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FACULTY OF ELECTRICAL ENGINEERING AND COMMUNICATION

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DIGITAL GRAPHICS: PAINTING

BACHELOR'S THESIS

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NÁZEV TÉMATU:

Počítačová grafika: Malba

POKYNY PRO VYPRACOVÁNÍ:

Vymezte koncept digitální malby a její požadavky na technické a programové vybavení počítače. Popište nástroje a techniky digitální malby a prezentujte jejich použití na konkrétních příkladech technik kresby nebo malby.

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2) Conner-ziser, J. (2017). Traditional vs. digital painting: A process comparison. In Breathing Color . Retrieved from https://www.breathingcolor.com/blog/traditional-vs-digital-painting/

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slides]. Retrieved from https://www.dropbox.com/s/mjk2kziawltscl5/02_softwarova_estetika.pdf?dl=0

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Abstract

The aims of the bachelor's thesis are to frame the concept of digital painting, its hardware and software requirements and to describe tools and techniques of digital painting. The first chapter deals with general concepts of aesthetics in traditional and computer art, provides a historical survey of the evolution of digital art and establishes the concept of metamodernism in art. In the second chapter, art techniques both digital and traditional are described and supported by examples according to painting styles and art movements. The question of expressing emotions in digital painting and psychology of image perception are explained from a digital and traditional artist's viewpoint. Moreover, the role of the computer in a creating process is determined. The third chapter focuses on the non-photorealistic rendering method of creating artwork in an abstract stylisation style on the ground of the *Stylize* editor and the manual for this editor (beginner level) is provided as well.

Key words

digital painting, generalized aesthetics, metamodernism, lighting, abstract stylisation, image perception, image segmentation, non-photorealistic rendering

Abstrakt

Cílem této bakalářské práce je vymezit koncept digitální malby, její požadavky na technické a programové vybavení počítače, a následně popsat různé nástroje a techniky, kterých digitální malba využívá. První kapitola se zabývá pojmem estetiky jak v tradičním, tak i v počítačovém umění, popisuje historický přehled vývoje digitálního umění a zavadí koncept metamodernismusu v umění. Druhá kapitola je zaměřená na malířské techniky (podle uměleckých směrů), které se používají v tradiční a digitální malbě a jsou podporované příklady. Otázky vyjádření emocí prostřednictvím digitálních nástrojů, psychologie vnímání obrazů a role počítače v procesu tvorby jsou rovněž podrobně popsané v rámci druhé kapitoly. Třetí kapitola se týká metody nefotorealistického zobrazování digitálního obrazu ve stylu abstraktní stylizace. Na tomto základě vytvořen manuál pro začátečníci editorů *Stylize*, který je také součástí třetí kapitoly.

Klíčová slova

počítačová malba, zobecněná estetika, metamodernismus, osvětlení, abstraktní stylizace, vnímání obrazů, segmentace obrazů, nefotorealistické zobrazování

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Prohlášení

Prohlašuji, že bakalářskou práci na téma *Digitální grafika: Malba* jsem vypracovala samostatně pod vedením vedoucí bakalářské práce a s použitím odborné literatury a dalších informačních zdrojů, které jsou všechny citovány v práci a uvedeny v seznamu literatury na konci práce.

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V Brně dne ....

Ekaterina Bobyleva

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Introduction

We are living in the postmodern era, where technology has a huge impact on every part of modern life, and art is not an exception. Art has moved from the postmodern period to a new stage which is called metamodernism, which means coming back to the original ideas, original truth, wherein using the postmodern tools. How exactly does art change with the impact of technology in new era? What is meant by digital art nowadays? How is it possible to combine technology, math, logic and algorithms with art, creativity, beauty and artistic sight? How has the perception of the image changed over the decades? And what is meant by the original truth of metamodern's artists?

