THE TECHNICAL ANALYSIS OF THE PHOTOREALITY NOTION IN MOCAP 3D FACIAL ANIMATIONS

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FEBRUARY, 2022

THE TECHNICAL ANALYSIS OF THE PHOTOREALITY NOTION IN MOCAP 3D FACIAL ANIMATIONS

BY

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DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ART

IN

ANIMATION DESIGN

YEDITEPE UNIVERSITY

FEBRUARY, 2022

PLAGIARISM

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

In this thesis, the use of mocap (motion capture) technology, which is used to transfer motion data to digital, in 3Dimesional (3D) face animations is investigated. With Mocap Technology in 3Dimensional animation, the movements are transferred from real life to virtual actors, providing us with more realistic images without exaggeration. In this way, photorealistic characters obtained in the virtual environment and motion data transferred in accordance with the laws of physics reveal photorealistic moving images in 3Dimensional animation. Within the scope of this thesis, which includes the technical and visual analysis of facial expressions that plays an important role in the transfer of emotions in animation and can be transferred to virtual actors with 3Dimensional mocap technology, an answer is sought to the questions of the importance of facial animations in emotion transfer in animation and why the use of Motion Capture technology in facial animations is needed. The aim of this thesis is to contribute to the literature by examining the studies on the use of motion capture technology in facial animations created with 3Dimensional production technique, which plays an important role in expression and emotion transfer. Various findings are obtained from the interviews with the designers and analysis of selected movie characters within the scope of the thesis, these findings are examined, evaluated and concluded.

Keywords : *Animation, 3D Animation, Motion Capture, Facial Animation, Photorealism*

ÖZET

Bu tezde, hareket verilerini dijitale aktarmak için kullanılan mocap (motion capture) teknolojisinin 3Boyutlu (3B) yüz animasyonlarında kullanımı incelenmiştir. 3 Boyutlu animasyonda Mocap Teknolojisi ile hareketler gerçek hayattan, sanal oyunculara aktarılarak bize daha gerçekçi ve abartıdan uzak görüntüler sağlamaktadır. Bu sayede sanal ortamda elde edilen fotogerçekçi karakterler ve fizik kurallarına uygun olarak aktarılan hareket verileri 3 Boyutlu animasyonda fotogerçekçi hareketli görüntüler ortaya koyar. Animasyonda duygu aktarımında önemli rol oynayan ve 3 Boyutlu mocap teknolojisi ile sanal oyuncuya aktarılabilen yüz mimiklerinin teknik ve görsel analizini içeren bu tez kapsamında animasyonda duygu aktarımında yüz animasyonlarının önemi ve yüz animasyonlarında Hareket Yakalama teknolojisinin kullanımına neden ihtiyaç duyulduğu sorularına yanıt aranmaktadır. Bu tezin amacı 3Boyutlu yapım tekniğiyle oluşturulan, ifade ve duygu aktarımında önemli rol oynayan yüz animasyonlarında motion capture teknolojisinin kullanımına yönelik çalışmaları inceleyerek literatüre katkı sağlamaktır. Tez kapsamında tasarımcılarla yapılan görüşmelerden ve seçilen filmlerde yer alan yüz animasyonları üzerinde yapılan analizlerden çeşitli bulgular elde edilmiş, bu bulgular incelenmiş, değerlendirilmiş ve sonuçladırılmıştır.

Anahtar Kelimeler : *Animasyon, 3Boyutlu Animasyon, Hareket Yakalama, Yüz Animasyonları, Fotogerçekçilik*

ACKNOWLEDGEMENTS

Special thanks to my advisor, Prof. Dr. Neda Üçer, for her guidance in shaping the research methodology and optimizing the thesis.

To my family, who always support me, my father Özgür C. Özerdem, my mother Burçin Özerdem and my sister İrem Özerdem

TABLE OF CONTENTS

Plagiarism……i

Abstract…….…..….. ii

Özet…….……..... iii

Acknowledgments…… iv

Table of Contents.....v

List of Figures..…….…..viii

1. INTRODUCTION.....1

2. ANIMATION.....6

2.1 Basics of Animation 7

2.1.1 Persistence of vision.....7

2.1.2 Main Poses / Key Frames.....10

2.1.3 In-between.....11

2.2 Historical Development of Animation.....11

2.2.1 Early Times of Animation…….…12

2.2.2 Animation in 19th and 20th Century……..14

2.3 Animation Techniques……18

2.3.1 Traditional Animation Production Techniques.....19

2.3.1.1 Cel Animation……..…..19

2.3.1.2 Stop Motion Animation……..…..……..…..……19

2.3.2 Digital Animation Production Technique.....20

2.3.2.1 2D Animation……..…..…..20

2.3.2.2 3D Animation…….…20

2.4. 3D Animation and Motion Capture Technology.....21

2.4.1 3D Modelling.....21

2.4.2 Realistic Motion with Motion Capture in 3D Models.....25

2.4.2.1 Uncanney Valley.....26

2.4.2.2 Rigging.....27

2.4.2.4 Motion Capture Technology.....28

2.5. Using Motion Capture Technology in Facial Animation.....29

2.5.1 Facial Modelling and Facial Animations.....29

2.5.2 Facial Motion Capture.....32

2.6. Photo-realism.....33

2.6.1 Photorealism in 3D Animation.....33

3. RESEARCH.....34

3.1 Research Scope.....34

3.2 Importance of research.....34

3.3 Methodology of research…….…..…….36

3.4 Limitations of research…….…..…….37

4. TECHNICAL ANALYSIS OF PHOTO REALITY IN FACIAL ANIMATIONS CREATED BY MOCAP TECHNOLOGY…….…..……39

4.1 Analysis of the Selected Animation Films ……..…….42

4.1.1 Polar Express (2004).....42

4.1.2 Beowulf (2007).....45

4.1.3 The Adventure of TinTin (2011).....48

4.1.4 Final Fantasy Kingsglaive (2011) 50

4.1.5 Gantz: O.....51

4.2 Findings of the Animation Film Analysis…….…….53

4.3 Findings and Analysis of the Interviews……..…..……55

4.3.1 Findings of the Interviews……..……56

4.3.2 Analysis of the Interviews…….……63

4.4 Analysis of the Photoreality Notion in Mocap 3D Facial Animations.…..…..…68

5. CONCLUSION…….…..…..……77

REFERENCES.....79

Appendix A…….…..…88

Appendix B…….…….89

Appendix C…….…..……97

Appendix D……..…..…..……106

LIST OF FIGURES

Figure 1 Thaumatrope……8

Figure 2 Phenasiscope……8

Figure 3 Zoetrope……9

Figure 4 Praxinascope……10

Figure 5 Main Poses & Keyframes……11

Figure 6 Drawing in Altamira Cave……12

Figure 7 Wrestling stages in the Egyptian tombs……12

Figure 8 Greek figures……13

Figure 9 Tale of Genji Illustrations ……13

Figure 10 Turkish Shadow Theatre……15

Figure 11 Camera Obscura ……16

Figure 12 Vertex, Edge, Face and Polygonal Models……22

Figure 13 3D mesh-triangles with different resolution……23

Figure 14 Different Topological Structure of Same Model……24

Figure 15 Mori's Graph of the Uncanny Valley…….. 27

Figure 16 Polygon numbers of 3D Model with Mapping ……31

Figure 17 Unnatural Shading on Polar Express Character's Eye……43

Figure 18 Hair Simulations in Polar Express……44

Figure 19 Beowulf Character Face……45

Figure 20 Beowulf water simulations……47

Figure 21 The Adventure Of Tintin Movie Mocap……49

Figure 22 Final Fantasy Kingsglaive Movie Characters Face and mimics……50

Figure 23 The Final Fantasy Kingsglaive Movie Scene……..…51

Figure 24 Gantz:O Movie Characters……..52

1. INTRODUCTION

During the Covid-19 pandemic, the importance of the digital technology in communication emerged. Animation became an important tool in the manufacture of content for advertising, social media and the cinema, Tv industry. The content produced with the animation programmes and animated characters which their production process do not depend on time and place. This once again revealed the importance of the animation industry. In Bebka Animation Report (2018), it is emphasized that the animation industry is one of the fastest growing industries in the world and also in Turkey (p. 10). During the pandemic which caused a great transformation around the world, the animation industries development accelerated pace. During the pandemic, the house turned into an activity and working space as well as a living space. The increase in the time spent at home caused people to focus on new activities. Television, game consoles, virtual world contents as communication tools, home entertainment systems came to the fore, and the animation industry that produces content for these are undoubtedly experienced a great development and growth. Today, animation is not only a tool that produces content for children, but also a communication, education and entertainment tool that appeals to all segments of society. In addition to being a curriculum production tool, animation has the feature of being a sector that directly or indirectly affects many sectors such as automotive, electronics, medicine, aviation and defense, and this issue was mentioned in the National Science and Technology Policies 2003-2023 Strategy Document published in our country (Bebka, 2017). In addition to being a developing sector of great importance, animation can be traced back to human efforts to

communicate, which existed since the first ages of history. The word animation, which has a deep-rooted history, comes from the origin of "animare".

To animate, and the related words are derived from the latin verb animare, which means ‘to give life to’, this largely means the art of creating the illusion of motion in inanimate stationary pieces like shapes and forms (Wells, 1998, p. 10). Animation can be described as a branch of visual art in which motion illusion is created. Because motion is a proof of the existence of life. The fact that something can move on its own can be considered as proof that this thing is alive. In other words, in order to understand life, we must research movement (Dündar, 2013, p. 11). The main task of the animator is to reflect the movement realistically in order to create the illusion of movement, which is the basis of the animation.

With the development of technology, the production stages of animation have also changed and traditional animation production techniques have evolved into digital production techniques. With the development of 3D animation, a new era begun in animation, as by 3D modeling, everything similar to existing can be produced in digital environment. It became very difficult to distinguish these images which are obtained by modeling from the reality (Amann, 2017, p. 48). The problem of how the characters movement is created in a 3D virtual environment gained a new dimension as the main problem of animation. A 3D model can be compared with a sculpture made of clay. Just as a sculptor creates a sculpture by processing clay, the person who creates the 3D model creates the desired object by shaping a plasticine in the virtual environment (Çakın, 2012, p. 54).

The animator sets up the skeleton and musculature of the modeled character in order to give movement and animate the character. This stage, called rigging, is the stage in which the internal skeleton of the character, certain movement controls and special functions are created (Çakın, 2012, p. 88). By connecting the modeled image to the skeleton system, the 3D character is ready for action. With Mocap technology, movement in animation can be achieved by the movements of the sensors placed at the joint points, that is, by detecting the position data by the cameras and reflecting them to the character in the virtual environment (Parent, 2002, p. 369). Afterwards, these data applied to virtual actors and animate them (Küçükoğlu, 2017, p. 107).

The characters reflect the emotions to us with their poses and gestures. When we look at the first examples of animation, we can see the emotions conveyed by exaggerated facial expressions and poses. In 3D animation giving the facial expressions of the model with the controller causes both the prolongation of the production process in terms of time and the shaping of the expression in the animator's hands, according to the animator's style of expression, often exaggerated. Also every animator has their own unique style which makes animations have limitless visual expression (Purwaningsih, 2017, p. 58). For this reason, mockap technology is used to convey emotion in photorealistic animations, and it is not open to interpretation.

It is possible to talk about the effect called uncanny as an obstacle in front of realistic animation. It causes an effect that creates feelings of “mistrust, unease and even hostility” against the character (Jentsch, 1970, p. 3). Thanks to developed instinctive abilities, the individual has the ability to recognize what is different from himself. The

mind identifies a character in self-similar form as a human, but quirks in the character (visual or motion) cause the mind to identify that character as an uncanny being. For this reason, the uncanny effect is considered as one of the main obstacles to photorealism.

The aim of this study is to contribute to the literature by examining the studies on the use of motion capture technology in facial animations created with 3D production technique, which plays an important role in expression and emotion transfer. It is also questioned whether the photorealistic facial animations with mocap technology overcome the uncanny valley effect.

The first part, is introduction part of the thesis. In second part, the data which are obtained during the literature review are compiled in a theoretical framework. In this chapter the definition of animation, historical and technical development of animation, importance of mocap technology in photorealistic facial animations are examined. In the third part, the scope of the research is determined. And also attention is drawn to the importance of the research. Information is given on the methodology of the research. The limitations encountered within the scope of the research are also shared in this chapter. In the fourth chapter, Polar Express (2004), Beowulf (2007), The Adventures of Tintin (2011), Final Fantasy: Kingsglaive (2016) and Gantz: O (2017) movies facial animations are analyzed. The believability of the characters is examined according the design and production technique. In addition, the answers received from the 3 designers interviewed within the scope of the research are

analyzed in this section. Then the findings are discussed and in the conclusion part, the findings are shared and suggestions are given.

2. ANIMATION

Today, animation is used as an effective visual art and tool. Especially visuals, which can be obtained through 3D modeling, play an important role in many fields such as media, communication, education, health, engineering and architecture. And also it became an indispensable actor of digital content platform and media (Küçükoğlu, 2017, 33). However animation is not newly developing concept and it is revealed from a search that is existed throughout history. Artists continue to try to express movement, emotions and moods in their works throughout history (Marlow, 2006, p. 6). It is possible to find an expression and a transference in almost every work which are produced in painting, sculpture and architecture. “As Darwin (1872), actions which expressing feel and emotions of humans and animals, speak louder than pictures” (Blake & Shiffrar, 2006, p. 48). In other words, the transmission of a movement provides a more effective communication than the transmission of stagnation. Until the moving image discovered, artist tried to explain movement with drawing the most crucial moment. They worked on how the movement is transmitted on a single frame. According to Sofuoğlu (1985) “When a painter wants to create the illusion of life and motion, he tries to do so by separating some snapshots that give the impression that the model is suddenly frozen as it moves” (p. 4-5). In the art of painting, before and after the movement reflection of the movement should also be considered. In animation, before and after the movement should be drawn in order to convey the movement. Animation artist creates a whole picture by depicting the stages of movement. The eye's perception of these frames as a whole is based on a phenomenon called Persistence of Vision.

2.1 Basics of Animation

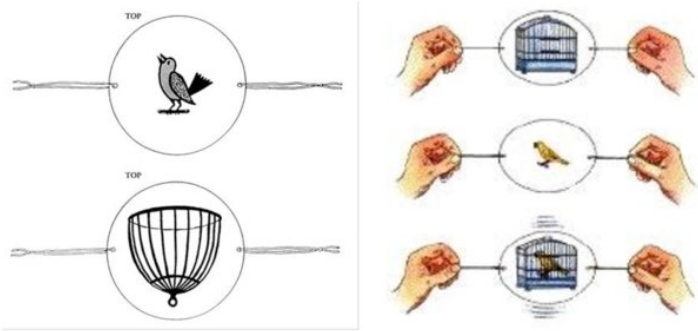
Just as the sum of the moments creates our life, the drawings, which expresses the moment in animation, creates a whole animation. The ability of these moments to create a smooth moving image is one of the basics of animation. According to Halas and Manvell (1976), filling the static drawings with life is main concerns in animation (p. 12). In order to a static form obtained on paper or digital to animated, the movement is decomposed into stationary phases. In a animation film, every second of the movie has successive phases of motion (Sofuoğlu, 1985, p. 3). These statical pieces are called main poses and inbetweens. These pieces are perceived as a whole on screen because of the phenomenon called persistence of vision.

2.1.1 Persistence of vision

If related static pictures which reflect the moment are presented with fast enough rate, pictures turns into continuous motion on screen (Parent, 2002, 2; Sofuoğlu, 1985, p. 3). This is called persistence of vision. Persistence of vision is inspired the creation of optical devices. Optical devices are the proof of the Persistence of vision theorem. Thaumatrope, Phenakistoscope, Zoetrope and Praxinoscope can be mentioned as examples of optical devices. Thaumatrope is a device introduced by John Ayton Paris in the early 19th century (Hünerli, 2000, p. 18). It is a device that allows two complementary images on both sides of a disk to be perceived as a whole upon the rapid rotation of the disk. Cage and bird images are one of the most well-known examples in Thaumatrope (see Figure 1).

Figure 1

Thaumatrope



Note. Ziatdinov, R. (2013). *Introduction to computer animation and its possible educational applications*, https://www.researchgate.net/publication/259211673_Introduction_to_computer_animation_and_its_possible_educational_applications/figures?lo=1

Phenakistoscope is introduced by Joseph Plateau in 1832 (Dündar, 2013, p. 14). The device is based on the logic of watching the sequential pictures containing the complementary stages of the movement on the disc in front of the mirror and creating a moving image(see Figure 2).

