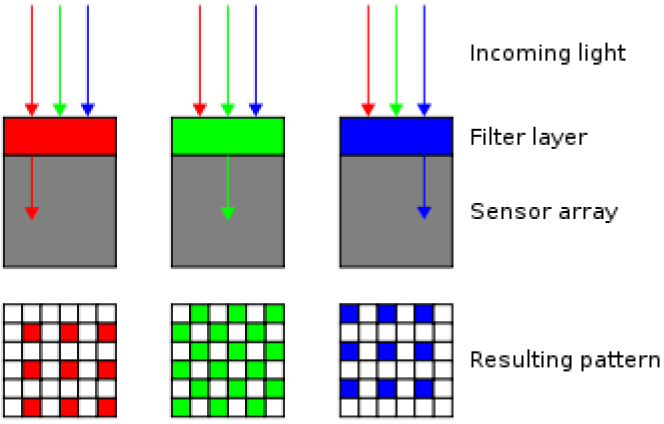

Fig. 8 Cross-section of Bayer filter

Fig. 9 Captured green screen image shown via channels (red, green, blue)

Fig. 10 Invisibility cloak

Fig. 11 Usage of Foldable chroma key screen

Fig. 12 Visible marker after keying out phase

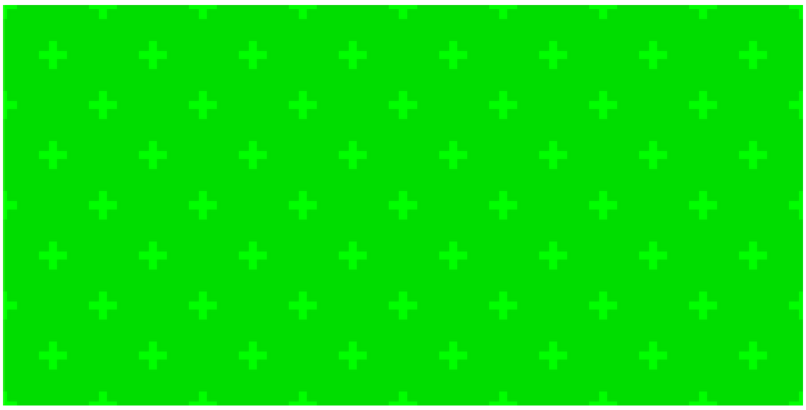

Fig. 13 Regular grid

Fig. 14 Random marker distribution

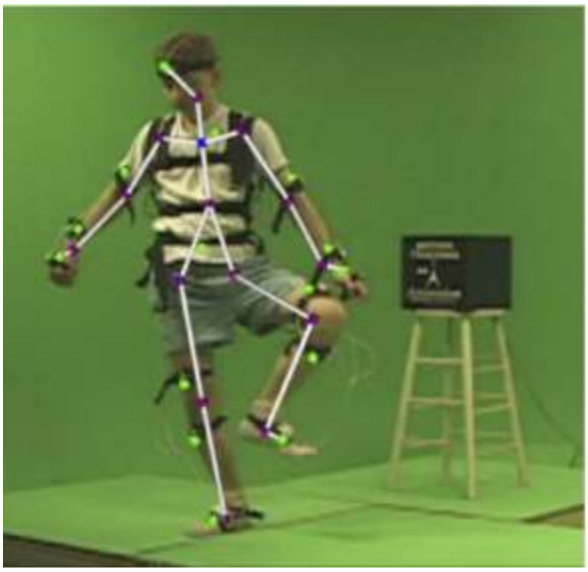

Fig. 15 Magnetic motion capture

Fig. 16 Mechanical motion capture

Fig. 17 Camera with infrared diodes

Fig. 18 Passive markers

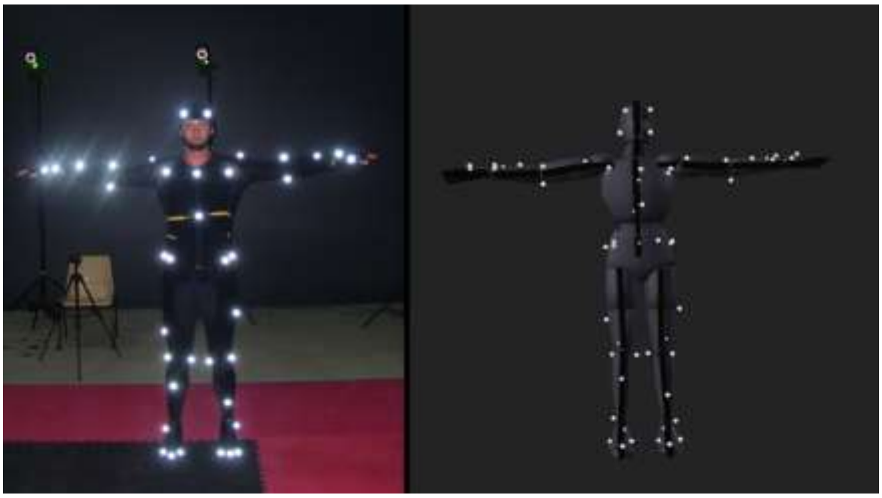

Fig. 19 Active markers

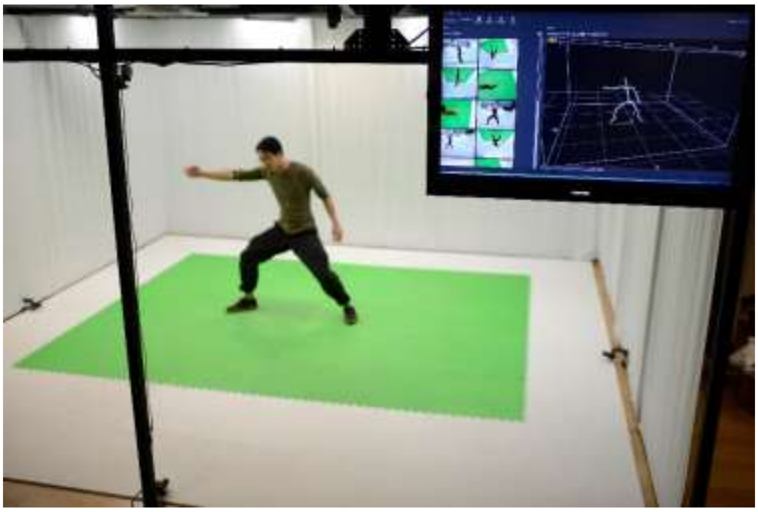

Fig. 20 Markerless motion capture

Fig. 21 Facial motion capture

Fig. 22 Character model

Fig. 23 Character with applied texture

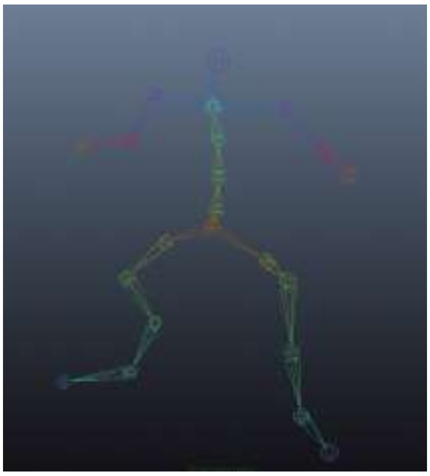

Fig. 24 Character's skeleton


Fig. 25 Animated character


Fig. 26 Animated character rendered together with lighting

Fig. 27 Colour grading (edited by Daniel Tetour)

Fig. 28 Scene utilising the forced perspective

Fig. 29 Scene utilising the green screen

Fig. 30 Action scene during escape from Moria

Fig. 31 Action scene during escape from Goblin-town

Fig. 32 Shooting of a tie fighter in front of a blue screen

Fig. 33 Star Wars prequels - behind the scenes

Fig. 34 Star Wars: The Force Awakens - behind the scenes

Fig. 35 Legolas during the action scene

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Fig. 23. Texturing (and especially Normal maps) can add visual detail and indicate geometric forms that are only available in the texture file. From *Getting Started in 3D with Maya*, by Adam Watkins, Elsevier Inc., 2012.

Fig. 24. Rigging and skinning begins to bring collections of polygons to life. From *Getting Started in 3D with Maya*, by Adam Watkins, Elsevier Inc., 2012.

Fig. 25. The process of animation is tough, but immensely rewarding. From *Getting Started in 3D with Maya*, by Adam Watkins, Elsevier Inc., 2012.

Fig. 26. Rendering and lighting. From *Getting Started in 3D with Maya*, by Adam Watkins, Elsevier Inc., 2012.

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