The term "digital art" refers to an artistic work or practice created by means of digital technologies in production or display of an artwork. It is essential to divide digital art into two different categories: generative digital art and interactive digital art. Interactive digital art is concerning with classic painting performed by digital means (graphic tablet, stylus, software such as *Photoshop* and *Paint*), while generative digital art is represented by the algorithms, according to which the software programme will transform the image or create it with minimal participation of the artist on this stage. Therefore it is crucial to find out the role of the computer in the creative process and what makes the digital image beautiful and special. How does a digital painting technique differ from a traditional one? Is it possible to convey human's emotions through digital hardware and replace a canvas with a tablet? What is the suitable software for digital artists and how should they learn to use it? These and other issues are the main focus of this thesis whose intermediate objectives are to frame the concept of digital painting, describe its historical development, discuss differences between traditional and digital painting techniques and lay down the requirements for computer graphics hardware and software. Relative to the following objectives the thesis is divided into three chapters.

Chapter One deals with the definition of aesthetics in traditional and digital art, historical development of the digital art and metamodernism as the leading concept under the influence of which digital artists work.

The difference between digital and traditional painting is covered in Chapter Two. Furthermore, there is information on psychology of image perception and expressing emotions through artwork, comparison of traditional and digital techniques, where image segmentation is described as a basic technique of the practical part of this thesis.

Chapter Three deals with non-photorealistic rendering and *Stylize* editor, which was chosen due to a variety of reasons:

1. This editor is not that well-known among the users since it was developed by one of the students of Masaryk University and has not been promoted among the wide audience.

2. This editor helps you to convert your photo image into artwork by using specific algorithms of generative digital art.

3. This editor is a perfect solution for creating metamodern works of art not only for the artists who have never worked with digital devices before, but also for the people who have no experience with painting.

Furthermore, in this chapter the working principle of *Stylize* is described and the manual for the beginning users is created.

1 Useful symbiosis: Nature, art, science and technology

This chapter describes what combines art, technology and nature in terms of aesthetics and the era of metamodernism. The overview of the digital art development provides the reader with essential knowledge of indissoluble connection between the traditional art, digital art, science and technology. As Lovejoy (2004, p. 165) established "Electronic media promote perspectives on aesthetic experience as well as on artistic production because they change the experience of art-making and ultimately the nature of what is seen". Thus, how electronic media has affected aesthetics, art and nature of what is seen or vice versa will be covered in the following subchapters.

1.1 Generalised aesthetics as a combination of art and science

"Beauty is in the eye of the beholder." /Oscar Wilde/

At first glance, it highly unlikely that science, mathematics and algorithms could have any aesthetic sides. In fact, art began to evolve together with science, to be more specific with the nature. A French intellectual Roger Caillois (1962) introduced the concept of generalised aesthetics which classified any phenomena in the nature into a categorization frame according to the form of the origin. On this basis, he defines beauty and art and their functions in the world order. Fractal computer graphics is derived from Caillois' theory and this categorization has the following parts (Staudek, 2017a):

a) *random forms* referring to appearance that does not require anything but time, has no repetition, and is unique like the shape of the mountains;

b) *growth forms* which you can see in the pictures of standard aesthetic manifestation in the nature including symmetry, orientation and repetition (see Figures 1, 2 and 3);

c) *art forms* such as figuration, abstraction, construction, and improvisation which include colours, compositions, proportions, and gestures;

d) *reproductive forms* including recycling and remix which does not bring anything new; later became known as pop-art, multiple art.

Staudek (2017a) imply that the art of computation with addition of generalised aesthetics gives us the beauty of both found forms and created forms. Aesthetic forms could originate differently: from growth and imprint, randomly or artistically (art + design).
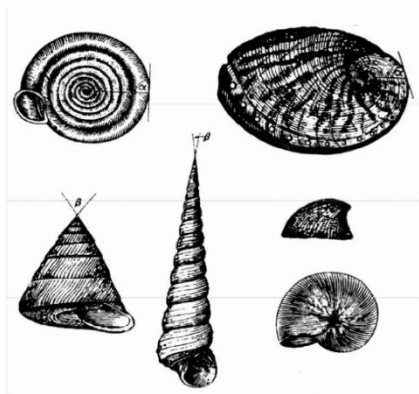

Figure 1. Shells as an example of growth forms. Adopted from Staudek (2017a, slide 31).