Figure 2

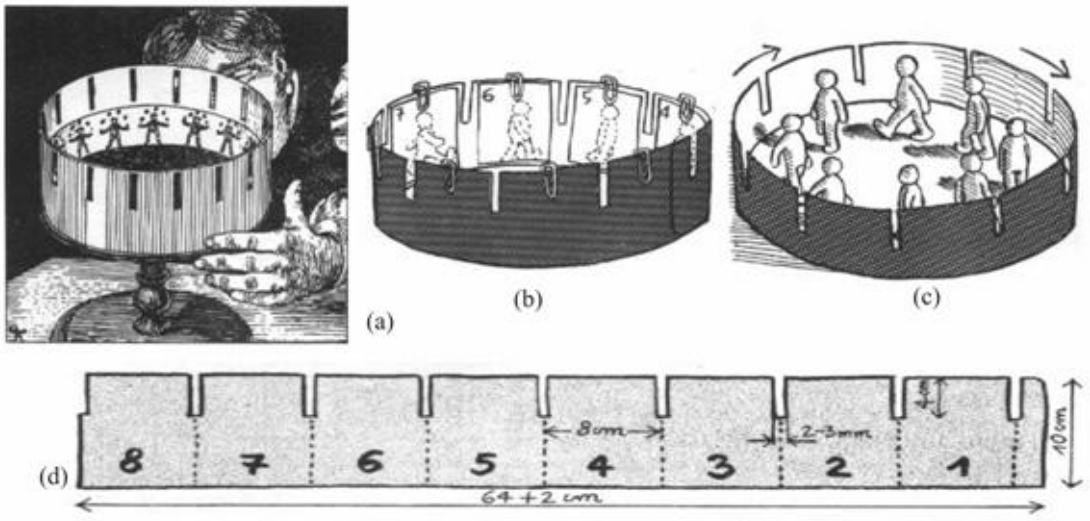
Phenakistoscope

Note. Standart Sinema. (2015). *Sinema Tarihi*, https://standartsinema.wordpress.com/tag/fenakistiskopphenakistoscope/

After, zoetrope is invented in 1867 by William George Horner. When viewed from the gaps at equal distances, the motion illusion in the images rotated inside the cylinder can be observed (Dündar, 2013, p. 15)(see Figure3).

Figure 3

Zoetrope



Note. Standart Sinema. (2015). *Sinema Tarihi,* https://standartsinema.wordpress.com/tag/fenakistiskopphenakistoscope/

Praxinoscope is invented in 1877 by the Parisian engineer Emile Reynaud (Dündar, 2013,15). Reynaud has come up with an invention in which the illusion of images can be traced inside the cylinder, just like in the zoetrope. However, this illusion can be viewed more easily thanks to the mirrors placed inside the cylinder. While the cylinder is rotating, the audience looking at the mirror in the middle of the cylinder can easily watch the motion(see Figure 4).

Figure 4

Praxinoscope

Note. Deviant Art. (2020). *Praxinoscope,* https://www.deviantart.com/silverbokeh/art/Praxinoscope-829753247

Motion in optical devices, like Thaumatrope, Phenakistoscope, Zoetrope and Praxinoscope, is seperated into stages. Each drawing in which the phases of the motion are depicted in the animation is called a frame of the animation. In animation, visuals consist of main poses and in-betweens.

2.1.2 Main Poses / Key Frames

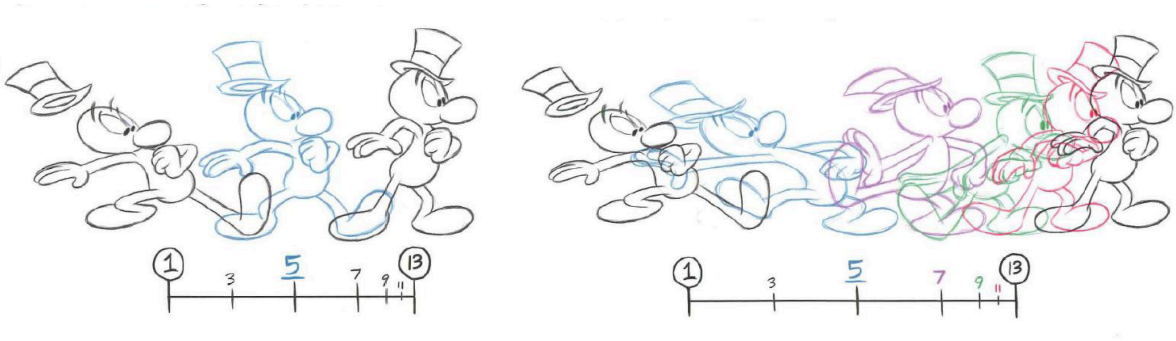
Keyframes are frames that express the beginning and end of the motion during the decomposition of the motion into phases in animation. The beginning and end of the movement serve as a guide in drawing the in-betweens. The deformation and changing position of an object over time are determined drawn as keyframes and in-betweens are completed with reference keyframes (Çakın, 2012, p. 93).

2.1.3 In-between

In-betweens determine how the motion proceeds. Depending on the number of in-betweens, the duration of the movement may change. In animations, motion shaped by the in-between. The number of in-betweens affects the fluency of the movement (Krasner, 2008, p. 308)(see Figure 5).

Figure 5

Main Poses & Keyframes



Note. Goldberg, E. (2008). *Character Animation Crash Course*, Silman-James Press, Los Angeles.

Persistance of vision and optical devices, developed from this theory are not the first examples of animation, it is not possible to say that they are the last. Animation techniques are also developed with the technology, such as the development of optical devices over time and finding different ways to provide the moving image.

2.2 Historical Development of Animation

Animation is developed, changed and survived to the present day. Animation, was born in the effort of self-expression as a communication tool, it became an important

part of branches such as art, technology and communication that have visual concerns today. Animation is traced back to prehistory.

2.2.1 Early Times of Animation

The first examples of animation is based on cave paintings, which can be accepted as the basis of many art branches. The quest to convey information with the help of drawings depicting movement can be seen in cave paintings(see Figure 6). In the Altamira cave in Spain and Chauvet and Lascaux in France, a drawing is found contain phases of motion (Çakın, 2012, s.5; Dündar, 2019, p. 5).

Figure 6

Drawing in Altamira Cave

Note. Animation. (2006). *History*, http://animationn.blogspot.com/2006/02/history.html

In later ages, artists of many cultures painted some stationary phases in order to explain the movement. Attempts to transfer this movement appear prominently in Egyptian period wall decorations and Greek period vessel painting after cave paintings (Dündar, 2019, 8). Scott McCloud's Understanding Comics (1998), he theorizes that the basis of cartoon art goes back to antiquity. Egyptian illustrations are also important transmitters in presenting stories and ideas (see Figure 7). (p. 66-67)

Figure 7

Wrestling stages in the Egyptian tombs.

Note. Kambon, B.O. (2018). Afrikan=Black Combat Forms Hidden in Plain Sight: Engolo/Capoeira, Knocking-and-Kicking and Asafo Flag Dancing, https://www.researchgate.net/figure/Detail-of-the-wrestling-scenes-in-tomb-15-of-Baqet-III-at-mnt-xwfw-modern-day-Beni-Hasan_fig1_326942344

Egyptians are not the only civilization to try tell story with figures. In the middle of the 7th century, in Greek ceramics related topics began to be lined up side by side (Esgin, 2014, p. 28)(see Figure 8).

Figure 8

Greek figures

Note. Britannica. (n.d.). red-figure pottery, https://www.britannica.com/art/red-figure-pottery

In 11th and 12th centuries Japanese painted their stories on scrolls that tell their stories(see Figure 9). The "Tale of Genji" scrolls are described in a novel with drawing and minimal writing (Pryor, 2004, p. 7).

Figure 9

Tale of Genji Illustrations

Note. Open Culture. (2016). *Splendid Hand-Scroll Illustrations of The Tale of the Genjii, The First Novel Ever Written (Circa 1120),* https://www.openculture.com/2016/01/splendid-hand-scroll-illustrations-of-the-tale-of-the-genjii.html

However, as an example, in shadow theater the drawings are divided into stages to a more live structure which destroyed the stagnation. This art, which is basically born from the same expression and transfer effort, is gained great popularity in Turkey and is survived to the present day.

The shadow theatre, which came to Turkey from Egypt in the 16th century, developed and became suitable for Turkish culture (And,1977; akt Hünerli, 2020). In the shadow play, the characters are composed of two-dimensional pieces combined from the joint areas to provide movement. In a environment, the lighting behind the curtain is the reflection of the shadows of the characters on the curtain and animating them (see Figure 10).

Figure 10

Turkish Shadow Theater

Note. And, M. (1985), *Geleneksel Türk Tiyatrosu,* İnkilap Yayın Evi

Different civilizations made experiments to explain the moment throughout history and produced visual studies in order to convey the information in the movement, which is a great source of information. They combined visuals and story to explain moment, and they told their stories that reached the masses.

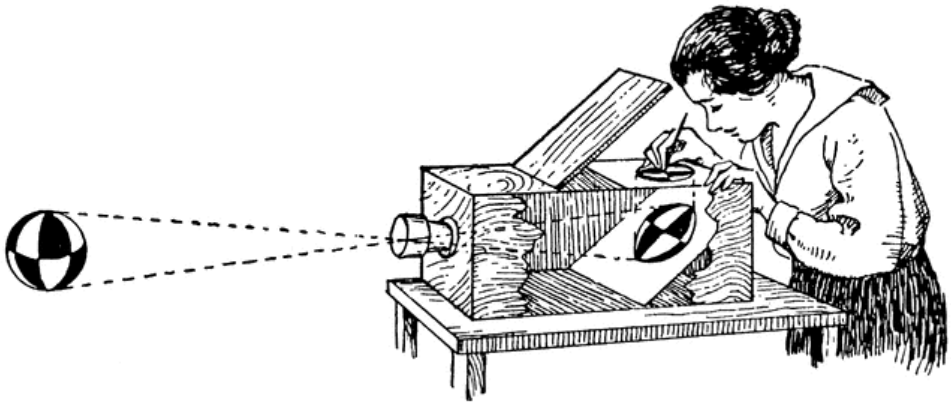
2.2.2. Animation in 19th and 20th Century

In 1800s, the first moving pictures are relevant with the discovery of the persistence of vision phenomenon and optical devices developed with this phenomenon. As the studies on the development of optical devices progressed, optical devices are evolved, resulting in short films suitable for collective screening, and short moving images are met with the audience in front of the screen.

Until the camera is discovered, the transmission of the image was due to the talent and imagination of the artist who created it. However, it can be thought that artists were in search of more realistic paintings. In Renaissance, Leonardo Da Vinci introduced the "dark box" (camera obscura) (see Figure 11) which can be explained as transferring the image to the surface with lenses (Kürekçi, 2014, p. 173). Then the picture in surface is copied by painter.

Figure 11

Camera Obscura



Note. Foster & Hughes, (1919), *The American educator; completely remodelled and newritten fro original text of New practical reference library, with new plans and additional material*, Ralph Durham Co.

The desire to copy the image has not lost over time. As a result of these searches, the device turned into the camera we know today. With the invention of the camera, it became possible to reveal not an imitation of the reality but a copy. Then the video camera is developed and motion pictures began to appear. The cameraman's point of view caused the visuals to have different meanings. Artists who experimented with

perspective and light found a new space to express themselves. It can be said that photography creates great excitement because it is a fast and reliable way. With the release of the first movie by the Lumière Brothers with the machine called Cinemagraf, moving images started to enter our lives (Hünerli, 2000, p. 20). Animation and cinema are developed together. Animations are considered as part of the history of cinema (Köşker, 2005; akt. Çolak, 2019). Artists, who gave the first examples of animation and cinema, added a new dimension to their occupation by blending the arts with this new technology. “Just as the first artists of the cinema came from the theater and fair shows, live paintings were among the first to draw cartoons in daily newspapers.” (Sofuoğlu, 1985, p. 3). In 1906, illustrator J. Stuart Blackton made his first animated film, Humorous Phases of Funny Faces, by photographing the images he drew on the blackboard. (Şenler, 2005, p. 102) In 1908, French Cartoonist Émile Cohl presented the animated movie “Fantasmagorie” to the audience. In 1914, Winsor McCay made the animated movie "Gertie the Dinosaur” (Hünerli, 2020, p. 21). An animated short film in which the main frames, intermediate frames are used, the contours of the character are drawn more clearly, and the Dinosaur Gertie, which we see for the first time in an environment (Fudge, 2020).

In 1919, the short animation "Felix the Cat" was released. “Felix took its place in the history of animation as the first animation star in the course of time” (Balaban, 2014, p. 32). In this period, animation became the part of mass entertainment. The animation characters started to gain personality and are separated from the pen to gained independent life (Sofuoğlu, 1985, p. 7). In the 1930s, Walt Disney founded the animation company named after him and stepped into the animation world with Mickey Mouse character. He made his first animated film by voicing the character of

Mickey Mouse (Finan, 2015). With the spread of computer technology, it started to attract the attention of artists. It is assumed that the first example of computer animation is created in 1957 by John Whitney Sr. (Withrow, 2009, p.12). These animations, which consist of motion graphics, are published in 1968 (Internet Archieve, 1968).

The first three-dimensional (3D) study is made by Ed Catmull and Fred Parke in 1972 and the hand modeled in this study is animated (Çolak, 2019, p. 63).

In the historical development of animation, it transformed not only visually but also technically. Cel Animation and Stop Motion Animation Techniques, which we can describe as Traditional Animation Techniques. Traditional Animation Techniques have left their places to Digital Animation Techniques, 2D and 3D Animation. With the development of digital animation technique, animation gained a new dimension, shaped by technology. In this way, animation moved away from being an art based on drawing (Balaban, 2014, p. 8).

2.3 Animation Techniques

Animation production techniques is classified depending on the process that covers the formation of the animation process. When we look at the historical development of animation, the production process is undergone a great change. Animation which are created with drawings or materials in the physical environment, virtually produced in the digital environment today. So production techniques is seperated to digital and traditional technique.

2.3.1 Traditional Animation Technique

Traditional animation techniques is the animation production process which does not take place in a digital environment. These technical methods are still used in animation. Especially the stop motion animation technique is used in the production of popular movies today. For example Kubo and the Two Strings (2016), Box Trolls (2014) and Isle of Dog (2018).

2.3.1.1 Cel Animation

The first example of this animation technique is given by John Bray. “Bray used this technique in his 1913 film "The Artist's Dreams” (Bendazzi, 1994; akt Melki, 2019). In the firs period of animation, animators start to draw the scenes on paper. Then, animators started to use transparent layers called "cels" (Çolak, 2019, p. 11). It is a layered approach where static elements and dynamic elements are drawn with different cels (Alankuş, 2005, p. 4).

2.3.1.2 Stop Motion Animation

Stop-motion; known as object animation, is the photographing of the object in stages appropriate to the movement that is intended to be described. Then combining these photographs for crate the illusion of motion (Yıldız, 2005, p. 1). It is similar to a two-dimensional animation, but physical objects can be used instead of drawings (Holliday, 2015, p. 32).

2.3.2 Digital Animation Technique

Thanks to digital technologies that accelerate the animation production process, animation can be widely used today. Computer-generated and processed images are used in many fields such as advertising, cinema, animation, health, engineering, architecture and education (Küçükoğlu, 2017, p. 69).

2.3.2.1 2D Animation

Thanks to graphic software suitable for image and vector-based work, it is possible to make 2D animation in the computer environment, where the effects of traditional animation are also seen (Küçükoğlu, 2017, p. 22). It is a production technique which drawn and animated in vector-based digital programs. Adobe animate, toon boom and adobe after effects are examples of these programs. In these programs, animation is provided by creating keyframes and inbetweens in 2D digital environment.

2.3.2.2 3D Animation

3D animation can be briefly defined as the animation of a character whose mathematical representation is created in a 3D virtual environment. 3D Modeling or scanning methods can be used to create this 3D representation. In modelling, like sculptor make any changes to create sculp the material, designer who create the 3dD model makes many changes and elaborations on the model by using the computer programs (Çakın, 2012, p. 54). In Three-dimensional scan technology scan objects in the real world, creating three-dimensional models in a numerical, virtual environment (Ülgen, 2014, p. 131). The created 3D Model is then animated with the help of 3D Modeling programs.

2.4. 3D Animation and Motion Capture Technology

3D can be briefly defined as length, width and height of object. Human perceives the environment in 3D. Artists have made various experiments in order to obtain 3dimensions in their works, and with the techniques that are developed over time, they have achieved the illusion of 3D by using perspective, light and shadow. The process of obtaining the geometric representation of an object in the computer environment in a vector format can be defined as 3D modeling (Withrow, 2009, p. 64).

2.4.1 3D Modelling

Every object that exists or imagined by designer can be transferred to the virtual environment as 3D model. These transfers can be done by the modeling artist or with the help of 3D scanning technologies. 3D scanners are often preferred in the health, engineering sectors, as they can transfer objects exactly the like in scanned form and scale. In addition, they provide great convenience in cinema and animation. However, in order for the object to be scanned, it must exist in real world. Because animation and cinema cover not only the existing but also the creative process, 3D modeling is usually done by animators. Just as everything in the world consists of the unity of atoms, objects in the digital environment are formed by the connection of vertex in digital programs.