Figure 2. Manifestation of symmetry and orientation in nature. Adopted from Staudek (2017a, slide 26).
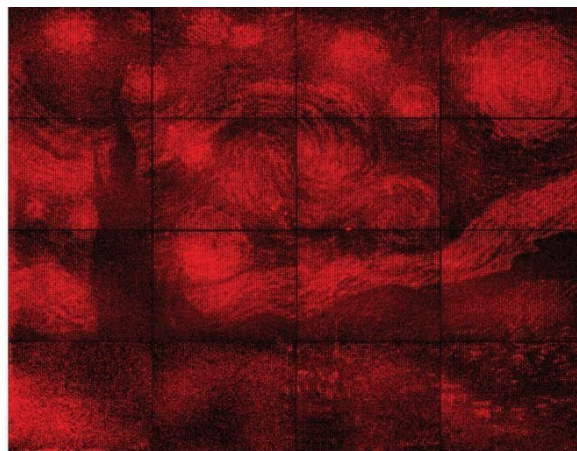

Figure 3. Van Gogh encoded in compound DNA molecules. Adopted from Staudek (2017a, slide 29).

Computer art has evolved in accordance with categorization described above. You may observe *random forms* such as Glitch art (a system malfunction that cannot be controlled and leads to random images on the display); since a lot of growth laws have a mathematical background, *growth forms* are used as a part of fractal algorithms, for instance, in the form of a logarithmic spiral; *art forms* as a wide range of movements, styles and ensuing techniques that are used in traditional and digital painting; and *reproductive forms* as one of the abstract painting styles, which will be described in Chapters Two and Three.

In this chapter, the concept of aesthetics in art was framed. And it became fully comprehensive that aesthetic forms appear everywhere: in nature, in art and science; sometimes these forms may be found randomly by mistake or where they are least expected. What is beautiful and what is not is a question of a taste and preferences, the only thing you need is the power of visualisation.

1.2 Evolution of digital painting: From an oscilloscope to interactive media

It should be noted that even though digital art did not emerge at the same time as a digital computer, it has its analogue roots. As mentioned in the previous section, the idea of generalised aesthetics brings a concept of aesthetic in science as well as in the nature and art, thus when the first graphic output was depicted we could talk about the beginning of digital art. As specified by Staudek (2017b) it is possible to divide the history of digital art into the following periods:

1950-1955: An analogue signal representing aesthetics

When modelling a signal of electrical quantities and computing differential equations, it becomes possible to gain graphic output from the oscilloscope and plotter (drawing of the measured signal in the time domain is illustrated in Figure 4). The picture created in such a way showed the beauty of simple lines and can be considered as the beginning of the digital painting. The film creators were those who appreciated oscilloscope art (Staudek, 2017b).
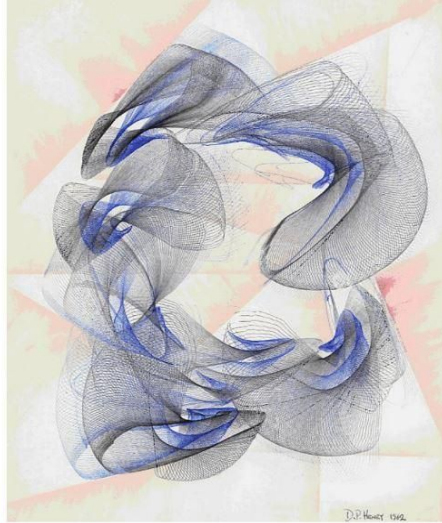
Figure 4. Measured signal in the time domain by a harmonograph.
Adopted from Staudek (2017b, slide 6).