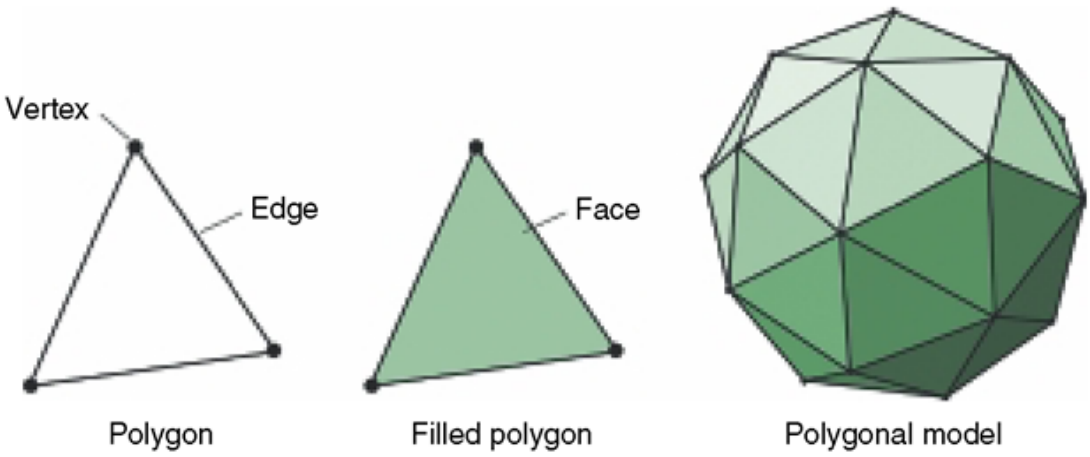
Vertex: The smallest part of the object in animation. They are the points that connect the edges to each other.

Edge: Edge 2 is the edges formed by the combination of vertex.

Face: It is a surface consisting of Edges and Vertexes that allows objects to be shaped (see Figure 12).

Figure 12

Vertex, Edge, Face and Polygonal Models

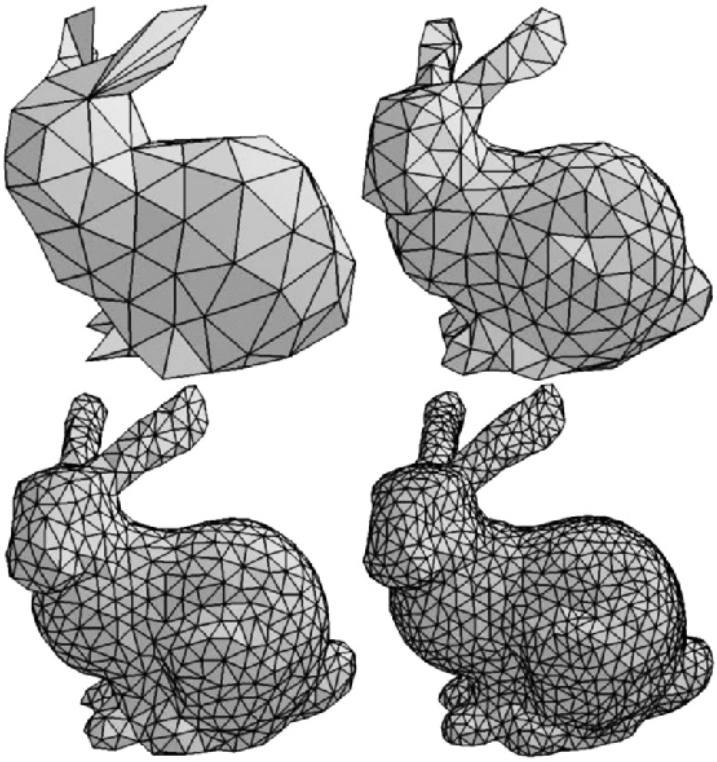


Note. Clarke, M. (2015). *Polygons*, https://mitchellnextgengames.wordpress.com/2015/10/23/polygons/

These 3 parts combine to form a polygon. And the combination of polygons creates a whole model. Increasing the number of polygons means increasing the details in the model (See Figure 13). Today, it is possible to produce detailed and complex models with polygonal details, thanks to the developing computer processing power.

Figure 13

3D mesh-triangles with different resolution



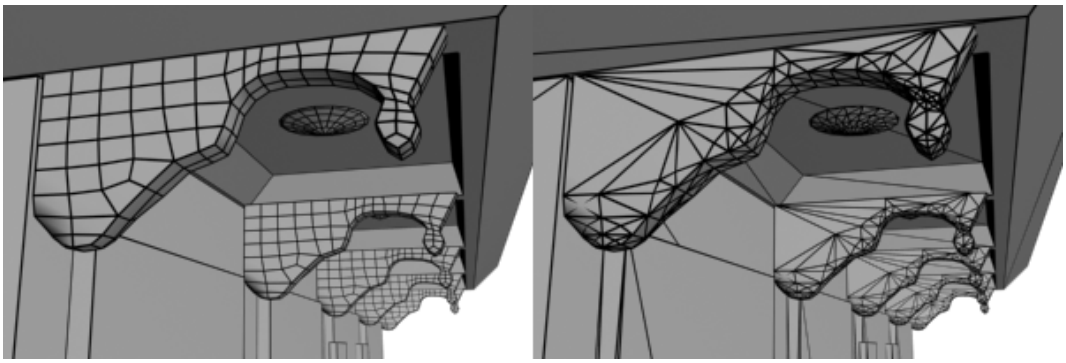
Note. Novakovic, P. (2017), 3D Digital Recording of Archeological, Architectural and Artistic Heritage, https://www.researchgate.net/publication/322096576_3D_Digital_Recording_of_Archaeological_Architectural_and_Artistic_Heritage/figures?lo=1

It should be considered that as the number of polygons increases, calculation of graphics will become more complex and increase the time which are create animation. For this reason, it is not enough to see only the number of polygons in animation. The structure and order of the polygon as important as the number of polygons. The mesh, which stands for the term topology creates the model and expresses the ordered structure of polygons, is of great importance in animation (Çakın, 2012, p. 55). The

same 3D model can be created in different topologies (see Figure 14). But it is crucial to keep the topological structure of the model simple and ordered for the particular animation

Figure 14

Different topological structure of same model



Note. Turbosquid 3D Resources, (n.d.). *Topology*, https://resources.turbosquid.com/checkmate/checkmate-product-presentation/topology/

According to Cannon (1981), the movement in the 3d model can be achieved by deforming the digital data (Cannon, Hunt 1981). The movement in the 3D model is caused by the position, rotation and dimensional deformation data in the vertex edge or face. With 3D modeling, objects and accessories, scenes and characters can be modelled. Objets and scenes are static parts of the animation. However, because of their nature, character should be moved. These models, which will be animated, can then be modeled in a way that supports the anatomical structure of the movement. Movement takes place at the joint points in the skeletal system. Until today researchers are tried to enact articulated bodies from a mechanical point of view.

(Colak, 2019, p. 62). The movement can be considered as mechanical movement, as the basis of the movement originates from the joint points. Body, hand and face animations are 3 basic character animations. Although the movement in the body and

hands is mechanical, because the movement consists of joints however facial animation is reflexive animation and the mimics are created with muscles not by joints. So facial animation have some differences.

It is an artificial skeleton system placed on the model as rigging in 3D animation. With the movement of these joint points elongation, stretching and deformation can be achieved in the model. This change information can be processed mathematically as well as manually controlled and changed by the animator. However, movement that is up to the initiative of the person can cause problems in realistic animations.

2.4.2 Realistic Motion with Motion Capture in 3D Models

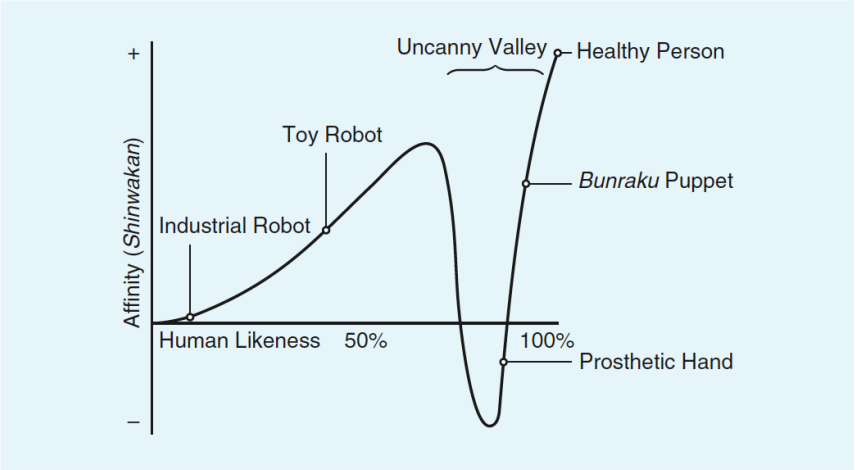
The development of technical facilities helped to obtain more realistic motion pictures. Firs of all photography machine then the camera start to conveyed the image to us exactly. Later, images are tried to be obtained in digital. Images could be both simulated and manipulated in digital environment. The search for realism in motion in Photo-Realistic 3D animations began to appear not only as a quest but also as a necessity. Human beings are prone to notice flaws in movement with their innate instincts. Disruptions in the movement or realism of the character cause the viewer to become alienated from the character and to feel the uneasiness called uncanny valley effect.

2.4.2.1 Uncanny Valley

In 1906, an article is written by Jersch on unfamiliar things that make people feel "mistrust, unease" and gave the first definition of uncanny. Later, Freud (1919) deepened these studies and revealed that the frightening and irritating feeling on the uncanny effect is a mechanism of self defense to recognize unfamiliar dangerous things. Then Masahiro Mori (1970), realize that humanoid robots and prothesis create uncanny effect on people. And he reveals the reason why photorealistic characters evoke an eerie sensation in the audience. According to Mori movement is important to overcome uncanny. Because as the humanoid movements of artificial beings increase, there is a certain closeness to these beings. However, since certain nuances cannot be caught, this eeriness intensifies (1970)(see Figure 15). A 3D model can be obtained at the end of the character production process, pushing the boundaries of photo-realism, indistinguishable from the reality. However, since the motion qualities of these characters cannot develop parallel with the high level of reality in the appearance, it creates a feeling of uncanny on the audience (Dündar, 2013, p. 2). It is very important to ensure the truth in this some movement. In the 3D modeled character, only the external image is modeled, but although this image can be shaped like clay, it is necessary to examine a mechanical system for the formation of mechanical body movements. Movement in a 3D model depends on the skeleton system. Systems called rig are established that determine the character's movement and joint points. The skeleton system, is combined with the character and the character starts to be animated. This system, called rigging, is enabled realistic movements to be obtained with the use of tracking and mocap technologies in the system.

Figure 15

Mori's Graph of the Uncanny Valley



Note. Mori M., 1970, The uncanny valley [from the field]. *Robotics & Automation Magazine*, IEEE, 19, 98–100.

2.4.2.2 Rigging

The human skeleton system is a complex structure, with two hundred bones and six hundred muscles. Movement is obtained joint points in skeleton system (Parents, 2002, p. 317). While the movement that takes place in the joints in the skeletal system is transferred to a 3D character, it is provided by the connections we call rig and placed at these joint points. These joints also affect other in hierarchical structure. Changes in these anchor points cause the character to deform, that is, to move, in accordance with these changes. In this way, the complex movement structure of the human body is simulated in the 3D model by connecting a simplified skeletal system to the model. This process is called rigging. Fingers and face animations are also ready to be animated with a more complex but simplified rig system in itself.

2.4.2.3 Mocap Technology

Animator tries to imitate the movement by taking reference from real life in order to animate the character. It tries to reveal a copy of the truth by making use of references. With the increase in visual realism, especially while creating 3D animation, mocap technology, as a system that can convey the realism and movement in motion, also become important for animation cinema. “Motion capture is the process of recording a live motion event and transferring it into usable mathematical terms by tracking the number of the key points in space over time”(Menache, 2000, p. 1). Thanks to Mocap, the mathematical position and rotation data transferred from the real world by means of tracking points allow the creation of realistic visuals with the cameras that monitor and transmit this data (Nedel, 1998, p. 86). While using motion capture technology, the player who will portray the virtual character wears a specially designed suit. The motion data transmitted by the cameras from the tracking points connected to the joints of this suit allows the movements of the virtual character to be shaped. In this way, the movements of the characters are copied to the stage in a realistic way. These systems, called marker-based mocap systems, are the preferred forms of use in large studios today. In addition, although there are systems called markerless, it is possible to say that they are not the most preferred systems in big budget productions due to their margin of error (Shingade & Ghotkar, 2014, p. 27). Also, it should also be mentioned that the motion tracking in face animations is customized due to the more complex structure of the face model created in high details.

2.5 Using Motion Capture Technology in Facial Animation

The human face is an important part of communication. It plays an important role in communicating both verbally and non-verbally. Nonverbal communication can be examined as body movements and facial gestures (Erkoç, 2013, p. 1-7). What makes facial expressions so important is due to the human being a social being; We can distinguish other people by looking at their faces and decipher their emotional states through facial gestures (Parke & Waters, p. 12). We provide verbal communication with mouth movements. While talking, we communicate with the other person and support the narrative with facial gestures. As such an important source of communication, facial animations are an important element in establishing communication between the character and the audience. It is possible to talk about the importance of facial animations as the key to not falling into uncanny in photorealistic animation. For facial animations where details are important, it is necessary to create a realistic face model. With the mocap technology in facial animations, this realism is also supported in the context of animations.

2. 5.1 Facial Modelling and Facial Animations

There are basic organs on the face, including eyes, ears, mouth and nose. It also includes items containing mouth, tongue and teeth. There are also items such as eyebrows, eyelash and hair, beards on the face. All these parts are affected from muscles reaction. Facial gestures are also obtained from this reaction.

This can be assumed as one of the main reasons why mocap technology is preferred in facial animations. It is difficult to create realistic and exaggerated expressions because of the high detail in facial animations. Also gender, age, identifier skars, wrinkles

should be considered when the characters face modelling. The 3D face model should be modeled by taking these details into account, and for animation, a proper topological structure should be created by taking into account the human anatomy in the facial structure of the character.

The 3D topological structure of the model is also important in the process of texture coating, which is called texturing. Thanks to UV mapping, which can be called 2D acquisition of the 3D topological structure, designers can place the textures of the models. However, attention should be paid to the surface structure of the model. For example, human skin is not a smooth structure. It has a porous structure. The tree trunk does not have a smooth structure, the splinters and the bark have a naturally rough structure. As such, the characteristic features of the model should be taken into account. Such structures cannot be obtained with the help of a 2d texture overlaid on a smooth surface. At this point, displacement map, normal map and bump map are used to create this texture structure required on the surface.

The use of bump map and displacement is important to ensure the realism on the object surface. Bump map provides a relief image on the object without creating a deformation on the surface, while displacement map can create a real deformation on the surface, which helps to create a high resolution surface structure realistically even on a low resolution surface (Çakın, 2012, p. 85; Griggs, 2019). Thanks to such additions, it allows the formation of a detailed surface structure in the 3D model (Davies, 2015).

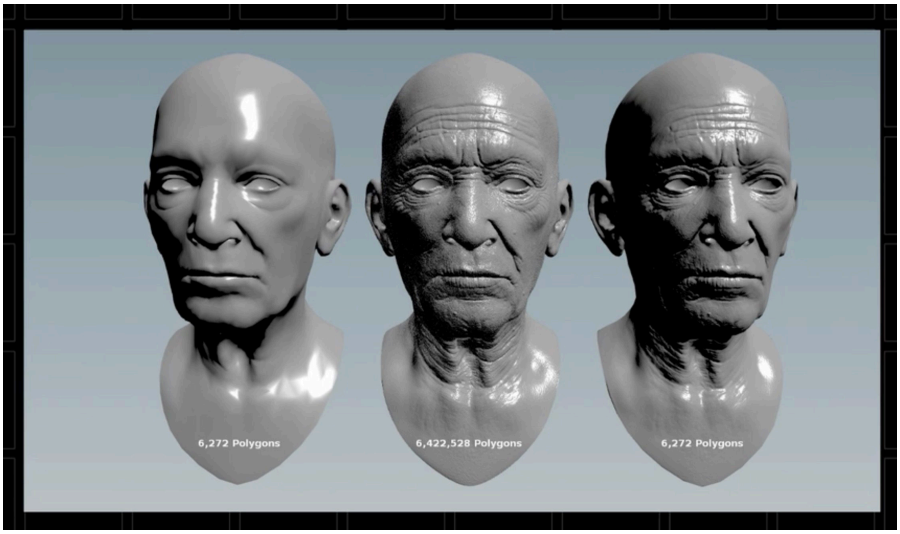
In addition, it is possible to create realistic visuals when material properties such as refraction shading, brightness, opacity, reflection are arranged in accordance with the modeling surface structure.

A face model becomes realistic after it is modeled in a smooth topological structure and detailed with normal, bump and displacement maps.

A detailed model of the Character (middle) can be created with a very high polygon count (see Figure 18). However, this will increase the calculation time of each frame of the animation. However, a low-resolution model created with a low polygon number can achieve a detailed and realistic appearance with the help of overlays such as displacement, normal and bump map (see Figure 16).

Figure 16

Polygon Numbers of Same 3D Model. Original (left), Detailed (middle), With Texture Map (right).