1955-1965: The interest of artists was stimulated

Oscillons are photographical records or representations of the equations. Some of the oscillons consist of up to seventy parameters such as a sine wave generator, a signal amplifier, and modulation circuits. Laposky points out, "Oscillons are normally not accidental or naturally occurring forms – they must be composed by the conscious decision and control of the artist using the apparatus. Whilst essentially abstract, they can also evoke figurative images, especially natural forms" (as cited in Staudek, 2017b, slide 11). The instance of oscillons can be observed in Figure 5. Oscillations have attracted an interest of artists because of the possibility to control the process. It is not a random form anymore as it has grown into one of the art concepts.
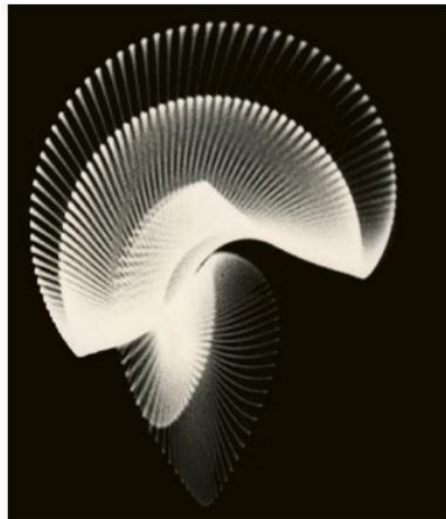

Figure 5. Photographic record of an equation made by an oscilloscope.
Adopted from Laposky (as cited in Staudek, 2017b, slide 9).

1960-1980: Scanimate, TV and advertisements

Scanimate (see Figure 6) is an analogue computer animation in real time. It allowed interactive control, recording and playback of video overlay elements to generate complex 2D animation (Carlson, n.d.). Deflection signals are passed through a special analogue computer that enables the operator to bend the image in a variety of ways, one example is illustrated in Figure 7. It served as an inspiration for the later video art (Staudek, 2017b).
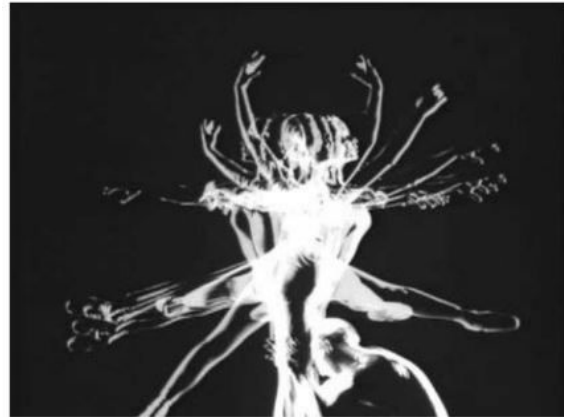

Figure 6. Analogue system for animation. Adopted from Staudek (2017b, slide 15).

Figure 7. Norman McLaren: Pas de Deux. Adopted from Staudek (2017b, slide 16).

1965-1970: Analogue computers were replaced by digital ones

Digital computers were more precise and smaller, therefore they were slower which resulted in a worse quality of graphic output. At that time art went in the direction of abstraction, Russian constructivism, German Bauhaus (see Figure 8) and op-art (optical art) as shown in Figure 9.
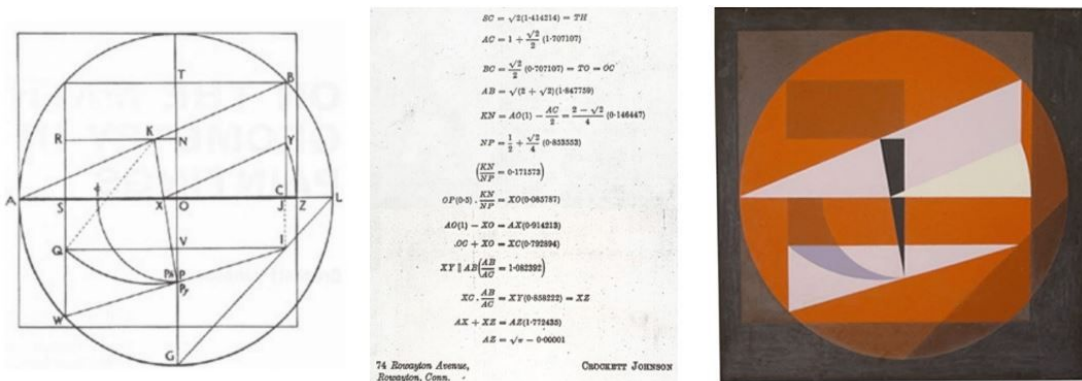

Figure 8. Crockett Johnson. Geometric patterns. Adopted from Staudek (2017b, slide 21).
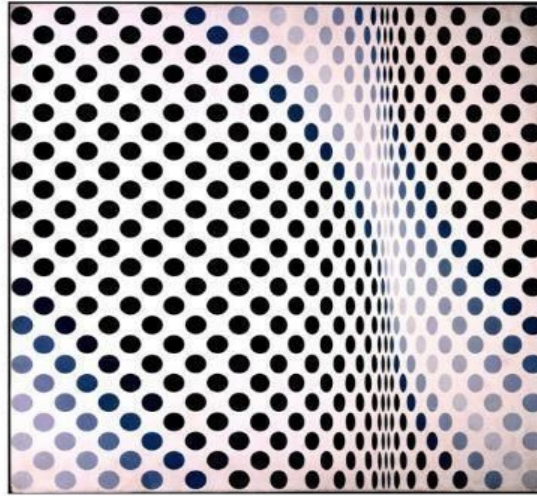
Figure 9. Bridget Riley: Pause. Adopted from Staudek
(2017b, slide 23).

In this period the role of the computer was overlooked, the computer was not just a tool, but it was able to evaluate the work of an artist and change parameters for a better result. From 1965 to 1967 the first exhibitions of computer art were held in New York.

1970-1975: *Experiments in Art and Technology*

Molnar (1975) remarks that "the computer-aided procedure is only a systemization of the traditional-classic approach". Computer art classes became the part of art school education. This period is also known for the projects of the Experiments in Art and Technology (E.A.T), a non-profit organization which was established to develop a collaboration of artists and engineers. Moreover, more exhibitions were organised such as EXPO in 1970. Animation Theatre, Electronic Theatre and Art Gallery were opened as well.

1975-1985: The role of an artist changed: He or she no longer needed to know how to program

More useful equipment was created such as the mouse, graphic output devices and the personal computer. Images became clearer, resolution was higher and more colours to choose from helped graphic artists to paint in the same way as Picasso and Matisse.

1985-1990: Graphics became one of the main creating areas

Fractals grew in popularity. The main source of inspiration was a geometric ornament. Generative art became the area of interest once again. This period was also famous for Andy Warhol's pop-art.

1990-2000: The computer got its full recognition by the artist society

This period is marked by the development and spreading of the movie and entertainment industry which required new techniques in the computer art. These techniques, referred to as "computer graphics", include shading, lighting, rendering, modelling, and animation.

2000-2010: Development of graphic and painting techniques, and new attempts to work with space - 3D paintings

During this decade, topical trends in digital art are: post-production[1], interactive media, live coding[2], deep learning[3], generative architecture[4], evolutionary design[5], artificial intelligence etc.

It could be said that the development of the digital painting sometimes goes inversely from the development of traditional painting. While traditional drawing evolved in a digital one, for digital painting due to the technical reasons some of more traditional styles of painting became available only a couple of years ago. However, computer art is evolving admittedly fast, every five or ten years new technology is coming and pushes digital art forward. We could only assume how art will look like over next years.