Note. Davies, M. (2015). *H15 Masterclass Mantra Rendering and Texture Baking,* https://vimeo.com/143618200?embedded=true&source=video_title&owner=1723479

2.5.2 Facial Motion Capture

It is a difficult process to obtain a human face digitally. The face is not symmetrical, and has individual characteristics. Also facial expressions is non-mechanical structure (Pighin, Salesin, Szeliski, Lischinski, & Auslander, 1997). They have more coplex structure. With innate talent notice changes in facial expressions (Parke & Waters, 1996, p. 1). The fact that the human face has such a familiar structure can also reveal its importance in animation. Facial expressions emerge reflexively, they usually reveal human emotions correctly. In theater and cinema, actors try to imitate human emotions. Another form of acting is animating acting. The characters try to convey the emotion to the audience through the animator. The feelings of happiness, anger, fear, sadness, disgust and surprise are universal emotions that can be easily distinguished in different cultures (Ekman & Friesen, 1971, p. 124). Any disruption in expressing familiar feelings on the characters' faces can break the whole charm. The audience falling into Uncanney Valley will estrangement from the character and the movie. Motion Capture technology started to be used in animation and more natural movements could be obtained. Using the mocap in facial animations, certain tracking points are determined on the face of the actor who will make the animation in order to provide the movement. These tracking points are more than those used in body animations because they cause movement in a wider area during the formation of a facial mimic. While how many track points will be used depends on the character and the player's face, too many track points will cause the computer to take longer to process this data. In facial animations, these tracking points are followed by a helmet placed on the face and cameras on this helmet.

2.6 Photo-realism

The history of photorealism dates back to the 1960s and America. However, its first definition is made in 1970 and this trend gained popularity (Bağcı, 2008, p. 2). “The aim is to apply the highest possible accuracy of the details presented by the photo.” (Akkayayüz, 2019, p. 44). The rapid and precise image that photography can achieve primarily influenced the art of painting. The painters focused on transferring the precision that photography can achieve to their works, conveying the moment in their paintings, and tried to minimize the difference that may occur between their works and the photographic frame (Aydın, 2009, p. 126). Today, the search for photorealism continues in the virtual world as a copy of the real world. In digital artworks, works produced through this movement are revealed, and photorealistic characters and animations met with the audience in animation.

2.6.1 Photo-reality in 3D Animations

Just as painting artists who are influenced by photography reveal the reality provided by photography; there is also a search to reveal the visuals created in the digital environment in a way that cannot be distinguished from the reality.

It can be said that especially 3D models can be created in realistic forms. In addition, visuals created in 3D forms can be detailed in a realistic structure thanks to textures and materials, and it is possible to produce the most appropriate and closest visuals that are indistinguishable from the real. With the production of these photorealistic images in animation, more human-like characters have begun to be created in 3D characters with a photorealistic approach. Mocap facial animations in 3D photorealistic characters also form the basis of the research.

3. RESEARCH

3.1 Research Scope

Within the scope of this thesis, which includes the technical analysis of facial expressions that play an important role in the transfer of emotions in animation and can be transferred to virtual actors with 3Dimensional mocap technology, an answer is sought to the questions of the importance of facial animations in emotion transfer in animation, why the use of Motion Capture technology in facial animations and how photorealistic technology create an uncanny effect on viewer. The mocap technology aims to overcome the uncanny effect so within the scope of this thesis it is aimed to investigate if really the mocap technology can help to create photorealistic virtual character or not.

The main hypothesis are as follow :

- Photorealistic 3D Facial Animations are realistic and non-exaggerated animations.
- Facial animations are effective to reflect expressions and emotions.
- With mocap technology animated photorealistic characters can overcome the uncanny effect.
- Photorealistic virtual character animation became more common in animation.

3.2 Importance of the Research

The concept of Uncanny entered our lives with the emergence of the first humanoid creatures (robots). The basis of the concept of uncanny, which is examined in Jersch’s, Freud’s and Mori’s work, is based on the feeling of “creepy, eery" arising from the appearance of a familiar silhouette in a humanoid structure, but also in an unfamiliar structure. With the development of computer technologies, the emergence of CG

characters and the development of realistic characters in 3D, this concept started to be examined frequently (Geller(2008), Tinwell(2011), Melki(2019)). Within the framework of studies examining the uncanny effect, it is stated that facial animations are of great importance in order to overcome the effect. Thanks to the Mocap technology, realistic expressions can be transferred to the 3D virtual character. Overcoming the uncanny effect of facial animations is an important problem that is well recognized. It is also possible to say that mocap technology plays an important role in overcoming the uncanny effect. Within the scope of the literature review, articles which examine the uncanny effect in photo-realistic animation films are found. Academic literature studies are also found on ensuring realism in an animated film. However, there is no master's thesis that mainly investigates the importance of facial animations in this context and the effectiveness of mocap technology in this context. Although there are technical studies and theses on Mocap and artificial intelligence supported face identification and how this type of technology will develop in software, these studies can be described as out-of-field studies. In this context, this thesis, which deals with the subject within the scope of social sciences, can be described as an original study. And it can be assumed that it will have a contribution to the field.

3.3 Methodology of research

This thesis is designed as a qualitative research. One of the main reasons why qualitative research is preferred is its flexibility. As a more in-depth research method than the quantitative research method, the qualitative research method allows to discuss the subject from different perspectives (Karataş, 2015, p. 63). In addition,

many methodologists agree that it would be a more accurate structure to concentrate the research within the framework of a single method, compared to the research method known as mixed method and using both quantitative and qualitative research methods.(Gökçek & Baki, 2012, p. 3). For this reason, the qualitative research method is determined as the research method. In interviews with open-ended questions, participant are free to respond with that are more flexible and personal answers. In this way, the subject is discussed in more detail with the detailed answers given by the participant. In this thesis, research consists of two phases, analysis of movies and interview with designers. In movie analysis part, photorealism in visuals and the effectiveness of mocap technology in expression are examined by taking into account the production process in which the visuals are created. Whether the Uncanny effect can be overcame or not is also examined within the framework of this analysis. The films are selected on the basis that they are full CG animation productions and that the characters are animated with mocap technology. In this context, Polar Express, Beowulf, The Adventure of Tintin, Final Fantasy Kingsglaive and Gantz: O films are selected for the analysis. Analyzes include the point and evaluation of facial animations produced with mocap technology.

Then, the interviews are realized done with the Digital sculptor (Güray Gürüp), Character Artist and Digital Sculptor (Niyazi Selimoğlu) and 3D Generalist and Technical Artist (Ferhat Tanman) who are working with the art of animation and continue to work mostly in Turkey. Each participant produces photo-realistic works in 3D. Therefore, they are willing to discuss the issue.

Key points discussed in each interview;

- Photo Realistic animations and designers' thoughts on photorealistic animations

- Requirements for photorealism and the place and importance of mocap technology in photorealism
- The success of facial animations and whether the uncanny effect is exceeded in character animations. The role of mocap technology in this success.
- The effects of photorealistic animation and the use of mocap technology in this context on issues such as team, time and cost in the production process and their thoughts on the use of mocap technology in the future.

The interviews are based on (11) open-ended questions and semi-structured interview technique is used. Due to the COVID-19 pandemic, each meeting done online. Information about the scope of the thesis is given to the participant before the interview. During these interviews with the approval of the participant audio record was taken. The answers given are shared without changing the context and meaning, and the findings are shared within the scope of the thesis. The data obtained through the literature review and interview are evaluated by making content analysis. The interviews are decrypt and shared in the appendix part of the thesis with the approval of the participants.

3.4 Limitations of research

The analysis of movies are focused on photorealistic human characters. Creatures and animal characters are out of scope. The analyses on the thesis are focused on the production process of animations where the produced photorealistic characters faces, animated and rendered. All movies are considered to full CG animated movies. In cinema movies and series facial animations are out of the scope of this thesis.

The number of interviews is limited to 3. The thesis aimed at the beginning to have interview with 9 participant and online request are sent to them but only 3 answered positively to the request. Due to the busy schedules of the participants, the limitations of the pandemic process, and the limited number of experts in the field, the interviews are realized with 3 participants. Because large production technologies and mocap studios are not established in Turkey yet, and there is no application study in this field, especially in helmet systems that follow face animation. In this respect, designers who work on photorealistic works, produce studies on face models and facial animations, and participate in these animation works during the production process in this field are searched and listed as candidates.

Because of the limitation of COVID-19 pandemic the interviews are made on online. Audio recordings are taken as part of the interviews.

4. TECHNICAL ANALYSIS OF PHOTOREALITY IN FACIAL ANIMATIONS CREATED BY MOCAP TECHNOLOGY

With the increase of photorealism of virtual characters in 3D movies and the formation of realistic characters rather than stylized characters, the use of mocap technology as the key to realism in movement is become prevailing. The details are also increased in the facial animations, which play an important role in the communication of the photorealistic characters with the audience. With modelling softwares creating realistic characters is become relatively simple but characters which looks like real existing person in detail is still a very cumbersome task (Fechteler, Hilsmann & Eisert, 2019, p. 92).

First movie which in used mocap technology in 2001 Final Fantasy Spirit Within characters are modelled in realistic style and characters body animated with mocap technology. Because of the failure of facial animations in the movie 2 main problem revealed. First one is about visualization of photorealistic characters and second one is about animating them. When the characters visual became more humanoid they look familiar to audience. Whereas their movement and consciousness is not much. So characters became both familiar and non familiar at the same time and create “creepy” sense on audience which is called uncanny valley effect (Jentsch, 1906, p. 1). The film is criticized by the audience for both the failure of the characters' facial expressions and the sense of “creepy” called uncanny valley effect. Then the animators and scholars start to search how they can overcome the uncanny effect in photorealistic animation characters. Then they realized that the faces are play important role for animation. “We’ve gotten out of the valley with body movement—

now it's all about the eyes and facial performance." (Hal Hickel, akt Geller, 2008, p. 14)

The creation process of an animated movie takes place in the pre-production, production and post-production stages. Pre-production is the stage where the idea of the film is found, the scenario is created, the cast is selected, the visual language is decided and storyboards and concept drawings are made. Briefly "where is the work done on a product before full-scale production begins." (Aktaş,2019, p. 1)

In the production phase, it is the section where models is modelled, moving objects is animated, texture and material is assigned, lighting and rendering stages. The production process of the animation takes place at this stage.

Post-production stage can be described as the part where the rendered outputs are edited, the colors are arranged according to a color correction, the sounds are added. And the film is ready for the audience with the final touches. So finalize the movie in this part.

So it can be said that pre-production is creative and art process of the movie. Production is the technical process of the movie. And the post production process is about the cinematography. In addition to these processes, the director, art director and concept designers, who ensure that the film progresses without deviating from the creative scope and planning, continue their duties in 3 stages. Producers also have the power to control and intervene within the scope of these processes. In other words, they take part in all pre-production, production and post-production processes.

Creating 3D photorealistic image is the process which is completed in production stage. So selected films are examined by considering this technical process that

created them. Because of this reason facial animations will be analyzed according to the 3D production process, considering how realistic the facial animations are, taking into account the facial models, texture and material, animation (with motion capture), lighting and rendering stages. After all scenes are modeled and characters animated, light sources are put on the virtual scenes. However lights and shades is about the render engines. “Each render engine calculates lighting and materials differently, and as a result the rendered images produced will be different.(Autodesk, 2021,1)”. Camera shots in 3D scenes are export as 2D image and this is called render.

The animated character in the resulting film is also a popular culture element. Just like a real actor, he is a popular item with an audience. The audience feels excitement, anxiety and happiness for the character they watch. She is happy, sad, angry for him. The bond that develops depending on the narration of this story allows the audience to empathize with the character. Because of narrative structure of cinema a strong bond of empathy is formed between the character and the audience (Butler & Joschko, 2007, p. 59). But photorealistic characters faces, realistic visualization which created with production process animated with non-realistic its create unfamiliar expressions with familiar face to cause falling uncanny. Character will break the bond of the person with the character. This is called the uncanny effect. Within this thesis the uncanny effect is analyzed in 5 different movies.

These 5 animation movies are selected for 2 strategic reasons. First of all animation movies are full animated cg movies in which the characters are animated with mocap technology and photorealistic approach. Secondly, all of the selected movies are created in different times so we can investigate the evolution of mocap technology, characters reality and how they overcome the uncanny effect.

4.1. Analysis of the Selected Animation Films

Within the scope of the research, 5 films are determined, whose characters are created with the concern of photorealism and animated with mocap technology. These films are classified as Full CG Animation films. All of the elements of these films are created in 3D virtual environment and facial animations in these movies, are analyzed.

4.1.1 The Polar Express (2004)

Polar Express is an animated movie which 6 different virtual characters are animated by Tom Hanks with mocap technology. The film is criticized by scholars and critics for the lack of realism in the expressions and movements of the characters.

The main characters of the movie can be listed as Hero Boy, Conductor and Hero Girl. The facial models of the character are modeled suitable for the ages of the characters.

Textures of the characters look realistic, however the skin of the faces free of pores and wrinkles which are created with displacement and normal map. This prevents the natural looking of the faces. Because wrinkles help to reinforce expressions and identify the characters.

Another factor that causes the characters to break away from reality is the disruptions in the eyes. Eyes of the characters are so bright and reflective. The looks do not have the right focus, which adds a frightening to the characters. Characters don't blink at the right frequency either. Also eyes are unnaturally shaded in some scenes. Incorrect lighting and shading create an abnormal environment feeling. (see Figure 17)

Figure 17

Unnatural Shading on Polar Express Character's Eye

Note. Warner Bros. Entertainment. (2020). *The Polar Express | Full Movie Preview | Warner Bros. Entertainment.* https://www.youtube.com/watch?v=EeNzP7HdCoo

In addition, the movements of the teeth and tongue cause an uncanny feeling to the viewer due to the error in the lighting.

The production team states that they put a lot of effort into making the hair look realistic. Especially for the Smokey's hair, the production team has developed a program for every characters hair (FunFactsFilms, 2018). Although the distribution of the hair in the wind and the hair of the Red Beard man who is called smokey are simulated in a natural structure (see Figure 18), hovewer conductors hair in some scenes has the appearance of coming out of a plastic mold.

Figure 18

Hair Simulations in Polar Express

Note. Fun Facts Film, December 15, 2018, The Polar Express - 10 Behind The Scenes Facts, https://www.youtube.com/watch?v=1mN4VAwhrk4

And for characters facial animation it can be said that, the expressions are stagnant. It is also observed that the mimics of the actor are not fully transferred to the characters. For such reasons, the realism of the character's facial animations is interrupted. Because of these little details characters disturb the audience and create uncanny effect on them. These movies criticisms show that especially eyes are important for realistic animations. However, this movie added experience in photorealistic animation reflect directly the mistakes and prepared the ground for making more realistic animations with compensating for errors. Photorealistic approaches inspired later directors and producers, and more characters came to life with this approach.

4.1.2. Beowulf (2007)

This movie can be described as a movie with more successful facial animations than the Polar Express. This move has a wider actor and actress cast. It is possible to talk about 5 main characters in this movie. Beowulf, King, Queen, Wiglaf and Grendel's mother are the main characters of the movie.

In this film, the characters are actually modeled on the facial structures of the actors who portray them. Especially the face of the king has the face of Anthony Hopkins, Grendels mothers face Angelina Jolie, Wiglafs face Brendan Gleeson and Quenn Healhtheows face Robin Wright. The Beowulf, character is stylized in accordance with the character's athletic structure but character still has Ray Winstone's face structure.

> "lm Beowulf, McDonald said, "Our intention's not to fool people that it's actually Anthony Hopkins on the screen—they know it's not. Instead, we want to get something that's convincing within the realm of that world we're portraying. In Beowulf, there is a lot of character detail, but our intent is never to hit that mark and be truly real." (Akt: Geller, 2008, p. 12)

The facial structures of the characters are modeled in accordance with their age. When we look at the facial textures, we see that they are more distinctive. We can see that the characters have distinctive scars, spots or wrinkles on their faces (see Figure 19).

Figure 19

Beowulf Character Face

Note. Movieclips, November 23, 2011, *Beowulf (2/10) Movie CLIP - They Say You Have A Monster Here (2007) HD*, https://www.youtube.com/watch?v=-A9rFt7ITy4&list=PLZbXA4lyCtqrM2Mkb9YF2NA-Ih5xJlbEO&index=2

Hair, beard and eyebrows have a more realistic structure. They have their own random distribution.

Lighting and shading are in a natural structure. There is a natural transition between light and shadow on faces. There are scenes where it seems far from natural due to the dark structure applied to the teeth, tongue etc. in the mouth.

This movie also had an uncanny effect on the audience. In particular, the monster character called Grendel is completely far from a realistic image.

One of the main problems in this movie is in revealing the water simulations. The scenes realism became unconvincing with the increase in the brightness of the characters faces in sea or rain (see Figure 20). Refraction (refraction values of

materials such as water, glass) and reflection is not true in water simulations and fluid structure of water is not realistic.

Figure 20

Beowulf Movie Water Simulations

Note. IMDB. (n.d.). Beowulf, https://www.imdb.com/title/tt0442933/

With the effect of the tracking system used in the eyes, a more natural eye movement could be obtained. In Polar Express and Beowulf movie facial animations are created with marker based mocap technology. This system is that the tracking points which are pasted on actors faces, provides data containing motion information. However acting is not easy because of these points. Then the mocap studios in order to overcome this problem, they worked on markerless based mocap systems. However markerless based mocap system is not preferred in animation movies because it requires extra effort, more then one camera need to used for good results and multiple cameras also increases cost of the system (Shingade & Ghotkar, 2014, 27). Then the

Weta studio developed the facets technology. Facets technology can be described as the helmet with camera which camera just focused on facial mimics record. “The system captures nuanced details of an actor’s facial performance, figures out how the muscles are moved, and then maps them onto virtual characters, even if the character has very non-human proportions.” (Weta Digital, 2021). This system is marker based but markers are little points which are drawn the faces. Cameras directly focus on face so makers are little and recordable so more confortable. So actors could play the performance without any difficulty.

4.1.3. The Adventure of TinTin (2011)

The Adventure of Tintin is adapted from the Herge’s cartoon series. Therefore the characters are a bit more stylized in accordance with the original drawings. Modeled as a mixture of the actors portraying them and their original drawings, these characters create a smooth image for the viewer.

As well as the use of light and shadow that reinforces realism. Also wrinkles in face reinforce the mimics. Tintin is young character, the wrinkles is not come from age but its formed do to gestures like real person.

It is possible to talk about 5 main characters: Tintin, Haddock, Redhack and Dupond Brothers.

It can be said that the uncanny effect is overcome in this film. This is due to the fact that the characters are more stylized and story of the movie is adapted from a realistic narrative rather than fantasy. In the movie, the environments and objects are modeled and rendered very realistic. In the movie, hairs have a natural oscillation. Materials such as water and sand are reflected in a natural structure.

In Tintin animation movie especially mimics are various and realistic. Emotions such as surprise, happiness, sadness, anger, disgust and fear are expressed successfully in accordance with the situation. According to Ekman (1989) this 6 expressions are universal expressions and important ones. But just like real life they are not enough to tell story and in real life expressions can be categorized “spontaneous facial expressions” and “deliberate facial expressions” (Ekman and Rosenberg, 1977). Just as an actor can simulate these expressions realistically, these mimics of the actor should be successfully transferred to the virtual character with mocap technology. According to the progression of the narrative, the smoothness of the transition between these mimics and expressions is successfully reflected in this animated film. It is possible to talk about more stable expressions in the films Polar Express and Beowulf. While we can talk about success for Beowulf, the expressions are more stable. But in this movie expressions can be describe as dynamic and successfully realistic (see Figure 21).

Figure 21

The Adventure Of Tintin Movie Mocap

Note. Weta Digital. (n.d.). *The Adventure of Tintin*. https://www.wetafx.co.nz/films/filmography/the-adventures-of-tintin/

4.1.4. Final Fantasy Kingsglaive (2016)

This movie shots look like photorealistic. Everythings is designed photorealistic. Every material look like having the right reflectivity, color and refraction value. Every face has its own distinctive features. The faces has their own identifying features. In particular, the texture is processed in great detail. Hairs, eyebrows and beards are realistic.

The expressions are also natural (see Figure 22), but still create a feeling of uncanny in some scenes.

Figure 22

Characters Face and Mimics

Note. Square Enix, (2016). *Final Fantasy XV Kinglaive*, https://finalfantasyxv.square-enix-games.com/en/kingsglaive

The main character's reality is carefully presented in movie scenes but this realism is not provided in side characters (see Figure 23). This artificial expressions of the side characters is more noticeable in the realistic scenes and beside the photorealistic

characters. The color skin of the princess is too light. In some scenes the shadow is not enough shade on princess face. The photo-realistic environment, materials and objects here support the characters visualized with a realistic approach.

Figure 23

The Final Fantasy Kingsglaive Movie Scene

Note. Square Enix, (2016). *Final Fantasy XV Kinglaive*, https://finalfantasyxv.square-enix-games.com/en/kingsglaive

4.1.5. Gantz: O (2017)

Gantz: O is the movie in Netflix which is adapted from the anime series of the same name. Completed in 5 years, this movie surpasses the uncanny effect and makes it possible to watch the characters without alienating the audience (Kurozimi, 2016). It is not possible to say that the characters are completely realistic, but it is possible to say that the characters have smooth movements and realistic facial expressions. The facial models in this movie are modeled in realistic human proportions. Considering the ages of the characters, the face is tried to be modeled as naturally as possible.

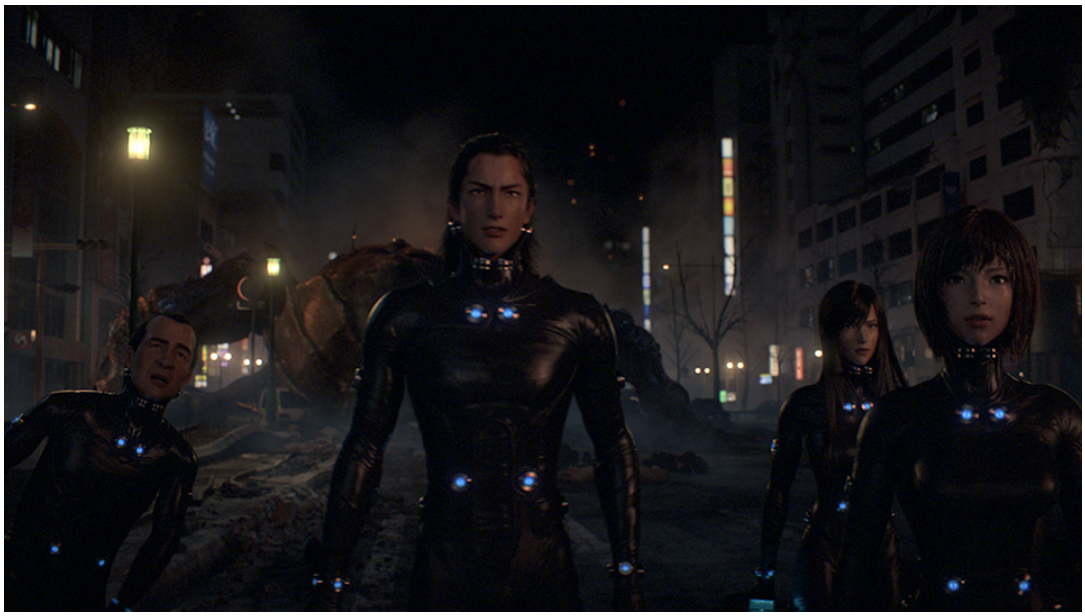
It is possible to see the hair and eyebrows of the characters in a realistic distribution and to say that they have a natural oscillation according to the movement in the scenes.

There are three main characters in this movie. These Basic characters can be said to be Reika, Anzu, Masuru Kato (see Figure 24).

It is possible to say that the mimics and poses are realistic.

Figure 24

Gantz O Movie Characters



Note. Digital Frontier, (2016). *Interview with Yasushi Kawamura His new challenge for "GANTZ:O"*, https://www.dfx.co.jp/en/cgmaking/gantz_O/index.html

Today, with such successfully realistic virtual actors, films that reveal a good story and can be watched without causing "eeries" in the audience are emerging.

The Resident Evil movies; Degeneration (2008), Damnation (2012), Vendetta (2017), Tv series Infinite Darkness (2021) and Gantz: O movie show that such productions (full cg animation movies) become prevalent in content platforms.

It can be said that recent photorealistic productions have gained popularity with accelerating computer power and the accelerating progress of software solutions. Improvements have also been made in Mocap technology, and solutions are produced for facial animations that make the actors less uncomfortable. New high resolution camera system with mocap technology

4.2. Findings of the Animation Film Analysis

After photorealism is fully provided in 3D character models, it can be provided by supporting motion with mocap technology. The characters in the Polar Express are designed in human form and animated with the concern of photorealism. However, the character faces are not detailed. The faces are non-porous and lack identical features. This distorts the believability of the characters. And the smooth images of the characters make the characters look artificial. This situation is solved by taking into account the body and facial structures of the actors who portray the characters in the movie Beowulf, as well as the textural details that indicate their personal characteristics (wrinkles, scars, freckles). In this way, the characters gained a more realistic and believable quality (Geller, 2008, p. 12). These detailed facial structures are also taken into account within the scope of other films examined. The characters are first created in their photo realistic form and then animated with mocap to provide photorealism.

The characters are designed in the form of actors and actresses who portrayed them. In the movie Polar Express, the character of Conductor is tried to be designed in the image of Tom Hanks, who plays himself. In this way, it is ensured that the mocap data collected by the mocap technology match the joint points of the virtual character to give better results. In addition, the character's faces that are familiar to the audience add a different taste to the animation. The audience gets the chance to watch a representation of the actor, not himself.

Today, animations are much more realistic and characters can be watched without the uncanny effect. However, it is not possible to say that this effect is completely overcomed.

It can be said that the uncanny effect achieves successful results in facial animations, especially in Tintin, Final Fantasy and Gantz O films. However, virtuality can still be noticed in movies. In Final Fantasy Kingsglaive, the artificiality and lack of detailed image of the life characters evoke the uncanny effect on the audience. The creatures in the Ganz:O movie are also responsible for the uncanny effect.

Helmet tracking systems specially developed for facial animations have allowed photorealism to increase in facial animations.

As the importance of facial animations in photorealistic animations emerged, systems with helmets specialized for facial animations began to be developed. In this way, a system that can transfer the mimics of the player to the character more effectively is put forward.

Recently, the number of photorealistic animations on content platforms is increased. Netflix is the platform widely used by the high number of members among digital content platforms (Lobato & Lotz, 2020). The number of photorealistic animation content on this platform is increasing. It should also be taken into account that content platforms are increasingly diversified and new platforms are emerged.

4.3.Findings and Analysis of the Interviews

Participants consist of designers who produce 3D photorealistic works and are knowledgeable about photorealistic 3D models. 3 Designers also work in the animation production pipeline. With the questions, not the technical functioning of mocap technology, but the visual contribution the 3D animation examined in line with the answers that included the participants' own opinion and thoughts. The answers given by the participants are decrypted and shared in the appendices.

Nine Turkish designers working on 3D modelling and animations are limited to participate to the research equalitative candidates who produce 3D photorealistic works in Turkey are determined to participate in the research. However, this number is limited to 3, with only 3 candidates providing positive feedback due to the limitations of the pandemic period, busy schedules of the candidate participants and geographical limitations. The analyzes and findings are evaluated in line with the opinions of these 3 participants. The same research can be repeated with more participants in future studies.

4.3.1. Findings of the Interviews

The limited answers given by the participants are examined and associated with the thesis topic. The findings revealed in the framework of the interview are as follows:

All 3 participants stated that successful photorealistic facial animations are achieved today. However, participants Ferhat Tanman and Niyazi Selimoğlu highlighted that they do not prefer photorealism in animation.

Ferhat Tanman, within the framework of his answers to the 2nd and 7th questions, said, “We can only talk about what we are seen from the movies here. That much is fine, of course.” and “I'm actually not someone who likes photorealism that much…… I don't like photorealism that much ……..So when we look, it gives me a much better taste for it to look realistic knowing it's CGI rather than feeling like we're watching a photo or a movie.” He stated that he did not like photorealism.

Güray Gürüp for photorealistic face animations within the scope of the 7th question said, “……it didn't progress very well, but there are some very fantastic things.” He mention that although there are not very good photorealistic face animations, there are also works that can be described as successful. Niyazi Selimoğlu, within the framework of the 2nd and 7th questions, “… I think especially the recent works are very good” is stated that successful facial animations can be produced. He also said “…… I like keyframe animation more than mocap. I like those exaggerated expressions, exaggerated attitude more .. …..…” and emphasized that he does not prefer photorealism.

Participants Tanman and Gürüp stated that it is important to use Normal and Displacement Maps in order to obtain photorealistic images. Tanman also highlighted the importance of topology and the CPU processing power that enables the photo-reality in animation. Selimoğlu stated that reference is important both in terms of animation and modeling.

Ferhat Tanman said, "…. It is very difficult to make them without a high CPU power….. ..In production works ….. the arrangement of the vertexes and the topology structure in accordance with human, facial-muscle mimics play a very important role. …. …. As far as I can see, the thing that supports photorealism the most is the good use of normal maps and displacements in facial mimics and mixing and animating them." Gürüp, said, "……… the texture maps, displacement maps. Normal maps … Zbursh resources. I bought it from 3Dscanstore.com so my works became more realistic……" and drew attention to the importance of texture maps.

Niyazi Selimoğlu said, "….. the important thing here is the reference. I mean, it's like when we're actually making a character model. …….. the better the reference, the better the things we look at, the better the result we will get……." he drew attention to the importance of the reference.

Tanman described mocap technology as a necessity in photorealistic animation. Gürüp states that mocap technology alone is not sufficient for photorealism, and he basicly thinks that even if we transfer the mocap data to the 3D model, an animator's intervention is necessary. Selimoğlu draws attention to the importance of acting based on his mocap experiences.

Ferhat Tanman said, “We don't have any other alternative, let's just say that. ….. Because whatever we do with hand in animations, it is not as natural as motion capture, and it doesn't give us that realistic taste. …….. there are some natural human movements that are so specific that sometimes motion capture is the only solution.” and he emphasizes the necessity of mocap technology for animation.

Güray Gürüp “Remaking of Gollum .. In The Hobbit series, uh.. well, there are muscles inside, for example …… we do something with giving shape to geometry, but there are not many animators dealing with the muscles inside. …… The Unreal Engine team is doing it more or less, but they also have a constant intervention, so it doesn't work like that. They are working on a lot of things, so I think they are working on it. ….……”

Niyazi Selimoğlu says, “…….. the better the actor you have, the better the mocap you get…….. the better your technology and the better the actor you have, the better results you get. and so the project has to be appropriate.” He emphasizes the importance of acting in mocap technology and planning the project.

Within the scope of the 7th question Ferhat Tanman draw attention to the importance of mocap in overcoming the uncanny effect and expressed that successful works can be produced thanks to financial resource and technical support. Güray Gürüp stated that the only successful work on this subject is the character of Gollum and that he thinks that the uncanny effect is overcome in the future works. Niyazi Selimoğlu, in his answer to the question, states that visually very successful and realistic images of the virtual character are created with the help of mocap technology, which brings out

the perfect images. He states that this perfection distorts realism. However he describes the recent animations as successful.

Ferhat tanman said, “We can overcome the event we call uncanny valley almost only thanks to mocap technology.…….I think that the event we call uncanny valley can be easily overcome at this time. I can say that it is just a matter of opportunity and money.”

Güray Gürüp said, “….. There is only one job that does not seem artificial. …… Gollum. ….They remake it in the Hobbit series. There is no such effect. So it will happen, in the future. ……” and he talked about a character that are overcome by the uncanny effect and expressed his belief that this success will be achieved in other characters in the future.

Selimoğlu said, “…….of course it has improved a lot, but may be even the audience can still notice some things when they look at it. …… virtual characters okay very good indeed- visually very good. But in animation…. I think the perfect image still grins a bit. ……. A scene doesn't bother the eye that much, but the perfect image bothers the eye a little……. I think it's pretty good, especially the recent work.” He says that there is some artificiality in his facial animations, but that he has a viewing experience without causing uncanny.

Regarding the change in the team structure experienced with the inclusion of mocap technology in the production process, Tanman states that a phase such as processing the mocap data and cleaning the data that may cause the uncanny effect is included in the workflow. Mentioning that he has experience in game workflow, so process may differ for animation. Güray Gürüp mentions that this technology is not developed in

Turkey, and that there should be more designer who can be trained on mocap and mentions that such competent people can come together to talk about a team structure. Niyazi Selimoğlu, talked about the changing fields of expertise in the sector. In the past, an animator had to undertake many tasks alone in the animation production process such as modeling, rigging animation .. etc. Today the expertise are increased and the subject has begun to be handled much more specifically. Expressing this, Niyazi Selimoğlu states that this can develop and deepen in the sector, and new specialties and new fields of work may arise.

Ferhat Tanman said, “Of course, the things that motion capture changes in our game workflow are a lot. …… . At the moment, we have the data coming from motion capture when starting the animation…… The incoming mocap data usually comes from “AI tracking” systems if low-budget productions. ....…. First of all, you need to “retarget” the bones in the incoming data in your own skeleton. In other words, we had to transfer each bone's rotation, position, etc. from our mocap data to the other bone. ……. So for now, your job is mocap data cleaning and retargeting in the workflow. Afterwards, the animator has to fix the problematic areas that he sees as “uncanny” or such as interlocking bones, or combine them with his own animations.” used expressions.

Güray Gürüp said, “There is no one struggling for this reason. …….. But I mean, people are studying at his school…..……I am sure there are such deep, technical and artistic trainings that blend together. Well, those men are needed, those men are in the team. ….. We do not have such productions… so there is no man.” he said.

Selimoğlu said, “In the past, there were more general needs. …… So you were making the 3D character, maybe it was the place, you were doing the process of

dressing the character with the skeletal system, which we call rigging. Maybe you were doing the animation too. …….. In time, specializations began to emerge. ……. That's why new business areas are emerging for artists. I also think that this will develop and deepen in the future.”.