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[1]   Post-production (n.d.) is final stage of the filmmaking process during which recorded material is shaped, packaged, edited and assembled into the whole.

[2]   Live coding is a type of art that experiments with programming mind-sets and written communication and it results in unique musical transformation in the sweep of code (Collins et al., 2003).

[3]   Deep Learning is a new area of Machine Learning research, which has been introduced with the objective of moving Machine Learning closer to one of its original goals: Artificial Intelligence (Gulcehre, 2015).

[4]   In generative architecture the designer work with materials and products indirectly by means of digital, computer-aided generative system (Herr, 2002).

[5]   Evolutionary design refers to a new form of computer design including 3D construction, generative architecture, etc.

1.3 Metamodernism as a new phenomenon in art

There is another way to look into the classification of the modern art history - from the traditional art's point of view. The timeline described in Chapter 1.2 starts from the 1950s, which according to the traditional art history was the era of modernism. Starting from the 1960s another phenomenon called "postmodernism" took the lead in all art manifestations (Forrester, 2013). Postmodernism covers most of the periods of the evolutionary process of digital art. Despite this fact, as stated by Vermeulen and van der Akker (2010a), there is a supplementary phenomenon that oscillates between modernism and postmodernism: metamodernism. Metamodernism combines incompatible: modernism and postmodernism, technology and art, it "[...] resembles the movement between the reachable and the unreachable, the presentable and the unpresentable, the beautiful and sublime" (Rudrum, Stavris, 2015, p. 363).

Metamodernism is a broad term covering the development of philosophy, aesthetics and culture that originated as a reaction to postmodernism. Although the beginning of the metamodernist period is not clear (considering it was a reaction to postmodernism it could be assumed around the 1970s), the wide discussion around this phenomenon started only after year 2000 and it has continued for the last seven years. The main idea of this phenomenon is to turn back to some inner truth, some original concepts, sincerity, wherein using postmodern tools and techniques.

As I mentioned before, metamodernism was born as a reaction to postmodernism. Sometimes it is hard to see the difference between these two concepts in paintings. Yet what differs the metamodernists is that they use the original masterpieces such as *Scream* by Edvard Munch, *Mona Lisa* by Leonardo da Vinci, etc., as the foundation of their works and then they make a statement by adding something of their own and something new to those paintings. This adding could be done by using both traditional and digital techniques. Although these statements vary, they are keeping to reflect the main idea of metamodernism which searches for the origins, for the truth. A great example of metamodern pieces of art is the Immersions Project (2015), the project of the Russian artists that combines digital and traditional techniques in order to create something new out of the worldwide famous paintings. For instance, by means of new technological art medium, they paint a picture *Exposed Munch* (see Figure 10),

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which represents the most famous work *Scream* and in the left corner the naked man with canvas is seen; it is Edvard Munch, the author of the *Scream* in the process of painting his masterpiece. It is the distinctive feature of metamodernism: to show what is beyond the painting, the hidden meaning. Many artists believe that the screaming man was the reflection of internal state of an author at this moment, which is why he was represented naked - he exposed his soul to the public. Nevertheless, this is not all, one more metamodern feature (combination of art and technology) is used in this project, which is the application of virtual reality (VR) technology. By using special equipment it is possible to get inside the picture, to be next to the main characters, to see and to feel the action. Or as Šobáňová et al. (2016) points out, "Any immersive media is therefore inherently interactive transforming a mere observer into real visitor" (p. 97). There is a lack of information on Immersions Project, although it is possible to find information separately on the metamodernism and VR technology in art.