Ferhat Tanman states that mocap technology is advantageous in terms of time, and describes the movement as painting on the drawing with mocap data. Tanman, who discussed the financial issue within the scope of the 8th question, also states that the systems change in which mocap data is obtained according to the budget. And the data needs to be cleaned more in productions with less budget, in short, it requires a laborious process. Güray Gürüp expresses that mocap technology is costly, but he says that he cannot overstate this expense considering the achievement of the production. Niyazi Selimoğlu, expresses that the production process has definitely accelerated with new technology and software, and states that creativity is increased in this way.

Tanman said, “Of course, motion capture reduces the production time a lot because even if we think that we have a very bad mocap data, at least we have data and we work on it by taking it as a reference. …….. So, of course, I can say that it accelerated the work in the sector. Incoming mocap data usually comes from “AI tracking” systems for low-budget productions. For example, there are systems that produce motion capture data from videos using AI. ….. Indie developers mostly use them. There are systems where clothes are worn on a click (for example, one of them is optitrack if I remember correctly). I know that these are mostly used in medium-sized

projects. The process differences that I can see between them are as follows: AI-powered motion captures have a serious cleaning process." he said.

Gürüp said, "It is costly, but of course, when you look at the …….. gain of production,…….. Of course, it pays off."

Selimoğlu "Now, as software develops, time begins to shorten. …… a lot of software is coming out. And time is running out …… You can act more creatively because you save time. So it will probably get shorter in the future. Systems are evolving, software is evolving …….".

Ferhat Tanman highlight that there are people dealing with mocap technology in our country and he believes that the development of technology will progress in the direction of systems based on artificial intelligence. While Güray Gürüp stated that Turkey will follow the production processes of this type as a follower, he expresses that this process is facing difficulties in Turkey. He discussed with an example within the scope of this question and previous questions, especially that the effort and successful works are not appreciated and supported. Niyazi Selimoğlu emphasizes that he thinks that the development of technology will be used efficiently and competently abroad, especially in production, and states that the demand in Turkey is still far from production with mocap technology. He emphasizes that such technologies, which are also very costly, are not preferred much due to the different demand for audiences in Turkey. He emphasizes that such technologies, which are also very costly, are not preferred due to the different demand for audiences in Turkey.

4.3.2. Analysis of the Interviews

Within the scope of this part, the findings that emerged within the framework of the opinions of the participants in the interviews are examined and analyzed. Participants evaluated the subject both from the perspective of a designer and of an audience. Due to the limited use of mocap technology in Turkey, the lack of mocap experience in big production this technology is not emerged as a frequently used technology in Turkey. Participants are also expressed this within the scope of the interviews. For this reason, interviews are held as artists who make photorealistic works and know mocap technology, and as experts who evaluate the works made with large productions from the eyes of an audience.

The fact that photorealistic animations can be defined as "the unpreferred animation method" emerged as a finding that was not expected when the research was started. Photorealistic animation is actually assumed to be a successful animation that offers the viewer a new and pleasant experience.

All 3 of the participants stated that successful works are produced in photorealistic animation, but as a audience, Tanman and Selimoğlu stated that they do not prefer this experience. Although Tanman stated that photorealistic animation offers a more enjoyable viewing experience as an animation genre instead of a movie, he stated that he prefers to watch an animated movie with "realism that preserves the taste of cgi" instead of photorealism as an animation.

Also Selimoğlu stated that he prefer the traditional animation with the exaggerated expression. At this point, although the participants do not express this clearly, they talked about exaggeration and exaggerated expressions in the animations that they

substituted for photorealism and compared with photorealism. Selimoğlu talks about exaggeration in traditional animation instead of photorealism and Tanman talks about exaggeration in anime films. Tanman states that the audience experience created by these exaggerated expressions and photorealistic cgi animations are started to give a similar pleasure. This comparison is used to indicate a contrast. Participants who stated that they preferred exaggeration or that exaggeration offered an enjoyable viewing experience compared it to animations that included realistic expressions, gestures and movements. In this respect, facial expressions and expressions are described as realistic and non-exaggerated animations.

The participant also mentioned the phases that they consider important for photorealism based on their own experiences. The phases which are designers describe as important for photo reality are important for detailing in the 3D model. Displacement and normal map, as stated by Tanman and Gürüp, are important stages that will contribute to realism while creating the rough skin and the pores structure of the face. However, for photorealism in the 3D model, if we are going to transfer a copy of the real thing to the virtual environment as if taking a photo, then the use of reference is important. In other words, the points that the participants draw attention to the detailing of the character and the fact that realistic visuals are created by carefully observing and processing the character during the production phase.
This is the 2 main problematic in visualization and animation presented in photorealism. Within the scope of animation, Tanman emphasized the importance of topology. Preparing the topological structure of the model in a regular and simple structure is reduced the margin of error during animation. According to Selimoğlu the

use of reference is also important in traditional animation and animation production. Selimoğlu also mentioned that Mocap data is a reference information. Animations are also formed directly from this reference information.

The importance of mocap technology in animation should be emphasized. Participants mentioned the importance of mocap technology while evaluating. However, they do not only emphasized their importance, but also 3 of participants drew attention to the Mocap technology is not sufficient alone and animation should be supported for photorealism. While discussing mocap technology, Gürüp referred to the muscle simulations used in the character of Gollum, which he described as the only character that did not feel artificial to him. In the previous review, is discussed that visualization and animation are the two important stages for photorealism. At this point, it is noted that the simulations used are also important. However, it should be noted that the evaluated character is a stylized character and is used within the scope of a movie. The character is not evaluated within the scope of the thesis, as it is a stylized character and is not included in the full cg animation film. In addition, this character is described as successful by 2 designers. Selimoğlu also mentioned the success of the actor who played the character of Gollum. And he also mentioned the importance of acting in mocap technology. Since the success of the player is transferred to the expressions, movements and mimics of the virtual character, the animation ability of the actor is reflected in the character.

The use of mocaps in facial animations is also important in photorealism. Thanks to Mocap, facial animations are transferred by the use of mocap data of real-life live actors' movements, instead of being shaped by animators in photorealistic characters. This technology is important in order to overcome the uncanny effect. Tanman draws attention to the necessity of mocap in overcoming the uncanny effect. He also mentioned the existence of animations that is watched without the uncanny effect. Güray Gürüp also stated that the only character that does not seem artificial to him within the scope of photorealistic facial animations is the Gollum character. Expressing that he found this character successful, he cites this face animation, which has overcome this effect today, as an example, and expresses that he thinks that this effect will overcome in other character facial animations over time.

The question about the change in the animation production process is asked to the participants. According to Selimoğlu, the change in the production process led to the formation of new fields of expertise. And about the inclusion of mocap technology in the animation process Tanman, emphasized the necessity of animators and team members who processed this data in the animation process. In other words, both 2 participants highlighted that the the designers who are experts in mocap started to take charge in the team. The production process, in which animators are involved and 3D characters "animated with geometry" in the hands of animators, changed and gained a technical structure.

It can be said that animators deal with data, not images. Tanman mentioned that the process of cleaning mocap data which came from mocap systems based on artificial intelligence, which he experienced, and correcting the points that animators see as

uncanny, is included in the workflow. In other words, the task of the animator is not ended, but is decreased and turned into a technical structure. Regarding the production process, Gürüp states that it is not possible to talk about the existence of a team structure in Turkey, because the mocap technology is not available in Turkey.

In addition, the participants examined the change in terms of time and cost. Also Tanman and Selimoğlu highlighted that the mocap technology shortens the animation production process. This eliminates the animator's process of interpreting character's movement. The virtual characters, which come to life simultaneously with the movements of the actor, ensure the simultaneous completion of the animation process thanks to the mocap data. Also Selimoğlu mentioned that the acceleration of the process provides an opportunity to increase the creativity in process.

As part of the last question, the designers are asked to share future role of this technology and their predictions about this technology. The designers mentioned that there is no mocap laboratory or large production company with mocap system in Turkey. Within the scope of these researches, mocap laboratory for big production is not found in Turkey. However, Tanman mentioned that designers with small and medium budgets try to create animation using artificial intelligence-based mocap systems with or without markers. These artificial intelligence-based mocap systems, which are not preferred within the scope of big productions, reveal data, but this data needs to be processed.

4.4 Analysis of the Photoreality Notion in Mocap 3D Facial Animations

Animation is a branch of art in which the illusion of the inanimate being alive is created by using various methods and a moving representation is created visually with shapes. Just like a movie scene, it can be said that the animation scene is created with visual and aesthetic concern. Therefore, it can be assumed that the animation audience prefers to see a representation of reality rather than as it is. In the first examples of animation, animations are made using stylized characters. This search for representational visuals are changed and developed with the evolution of technology and the introduction of computers into the animation production process.

3D visuals have become more and more realistic and nowadays it became a situation where visuals that are difficult to distinguish from the real can be created.

Today, thanks to the photorealistic approach, artists and animators, directors and producers found a new method of expression and "the animations created with this new method is attracting the attention of the audience, especially with the popularity of home entertainment systems and computer games." (Los Angeles Times16 Nov 2007Section C, p.1; akt: Warner Bros Ent.).

In animation, which is a narrative art, the most important communication tool of the character is expression and facial expressions. Today, with the development of 3D programs and computer technologies, it became possible to obtain very realistic images. Realism is also increased in 3D characters, and the modeled character gained the quality to have the real-life image of the modeled.

Especially in virtual human characters, this realism is increased, but at this point, the effect called uncanny is revealed. The Uncanny effect reveal when a person distinguishes between his developed instincts and what is different from himself. As the realism increases in human characters, the familiarity that develops towards the character can be defined as the formation of the feeling of "eerie" with movements or expressions that is described as unusual in the character. The Uncanny effect is discussed in many ways and explored in academic literature. The most well-known research today is put forward by Mori (1970). As 3D characters appear, the uncanny effect that these characters create on the audience is investigated by many researchers (Geller (2008), Tinwell (2011), Melki (2019), Falip, Castells &Escudero(2009)).

Two important factors are identified that cause the Uncanny effect. One of them is disruptions in visualization and the other is disruptions in movement. Today, thanks to the developing computer processing power, 3D modeling programs and add-ons, realism in 3D visuals can be easily achieved. However, providing realism in the animation phase is an important problem. At this point, mocap technology plays an important role. It is possible to talk about 2 basic mocap systems for body and face animations (Falıp, Castells, Escudero, 2009, 1). Especially facial animations still continue to be one of the most important problems in photorealism in order to overcome the uncanny effect. Today, successful animations is produced and the faces of photorealistic characters are carefully modeled, as it is of great importance in overcoming the uncanny effect. From the movies Polar Express until today, it is possible to talk about the existence of photorealistic animations that do not create an uncanny effect on the audience. In particular, the facial animations in Final

Fantasy:Kinsglaive are very successful in overcoming the uncanny effect. Within the scope of examining the faces of the characters in this movie, seen that detailed models and successful textures are used and realistic characters are revealed.

In addition, mimics and expressions transferred with mocap are successful. However, it should be noted that this success are limited to the main characters. Side character animations do not reach the level of realism that the main characters had. The same is said for the face animations of the movie Gantz: O. Although the uncanny effect is overcame in the characters, the monsters that exist in the movie create an uncanny effect on the audience. Although it supports the argument that character and face animations are produced successfully, it does not mean that the uncanny effect can be overcomed 100% without depending on the character face animations. Also, about the uncanny effect, the participants stated that successful photorealistic animations are produced. However, they highlight that there is still an artificiality in animation. Photorealism also draws attention as a form of animation that is not preferred by Tanman and Selimoğlu. Because although photorealistic animation scenes still have a visual concern, they are closer to a movie frame than an animation frame.

At this point, Tanman says, “So when we look at it, knowing that it is CGI rather than feeling like we are watching a photograph or a movie, it gives me a much better taste for it to look realistic.”. In other words, this “cgi taste” can be associated with the representational, symbolic or artistic aspect of animation. It is possible to see this representative aspect in The Adventures of Tintin (2011) movie. The characters are the characters created by keeping the original images in the cartoon and by referring to the faces of the actors who portray them. (Melki, 2009, p. 178). The expressions are

realistic and in harmony with the realism that exists throughout the film. Expressions are crucial in supporting photorealism.

Images should be prepared realistically in photorealistic animations, and movements should be animated with mocap technology and presented realistically. On realism, Tanman and Selimoğlu also emphasized that exaggeration adds a pleasant taste to animation. They compared this experience to mocap. This comparison are made to indicate a contrast, so it can be assumed that the participants described the mocap technology as realistic and non-exaggerated. However, the expressions of the Polar Express movie characters are also exaggerated at some scenes. It is not an exaggeration obtained by deforming the face of the character in traditional animation mentioned here. However, the expressions of the actor portraying the character are exaggerated instead of the natural expressions given in real life.

In this respect, the importance of the actor's ability to act should be emphasized. Mocap technology creates identitiy. The mimics obtained during the animation of the actor are directly reflected on the character. Because of this identitiy, the success of the virtual character expressions and mimics is proportional to the ability of the actor. In order to ensure this identitiy, the character's 3D models and mocap data must be matched. The proportions of the character and the actor must match in order for these data to accurately convey the movements of the actor portraying him to the virtual character. One of the main hypotheses is that the facial expressions of the characters in photorealistic animations are realistic and far from exaggeration. Two of the participants confirmed this hypothesis by comparing photorealistic animation and expressions with traditional animation. In addition, within the scope of the analyzes,

one-to-one in the expressions is observed, but it is observed that the expressions are exaggerated in the main characters within the scope of polar expressions. This is changed with the player's (Tom Hanks) animation ability. Tom Hanks exaggerated his expressions during his animations.

Characters are designed by considering the body proportions of the actor in photorealistic human characters or the faces of actors and actresses in facial animations. This situation is observed in the 5 films examined within the scope of the research. Virtual characters are prepared taking into account the structures of the actors. The rest is the actor's own acting talent. In the interviews, Selimoğlu and Tanman emphasized this identical and drew attention to the availability of this identical with high-resolution cameras in large studios. Also, within the scope of the 8th question, Tanman said, "What is remarkable here is that if we make the skeletal system and the character according to the actor and get the motion capture data from this actor, everything fits perfectly." This situation basically reveals the importance of mocap technology in overcoming uncanny. This importance is one of the main hypotheses put forward at the beginning of the research.

In Mocap technology, this identically is important in creating photo-realistic motion and animation. Within the scope of the interviews, Tanman described this situation as a necessity rather than an importance. Because people express that we can transfer the nuances of movement only with mocap. For the characters animated by the animator, the movement can only be conveyed by interpretation. However, mocap is effective in reflecting as it is. So it is also important for overcoming uncanny. Because no matter how realistic the character may seem, the human eye will notice the disruptions in

movement and the mind will perceive it as a danger signal. It is necessary to provide that realism in each frame of the animation scenes. For this, mocap technology both provides advantages in terms of time and reflects the accuracy in movement in terms of identically. In other words, it is effective in providing realism in order to overcome the uncanny effect in accordance with Mori's graphic. Therefore, mocap technology has an important role in overcoming the uncanny effect.

The first examples of photorealistic films, show that the uncanny effect is not overcome even when using mocaps in facial animations. This is because of the character images are not photorealistic. First, the realism in 3D visuals must be provided, then the realism supported by motion can overcome the uncanny.

Thanks to the improvements made in order to overcome uncanny and the helmet tracking systems, especially for facial animations, it becomes possible to produce animations that can overcome the uncanny effect in character facial animations.

In addition to the effective use of mocap, changes in the team structure and production process are also discussed. Participants also evaluated mocap systems in terms of time and cost. Expertise and team structure in the field are not developed in Turkey. Designers in Turkey serve as freelancers in and abroad, but although successful works are produced in photorealistic visual production, the existence of a competent team in animation is discussed. Mocap studio in Turkey could not be found on the basis of researches. There are news about mocap studios of universities, but no sharing found about the system.

Participants mentioned that there are no big studios and drew attention to the low number of people dealing with facial animations in Turkey. In addition, Tanman

expressed the use of artificial intelligence-based tracking systems in small and medium budget game productions in Turkey in line with his own experiences. He stated that the motion data obtained from these systems is not as clean as the data obtained within the scope of big productions. Selimoğlu and Gürüp also drew attention to the fact that mocap technology is not used in our country or it cannot be used due to the low number of competent person.

When asked about their future predictions, Tanman predicted that systems based on artificial intelligence would develop further. Selimoğlu and Gürüp pointed out that the audience demand and habits are different in Turkey and expressed that they think that there will not be much content to be produced with this technology.

Gürüp and Tanman also drew attention to the photorealistic images used in the "Love Death and Robots" series while describing photorealism. This series can be watched on the Netflix platform. Within the scope of the film analysis, the existence of 3 films belonging to the "Resident Evil" series and the Resident Evil series, apart from this series, are mentioned in the Netflix contents. One of the analyzed movies, Gantz:Q, is a production that can be watched on the Netflix platform. And photorealistic content is increased in this content platform, especially in 2020, 2021.

Due to the Netflix privacy policy, the viewing statistics of these contents could not be reached. However, the recent addition of photorealistic productions that are developed since 2016 to the Netflix library is considered as an indication that there is a demand for these contents.

At this point, the accuracy of the hypothesis that photorealistic characters are used more widely in animation production processes can be discussed. The prevalence of animated films using photorealistic characters also supports the prevalence of photorealistic virtual characters, which is the last hypothesis of the research. In addition to the animated films examined within the limitations of the thesis, photorealistic characters also develop within the universe of games, cinema and the metaverse universe, which is a new concept today. Photorealistic characters called meta-humans will not only create visual content, but will also become important communication tools that represent us within the framework of the metaverse (Özcan, 2021).

The findings revealed within the framework of the subject discussed within the scope of the interview and analysis support the hypothesis. However, due to the limited number of participants within the framework of the interviews, the subject could be examined within the framework of limitation.

The research can be repeated with different participant groups within the framework of further studies. While discussing the subject, the main question of the thesis focused on whether the characters animated with mocap 3D face animation can overcome the uncanny effect.

The answer to this question is sought, and within the scope of the research, it is concluded that today, photorealistic animations can be watched almost without feeling this effect on the characters.

Within the framework of the research conducted using the qualitative research method, 5 film analyzes are made and 3 designers are interviewed. The fact that

mocap technology are not developed there are limited number of experts in Turkey. Limited number of these experts produce photorealistic works on facial animations. For this reason, the subject is examined within the framework of the interviews with 3 participants, after only 3 participants affermative feedback due to the limitations of the pandemic, the limited participant candidates, and the busy schedules of the candidates.

These 3 designers undertook various tasks during the production phase of the animation production process. Also in film analysis, analyzes are made considering the animation production process. In this respect, the subject is evaluated through the production phase. In this way, it is focused on the production process, which is important for photoreality. Participant Tanman, mentioned that he evaluate the production process with game workflow and that there may be differences in animation production process. However, the mocap animation production process is examined within the scope of photorealism. The subject is researched on photorealistic facial animations and research is continued on the limitation of photorealistic virtual human characters. In literature research no findings are found which conflicted our findings.

In particular, Melki's doctoral thesis is emerged as the most effective academic literature in the field, and focused on photorealistic characters and the uncanny effect. However, face animations and mocap technology, which are the focus of this thesis, are separated from his study.

5. CONCLUSION

Today, thanks to advanced computer technologies, designers are competent to produce photo-realistic images. This success in visuality should also be supported by the movements of the character. While animating the character, mocap technology plays a key role in producing more realistic animation. The character's face is key in communication, and facial expressions must be accurately reflected in order to overcome the uncanny effect. According to the findings within the scope of interviews and analysis today, although the uncanny effect is not 100% overcomed, it can be said that it is largely overcomed. If human character faces are to be animated with a photorealistic approach, modeling the character by taking into account the face of the actor who will animate it helps to create more successful animations. Facial animations can be transferred directly from the actor's face with the mocap. According to these accurately animation visuals, the realistic actor's animation can also be described as realistic and far from exaggeration. Photo Realistic characters are used in movies, TV series, animations and games. Photorealism may not be preferred in animation, and there are animations that can be described as successful. Photorealistic animations have started to increase on digital content platforms. In Turkey, this technology is still in a developing stage.

Within the scope of this thesis, the success in animation of character face animations animated with mocap technology is examined and analyzed within the scope of photorealism. The findings reached within the scope of this thesis could be examined within a certain limitation, especially due to the pandemic limitation in the number of participants and the low number of experts at this field in Turkey.

For this reason, it is recommended to examine the subject in more depth in future studies. In addition, within the framework of the research, the participants stated that they do not prefer photorealism.

The subject can be evaluated in a new context on why photorealism is a visual language that the audience does not prefer in animation. In addition, in the interviews, the participants talked about the expensiveness of the production process with mocap technology in Turkey. However, it is stated that the audience's demand is not thought to be in this direction. The difficulties of production in Turkey with this technology may come to the fore as a subject to be investigated in depth, ethnically, culturally and geographically. Meta human, virtual characters, nowadays are heard frequently. It can be predicted that photorealism will come to the fore in the metaverse as well. A study can also be made on the role of these characters in the animation and communication for the future.

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APPENDIX A

QUESTIONS OF INTERVIEW

1) Could you introduce yourself and talk about your field of work in the sector?

2) What do you think about photorealistic animation? How would you evaluate animated films made with a realistic approach? (designer/ audience perception)

3) What are the stages in the animation production process that you consider important for photorealism?

4) How would you interpret the importance of Mocap Technology in Photorealistic animations?

5) Have you ever been involved in a project in a movie where mocap technology was used? Would you like to take charge?

6) How effective are facial animations in expression transfer? How would you interpret the importance of Mocap technology at this point?

7) Do you think successful facial animations can be produced? Do you think that the photorealistic animations overcome uncanny effect? What is the role of Mocap technology?

8) Did the change in the process cause a change in the team structure? What kind of transformation can we talk about?

9) How did it transform with mocap technology and photorealistic animation, production process in terms of time and cost?

10) What do you think are the effects of such changes on the film/animation sector (negative/positive) ?

11) Finally, how do you envision the future of this technology? What will be its place and future in the country?

Appendix B

The Interviews with Participant Ferhat TANMAN

(25.10.2021)

1) Could you introduce yourself and talk about your field of work in the sector?

I got the Bachelor Degree from Economy, It seems I am working in a not related sector but I was interested with 3D topics as a hobby. Later I thougt 'I already have a company why am I not dealing with this topic in a more professional manner' and I developed this business. I also had a desire to design and develop a game and we were attending game jams together with my friends. For this purpose we designed some games. Thats why although basicly this was not my main business I progressed a lot. I think by February 2022 hopefully this is going to be my sole and main business.

Normally I was always concentrated on the characters, as in small teams almost everybody develops environmental models called 'environment' but when you deal with characters things become more complex. This is why the people around try to avoid modelling characters a little. I tried to fill this gap as a 'team worker' as a bass player in a music group. As I loved drawing cartoon characters since I was a little boy I started doing this business with such a desire later on. I was working in the family company but this business also became something that I deal professionally as a hobby.

2) What do you think about photorealistic animation? How would you evaluate animated films made with a realistic approach? (designer/ audience perception)

I actually do not like photorealism much. I am trying to create characters close to photorealism to challenge myself. I really pushed myself to do it. I was trying to do coating painting saying 'can I reach photorealism by hand' without using Cross-polarized photographs or scanned data. I went towards this way to progress myself. I did not mean to create something that is photorealism oriented but sometimes I had to created character animations close to realism that kept the taste of game graphics as much as possible in the games. As a said I don't like photorealism much but I liked a lot the fantastic photorealistic images in the Love, Death and Robots series at Netflix. At the same time it kept the CGI taste. I mean somehow being realistic knowing that it is CGI gives me more taste than watching a photograph or film.

3) What are the stages in the animation production process that you consider important for photorealism?

This is a comprehensive question. I mean you should be really educated in this field and I have doubts if I am. When you talk about Photorealistic animation you need a huge processing power as you know. Without a huge CPU power it is impossible to do it. That's why personal Artists like us don't deal with it. Generally we have friends doing photorealistic animations like mimics and face animations on small scale using our limited resources at home or other other small opportunities. I have some trials on this issue. I can say that the topogy is the most important thing in this issue. Altough it seems that we have

almost ‘infinite’ number of poligons it plays an important role of array of vertex and the topology being coherent with human face and musce mimics. That’s the reason why I can give the first priority to topology. The second priority which supports the photorealism most is the good use of map and displacements on the face mimics and movement by mixing them. I saw on Youtube studies developing unbelievable realistic tissues using only displacement and normal map. I don’t remember the name who did the study but I can find and tell you later. Unfortunately I don’t have a detailed knowledge of whole body animation.

4) How would you interpret the importance of Mocap Technology in Photorealistic animations?

I should say we don’t have any other alternative. Because whatever we do with the animations created with hand we do not have as natural and realistic with the ones created with motion capture. Of course there are some creators whose excellent hand creations sometimes cannot be distinguished if it was done using motion capture. But there some specific human motions that needs motion capture as only solution.

5)Have you ever been involved in a project in a movie where mocap technology was used? Would you like to take charge?

No. I did not ever take part in Productions. I did not intend to take part. I am not interested in Production and Film sector. I only work in game sector as

much as possible. I dealed with few product visualization with an enthusiasm. Except from these I always worked in game sector.

6) How effective are facial animations in expression transfer? How would you interpret the importance of Mocap technology at this point?

Pretty effective of course. I can even say very effective. I worked on face animations in game engines a lot. I cannot give you image records at the moment but if you wish later I can send you parts of videos about face animations that I worked. For example is there something like in motion capture, with the improvement of new iphones they can follow the face mimics in real time. I saw lately that they developed a plug- in for Unity game Engine about this. We can see studies about this in social media. A personal mobile phone owner (If I am not wrong Apple ARKit) can successfully create nice face mimic animations. The feeling transfer seems to be successful also. As the result depends on the Artificial intelligence to recognize the human face only few small problems exist for the portions it could not recognize. They can be corrected by changing some multipliers on the engine in this way there are results that I can term as satisfactory. More qualified people at a glance can feel a problem which is not natural like a painter investigating a paint. I can say it is not so easy to distinguase these.

7) Do you think successful facial animations can be produced? Do you think that the photorealistic animations overcome uncanny effect? What is the role of Mocap technology?

We can overcome the Uncanny effect almost only by mocap technology. I can hardly imagine the present stage with the development of the technology at the moment with the high tech cameras, highly developed equipment, high number of cameras. We can only talk about the situation with the developments we can see in movies. That's pretty good, of course. Just as I can no longer feel the uncanny effect, I sometimes feel that it is much more enjoyable than watching a movie. In animes the mimics of some characters are exaggerated much but still we like to watch, watching some GG characters are like this. That’s why I think the Uncanny effect is overcomed easily today. I think it is only amatter of money and facility.

8) Did the change in the process cause a change in the team structure? What kind of transformation can we talk about?

When we talk about the change in the workflow as I am not in production business I don’t have much idea about it. There are a lot of changes in the game workflow due to motion capture. But in production as far as I know its effect is completely different that’s why I think we have to consider them seperately. You create models in game. There is a rigging period. In the old days immediately after the riggers doing the test rig animators started doing the animation and everything was finalized after they finish. Now we have the data ready coming from motion capture while starting animation. I should also note that the working structure of indie (independent) game developers and AAA studios may differ. I generally work with independent and a bit more experienced average developers that’s why I can give information at this

level. If the production has low budget the generated mocap data are generally coming from “AI tracking” systems. For example there are systems that use AI and produce motion capture data from videos (for example rokoko and deep motion) generally independent designers use such data. - There are a little bit more developed systems where you wear costume like optitrack. As far as I know These systems are more preferred by midisize projects. The difference between them is in AI supported motion capture there is a serious cleaning process, the incoming data about the bones should be retargeted on your skeleton. For every bone rotation, position etc. should be transferred to the other bone through mocap. This is what I know and observed may be there are systems that does the job as good as this that I did not observe. - As far as I can see the data generated from systems using motion capture costume are much better. I am sure the AI systems will be much better in future I am really hopefull about the machine learning and AI. Lately we observed various techniques. For the time being mocap data cleaning and retargeting is in our workflow. Later the animator corrects the parts that is considered as uncanny or intertwining bones or inserts the created animation parts. If we consider in large studios the process of capturing the moves of the actors are adjusted very sensitively using the system with costumes. For example an actor gives “T pose” (Stands still with holding the arms on both sides as if the body is like a T) and starts acting and the recorded data is transferred directly to the character modelled for the actor. If the skeleton (movement of body) and the character is designed according to the actor and get the motion capture data from the actor everything will be fit.

I would like to stress again that the our financial status specify the process. I mean the money spend (budget) for mocap system and for the actors.

9) How did it transform with mocap technology and photorealistic animation, production process in terms of time and cost?

Of course the production time gets much less using motion capture as we have at least a data that we can use and work on even if the data is not generated very carefully. At least like we have a kind of skit and we paint. That's why the work speeds up in the sector. But we should keep in our mind that the dynamics of Game sector and film production differ a lot.

10) What do you think are the effects of such changes on the film/animation sector (negative/positive) ?

Absolutely it is positive this is indisputable.

11) Finally, how do you envision the future of this technology? What will be its place and future in the country?

As far as I can see some people in our country are interested in this business. I know few places in game sector. It can be discussed if they use the technologygood or bad but they are working. Even few freelancers has the cheap suits and the sensors suitable low budge like Rokoko. Nowadys I know some frelancers having systems with camera. Some people work in this area. Except from them as far as I can see independent developers or medium budget projects seems to tend towards artificial intelligence systems generate

mocap data from videos. This is my idea of course. As I tried deep motion and these systems give nice data. You make a video you just record a motion in front of the camera and the system creates a nice animation that you desire through its skeletons which are compatible game engines. I know that there are lot of studies in this area and that's why I can say the future works will mainly will be in this field. There is a saying that the ' The Telephones and the Televisiong got smaller and we carry tem in our pockets' now we carry computers (mobile phones, processors) in our pockets and they are getting smaller and will probably reach microscobic size. Probably of course with Artificial İntelligence systems will enable to use less cameras, less costumes, and high qualiy and there will be more investment in artificial intelligence systems. That's all I can say.

Appendix C

The Interviews with Participant Güray GÜRÜP

(03.11.2021)

1) Could you introduce yourself and talk about your field of work in the sector?

As I said, I entered the industry in 2010. Pyramid Advertising Agency in Istanbul, an agency that used to be partner of Manajans, it is one of the oldest. For a while I gave graphic design services there. Then I did my military service. After that, we opened our own office in our hometown in Eskişehir. Well, we were providing basic graphic design services. I am somewhat versatile. Ah.. so there is illustration, there is also digital painting. I was doing basic graphic design works, photo manipulation, aaa creative works, anyway I was doing the whole thing.. But in 2018, I stepped into the 3D world. Actually, it goes back to old times, but when money making concerns were in action, I couldn't show much interest. I have been working on modeling solutions and photorealistic works since 2018. Whenever I have some time. I'm still working on 2d motion graphics. Ah, the sector actually is not, I can say, it is not very productive in Turkey. However, I was able to do business with a few people from abroad, on photorealistic works. Also, in 2011, I entered Anadolu University Department of Graphics. But I didn't want to continue. I didn't think it would add anything to me. I drew my own path. Both are difficult, being an academician is also difficult. It's also hard to start your own business, but that's it for now, I'm fine for now.

2) What do you think about photorealistic animation? How would you evaluate animated films made with a realistic approach? (designer/ audience perception)

Lastly.. Was it "Love Death and Robots"? There was such a series that I saw that this kind of work was featured on Netflix the most. So, I follow most animation companies that make them on their instagram accounts. They share it later, of course, but with interest (coughs) to see if they did it. (coughing) Sorry. I'm examining it again. a.. we don't have it in Turkey. I am actually preparing my Atatürk project for such a job. Ah.. in order to have something usable in production. I am constantly trying to improve in my free time.

I think I answered the question.

-Yes, thank you very much. it was enough

3) What are the stages in the animation production process that you consider important for photorealism?

I am trying to develop in animation to model Atatürk's face mimics as close to as reality. I work with the "blend shape" logic. Trying to give that expression in Zbrush and then transferring to Autodesk Maya and blending. Of course there are manual rigs like chick rigs eye rigs. Well, I couldn't find the opportunity to sit and complete it yet, but I completed an old version. Well, I deleted it and did it again. It was not delete really. Well.. I had further losses though. So I'm constantly trying to improve. I think the most important process here, the technique of models, is important. Also, Atatürk is a very difficult subject, so there are a few men, I will send them to you. It's super, they're even older than me in the industry. In other words, when you look at it,

the number of likes is more than for the Atatürk I did. But come see if it is okay? It is not. I can publish my first animation now. I don't know where I can sell it, but somebody says it is not okay. They will say it is not okay, so everything should be perfect. Obviously, someone an animation studio can support this, but …. the connections, the jealousy, the ignorance is always like that. You are by yourself nobody helps. Well.. the most important step is something else…. I buy scanning technologies. The texture maps, displacement maps. Normal maps … Zbursh resources. I bought it from 3Dscanstore.com so my works became more realistic and I don't think I could use them literally. I have more to learn, too. Well, I'm sorry, I got a call, I'll be right back. (. ……) Does my voice sound?

-Yes, I can hear now.

That's right, but model's are very important, but modeler will soon be meaningless.

We don't have such studios at the moment, but I mean, they sit the actor to portray a Wolverin character, they shoot it with the domed camera technology, I don't know its full name. Then they do the cleaning. Just like those websites, sites like 3dscan.com,I don't know how they do but they do those steps. Even film companies work with such places. Of course, there are men like us as their directors. It will not matter who do these cleanings, who do these animations soon. Perhaps this line of business will also atrophy. But modeler are always good.

4) How would you interpret the importance of Mocap Technology in Photorealistic animations?

What you call mocap technology, are these scanning technologies or?

-Motion Capture

We're talking about Motion Capture, okay. Those technical guys are not going too far right now. They're dealing with a lot more with those muscle structures —I mean, underneath.. — I bought a 60-hour Blu-ray set of The Lord of the Rings Hobbit series from abroad. It tells 60 hours of both films behind the scenes. The reconstruction of Gollum ee in The Hobbit series ah.. well, there are muscles inside, for example, we don't know it yet, I don't know it yet. It's just that we do something with geometry, shaping it, but there aren't many animators dealing with the muscles inside. There is no technology that can simulate those muscles, so capture… - There is nothing you can capture like in motion capture. Aaa.. The Unreal Engine team is doing it more or less, but they also have constant intervention, so it doesn't work like that when I bought the data and put it in. They are contradicting a lot, so I think they are working on it. But of course aaa .. I mean, if I have a new Iphone, I use Iphone8. Right now there is a new application, I will try it there, but I am sure I will not get good results, so high-budget motion capture technology is needed for it. Everybody doesn’t have it, of course. That's why I deal with blend shapes.

5) Have you ever been involved in a project in a movie where mocap technology was used? Would you like to take charge?

Sure, I'll get it tomorrow. I would like. I didn't get it eee.. it's not here, it's not in Eskişehir. I don't know who owns this technology in Istanbul. But right now I have a few meetings so I'm trying to get someone to push this. Especially augmented reality will become very important. We did a few things about it, for few municipalities in Eskişehir, this is how it is now ... with VR glasses or something, so... a digital museum can be built. A lot of things can be done, of course, using this. So you know, something called Metaverse is coming. It will be like a copy of our world, and the importance of such technologies will become more apparent. I make sculpture and physical sculpture, I also produce sculpture from concrete, I give digital support there in the workshop for one of our brothers. We made huge sculptures. Made of concrete. Well, it's not an easy task, but these are now … will always be digitalized. That's why you need to be positioned early. Well.. it is necessary to invest in such technologies now. Even a municipality should make this investment. Instead of doing something ridiculous... the city could miss something and invest in something like that. Better I think. Let's see.

6) How effective are facial animations in expression transfer? How would you interpret the importance of Mocap technology at this point?

So like I said, it still sounds very artificial. Aa.. Even in very good productions, we couldn't catch the thing aa.. as human beings, aa foreigners do this job, usually the best ones. Aaa.. there is still an artificiality, I do not know how they will solve it, so it didn't progress very well, but there are some very fantastic things.

7) Do you think successful facial animations can be produced? Do you think that the photorealistic animations overcome uncanny effect? What is the role of Mocap technology?

-……. I did not understand the question …… I understood the first sentence but you used a term there I guess I did not understand it

- Well, this is actually a point where the photorealistic characters disturb the viewer, it creates a sense of uncanny.

- Huh, what is it called?

- It's called the Uncanny or the uncanny valley or the uncanny effect.

- Huh, I didn't know. huh

Do you think that this uncanny effect can be overcomed in this way, or do you think that mocap technology will play a role in overcoming this effect?

There is only one job. There is only one job that does not seem artificial. How they did it. Gollum. The character of Gollum may be in The Lord of the Rings because he is something created from scratch and he has a past, but I think he is the best character ever. I think it's great. They recreated Gollum from scratch by employing the old concept designers, though aa.. They also did it again in the Hobbit series. It is not there, so there is no such effect. So it will happen, so this is in the future. Of course, I don't know what your opinion is, did you watch them, I think I don't get that thing of Gollum in The Hobbit series, even that artificial effect in most of the goblins.

8) Did the change in the process cause a change in the team structure? What kind of transformation can we talk about?

-Is it in the sense of animation production?

-Yeah yeah

-I mean, I don't think there has been any change yet in Turkey, because there are not many people who do it. if you buy it, you make a little investment. You can do body animations for a few 100 thousand liras, but there are no facial animations in Turkey. I know it’s not present. No one is working for this. Someone crazy will come out or do it himself, he will develop it. I mean, because he can't bury that money. So the team says.. -So noone knows about it. But I mean, people are studying at his school, so... now we didn't get that kind of education, but I'm sure there are such deep, technical and artistic trainings that blend together. Well, those men are needed, those men are in the team. I mean, they are part of a big structure, so how else will those guys affect the team? We don't have such productions... so there is no man. You know, if the man goes to production, if there is demand, if they come to study abroad, there is no such thing. We sell works to the world or to certain standards, either the Balkans or the Middle East. We did not manufacture these. They are all developed by foreigners. We even follow them very, very far behind. As I said, the number of CGI designers in Turkey is not more than 10. Thats it.

9) How did it transform with mocap technology and photorealistic animation, production process in terms of time and cost?

Time and cost. It is costly, but of course, when you look at the income of production, i don’t know. Of course, it pays off. I think it gives a lot. Well, I

mean—what you did, for one thing—they took Robert De Niro, Al Pacino, and rejuvenated them. And they did it through videos. In other words, no one could have done such a thing 50-60 years ago, but now it is being done.

10) What do you think are the effects of such changes on the film/animation sector (negative/positive) ?

Of course, positive effects sometimes negatively affects the actors. Sir Ian McKellen, who plays Magneto in many X-Men plays Gandalf, and many other English games, revolted. For example, he rebelled and got bored with playing in front of the green screen and not having an actor in front of him. So in the next middle-earth project—he's already old enough and probably won't play. Well.. I don't think he acted willingly in The Hobbit, but I mean, it's hard for an old theater actor, but the new generation knows this and participates in productions. So of course it's positive. Oh, the new beats the old, of course, the taste of all kinds of old ones is different, but now the new Lord of the Rings series is coming. What Amazon Prime has done—that is, it will contribute to all kinds of old, but it will beat the old, I'm sure.

11) Finally, how do you envision the future of this technology? What will be its place and future in the country?

We, as Turkey, will follow, but as I said, we always follow from behind. Nothing you didn't develop yourself, ee.. so everything is sluggish. So why don't I just deal with this why my monthly earnings are not 3000 dollars 5000 dollars 6000 dollars? Why so? That's what they say in the 19th century, they

say it's like every specialization age. I want to specialize, as I get special, something happens now. I mean, even if I did that job with him or not, I don't enjoy that job very much, but I also need to earn money. Oh! I spent my life with it. I mean, it's more or less okay, I did the job at a certain standard, but—for example, I'm modeling a mask for a child. I'm making textures. And they say, "Are we going to put it on the stock photo, brother, can you model this kid?" But I say this is not cheap, I mean you have to pay more than you pay for the mask. They don't understand this! And I'm barely doing it with low budget. I am really doing it good. The camera should bend at an angle to show the details of the mask. Well, the child also needs to be realistic. You have to buy resources again for it this and that. I mean I'm sure in the future. We could not have imagined them anyway, foreigners discovered and revealed. They will bring out even better ones, and we will follow them. I think it will be like this.

Appendix D

The Interviews with Participant Niyazi Selimoğlu

(09.11.2021)

1) Could you introduce yourself and talk about your field of work in the sector?

My name is Niyazi Selimoğlu. I was born in 1984 in Rize. Actually, I got the Bachelor Degree from Economy. But because of my interest in games, I started this business years ago. Then I worked in some game companies, I worked in production companies. I have worked full time or freelance. I mainly produced 3D assets, sometimes 3D characters, sometimes an environment model etc. If something else is necessary except from the game, I also did them, such as particle effects, in general, I worked like this for about 10 years. After that, I've been working remotely for a few years now, completely freelancer. I make 3D models and sell them, sometimes I work as a volunteer. This is how I continue.

2) What do you think about photorealistic animation? How would you evaluate animated films made with a realistic approach? (designer/ audience perception)

Mocap has been developing a lot lately, for example, after the Avatar movie—it was the best mocap avatar I've seen in 2019, sorry in 2009—it's been used often in movies after that. Well.. of course, the better the technology you have, the better, but the actor in your hand must be good too. For example, think of the Lord of the Rings, Gollum character, it makes a big difference that the

acting is actually good in mocap. Well, how can I say about, actually I like keyframe animation more than mocap. I like those exaggerated expressions, exaggerated attitudes, but as I said, mocap is overused in animation production. Mocap can handle many of your tasks. It can also ease the work of the animator. It gives them a nice reference. Let's see how it will look in the future, even now when I look at it, maybe it's a bit of a grin, maybe a little bit, but uh... I think it was pretty good. Maybe very realistic animations on mocap in a few years. In fact, some actors are talking about it now, because you know, some actors are getting old -- getting older -- they can't get into every role. Even Cem Yılmaz made a statement that maybe I could do things like shooting a movie with a virtual character in the future. Let's see, we'll see. I think it's going pretty well right now.

3) What are the stages in the animation production process that you consider important for photorealism?

-What are we going to talk about here, is it that important mocap or are we talking about hand-made animation? So from Keyframe animation.

-Well, 3D is photorealistic, but if you wish, you can give examples on others. So it's no problem for me.

-Can I have the question again? I missed a bit

-Of course (question asked)

So, as I said, animation is not a subject that I am very familiar with. But when I look at the production stages that I watched, the important thing is, for example, if you are going to animate a lion, you bring it to the studio and

attach sensors to it, all the movements, actions, behaviors of the lion -or bring a horse or bring a cat and follow them. Such things can be used. And by looking at them, a realistic animation can be made by referring them. The same thing actually goes for the keyframe. Well, for example, as I said in the movie lion king, a lion is brought to the studio and here's how it is done because its movements are followed, how does it act, how does it behave? As I said, the important thing here is the reference. I mean, it's like that when we're actually making a character model. When we are going to produce a character, well.. the better the reference, the better the things we look at, the better the result we will get. So that's probably it. Good reference.

4) How would you interpret the importance of Mocap Technology in Photorealistic animations?

-So yes, as I said, these are the things I know, I'm not an expert of the subject, so I don't know what to say. mocap..

-Well, you can interpret it from the perspective of a spectator. It's not a problem for me if you share your thoughts. Thank you very much.

The mocap looks, how can I say, well, when you look at it realistic, you know the expressions, gestures, movements, etc. It's very real, but it's also a bit of an artificial image. Because, as I said, the better the player you have, the better the mocap you get. So it also depends on the performance of the players. The actor is so good in the Lord of the Rings character. He portrayed the character so well nothing is left for the animator. But there are some mocaps, for example, we used it in a game project and the mocap artists were very amateur

and bad, so let's be honest, we had to fix many things. We did a project in Los Angeles, I was working in a company in Beşiktaş at that time. Shaquille O'Neal's mocaps came to us, I'm talking about million-dollar mocaps, but the man is not a actor, he is a basketball player. He is very tall, he is more than 2 meters and the character we made was a cartoon character. And the movements that didn't fit were very artificial, it was a very bad image. We never used those mocaps. So I'm talking about the million dollar mocaps as I mentioned. So everything went to waste. That's why, as I said mocap, the better your technology and the better the actor you have, the better results you get, and the project should also be appropriate. As I said, it's good if these happen, otherwise you may need to fix it.

5) Have you ever been involved in a project in a movie where mocap technology was used? Would you like to take charge?

There was a game project in Las Vegas that I just mentioned, gamepods etc. animations of the casinos were going to be done with mocap, but as I said, I'm not interested in mocap, I just made 3D characters. Other friends made Mocap. Apart from that, I worked with an independent developer and we tried a mocap there, but it was much more amateur like that, it was Eskişehir if I'm not mistaken. Well, it was recorded in a studio. The mocaps were not very good, and the friends who recorded the mocap were also unexperienced. We had to call them back all the time because the character will drive a car, how should we make a reference, whether we should give a steering wheel or a piece of wood in his hand, you know how he will imitate that movement, we

were quite confused and I should say honestly that it was not okay. But as I said first, that project in Las Vegas - it was kind of big project. It was not okay because we tried to fit an animatic character, a sketch character into a realistic one. The Shaquille O'neal project was not successful. I have 2 such experiences, that's all about mocap. Other than that, I have no other experience about mocap.

6) How effective are facial animations in expression transfer? How would you interpret the importance of Mocap technology at this point?

We actually use it for reference as well, I mean facial expression of the character laughing and getting angry while we model the character's laughter, anger, surprise, etc. These are good references for us. Mocap … you may have heard about photogeometry / 3D scan, for example, we use that expression here. Here it is very nice as a reference. Those wrinkles, the structure of the mouth when you smile, the structure of your mouth, nose and eyes when you are angry, are very good references for us. But in animation, of course, they take them directly and use them. The character is there one-to-one .. the virtual character does what the real character does. You have seen many examples of this. I can even share it here, so we can't write right now, but that mocap data is a good expression reference for us, too. In other words, all those 3D scan data we have received recently are a very good anatomy reference for us right now.

7) Do you think successful facial animations can be produced? Do you think that the photorealistic animations overcome uncanny effect? What is the role of Mocap technology?

So Mocap ….. of course it has improved a lot, but maybe even the audience can still notice some things when they look at it. Well, the virtual characters are okay, very good indeed- visually very good. A scene doesn't bother the eye that much, but the perfect image bother the eye a little. Just like in music, think about the music you listen to on old stone records, it sounds much nicer, but those techno music you listen to now, mechanical music sounds more artificial. I think Mocapte has a bit too, Still, those perfect movements in those artificial movements, maybe that perfection in the digital character, it bothers the eye a little bit, but apart from that, I think the recent works are very good, especially.

8) Did the change in the process cause a change in the team structure? What kind of transformation can we talk about?

In other words, there were more general needs in the past. How can I say, for example, if you were working as a 3D artist, you could get involved in many jobs. In other words, you were making the 3D character, maybe the character was passing through, here is the skeletal system dressing - we call rigging - you were doing that process. Maybe you were doing the animation too. Of course, I'm talking about much earlier, that is, 15-20 years ago. Over time, specializations began to emerge. In other words, to make a character model and then just a head model, head animation, maybe just animal animations. Or

at work … for example, you know there were a lot of robots in the movie transformers. It seems like 2 animators are animating only 1 arm of a robot. So much now that it has fallen into specialization or one person only makes the head of a character. Another person is doing the leg. For example, in the King Kong movie, it was 2005, if I'm not mistaken, someone made Kin Kong's head, another artist made his leg, someone else made his torso. Likewise, their animations are probably the same, and that's how specializations are getting less and less. In other words, as in medicine, every disease used to be treated internist, now it has decreased. Now there is an expert for everything. I don't know, there is a bone specialist, there is a heart specialist, there is a kidney specialist. Think of it as in neurology, maybe neurology will shrink in the future, there will be "epilepsy", I don't know, it will be "als". These things exist in 3D as well. First you were doing everything, then it was divided into areas. Then the place came, I'm just making up a single head, a single hand, maybe a single finger in the future, but at the moment, the expertise is increasing. That's why new business areas are emerging for artists. I also think that this will develop and deepen in the future.

9) How did it transform with mocap technology and photorealistic animation, production process in terms of time and cost?

Now, as software develops, time begins to shorten. Previously, even for a simple "UV" opening - let's say a 2D map of the UV character, here's a two-dimensional map of the UV character - let's say we opened it to paint it - uv

mapping, like UV coordinates. We were trying to open it for 1-2 days sometimes. Now we have a lot of tools about it. In other words, it takes about 5 minutes and 10 minutes, maybe even shorter, depending on the situation. That's why tools are developing and time is getting shorter as technology develops. New software comes out all the time, new painting software, new animation software, new particle-based 3D modeling software. And time is shortened with it and things are increasing, how do I say? Creativity. You do not spend much time dealing with technical issues, now you go directly to production. And now what you produce is up to you. You can act more creatively because you save time. So it will probably get shorter in the future. Systems are developing, software is developing, yes, I guess it will continue like this.

10) What do you think are the effects of such changes on the film/animation sector (negative/positive) ?

So it actually depends on what you're doing. If you're doing animation, the movie you're talking about isn't production, it's more like dream works like pixar, they don't use mocap anyway. They do traditional animation, so mocap works great in production. It handles a lot of your work, maybe instead of hiring an animator, you can set up a good mocap studio and do a lot of work there, but as I said, other animation studios do manual animation, which we call keyframe animation ee.. I don't think they will use mocap anyway, they probably put a stamp at the end of the movie saying they did not use mocap in

their movie.. So it will definitely come in handy in production. But I guess it will probably not be used in classical animation.

11) Finally, how do you envision the future of this technology? What will be its place and future in the country?

Of course, it is currently used a lot abroad and will continue to be used even more. There is a lot of investment being made in this area. It's constantly evolving. There is something new every day. But is there a need for mocaps in Turkey? Because our productions are slightly smaller productions, the things people demand are different. You see a lot of sci-fi movies abroad, like Batman, Superman, except for Chinese superheroes. I mean, people don't go out because they don't want to watch that kind of work. More like historical movies or comedy movies, so I don't know if mocap is used in Turkey because it is a very expensive technology. I mean, let's say that a movie in Turkey costs 5 million dollars and 10 million dollars. You know, I'm making it up right now, but that mocap you will use will probably be more expensive than that movie for Turkey. So I am speaking for Turkey. It is very expensive abroad, I mean, these are costly jobs. I guess that it will develop abroad, but frankly I do not think that it will be needed much in Turkey.