Figure 10. Exposed Munch (Immersions project, 2015)
Adopted from https://www.youtube.com/watch?v=bCrnH6xNBzI

Let's remind ourselves that metamodernism is not only a period of time in art history, it is a philosophy and aesthetics concept, the broad term which influence economics, politics, architecture, data analysis, and the arts (Vermeulen & van den Akker, 2010b). It denies the postmodernist concept, trying to eliminate the naivety of postmodernism and searching the original truth, meanwhile using means of postmodernist techniques. As for the shapes of art objects, they are practically the same as in postmodernism. Šobáňová et al. (2016) claims that "it is the 'humanisation' of

informatics which is the current trend that points to the need to react to the ongoing penetration of information technology into society." (p. 391). In other words, it is the original truth of metamodern concept, the need to move from mechanical images back to traditional ones, albeit by means of information technology both interactive and generative. This is why it is important to integrate classical aesthetic education (the one that is covered in previous paragraph) into IT studies.

To sum up, the concept of aesthetics in the era of metamodernism allows us to connect nature, technology and art by creating something truly beautiful and connecting all of that to the common historical origins.

2 Difference between digital and traditional painting

As it was briefly mentioned in the subchapters above, there are many styles and movements in the painting both traditional and digital, and it is essential to list them for better understanding of the following chapters. In general, the origins of painting is considered to be Italian Renaissance art consisting of naturalism[6], humanism[7], fresco painting[8], tempera painting[9], and oil painting[10] (Art movements and styles, 2017). Most of the named movements were not available for digital painters due to the lack of tools and techniques at the beginning of the digital age, however, nowadays digital artists revert to origins trying to recreate Renaissance art using computer tools and software programmes as painter's medium. Next, traditional painting moved towards new art movements which included Impressionism[11], Post-Impressionism[12], Cubism[13], Fauvism[14], Expressionism[15], Dadaism[16], Surrealism[17], and Pop-Art (Art movements and styles, 2017). Modern art is also represented by abstract painting – less detailed than Renaissance art – which became popular with pioneers of digital art and is still one of the most popular digital movement.

Corresponding to the chosen style of painting, the artists should employ some of the appropriate techniques to perform their work, such as colour-fading, lighting and

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[6]   Naturalism is a movement that is inspired by the lifelike accuracy of classical sculpture.

[7]   Humanism was inspired by humanism learning, where humanism had more influence on its subject matter than a form.

[8]   Fresco painting is a technique associated with large scale murals.

[9]   Tempera painting was the main medium used during the Early Renaissance for smaller scale paintings on wooden panels. Any pigment which is tempered with a water soluble binder such as egg yolk, glair (egg white), gum arabic or animal glue is referred to as tempera paint.

[10]   Due to it versatility as medium, oil painting produce the most intense colour, the greatest tonal range and a workable drying time that allowed the artist to render the finest naturalistic detail possible.

[11]   It is an outdoor plein-air painting, characterized by rapid, spontaneous and loose brushstrokes. Its guiding principle was the realistic depiction of light.

[12]   It focused on the emotional, structural, symbolic and spiritual elements that were missing from Impressionism according to Post-Impressionism painters.

[13]   Cubism brought different views of subjects (usually objects or figures) together in the same picture, resulting in paintings that appear fragmented and abstracted.

[14]   Fauvism uses so-called symbolic colour. Painters proposed that colour had a symbolic vocabulary which could be used to visually translate a range of emotions.

[15]   It is a style of painting in which the artist or writer seeks to express the inner world of emotion rather than external reality.

[16]   Dadaism or Dada was a form of artistic anarchy born out of disgust for the social, political and cultural values of the time.

[17]   Surrealism is the style in which painters sought a new kind of reality, a heightened reality that they called 'surreality', which was found in the world of images drawn from their dreams and imagination.

shadowing, blending, changing the shape of the edges. At the present all of them are available for digital artists as well as for traditional ones, though there are some techniques which offer digital painters even more possibilities, for instance, rendering. Meanwhile, digital techniques help the artists keep their working place clean, and they do not have the need for large-spaced studio anymore. Nevertheless, they can save time for the creation of one piece and reprint as many copies as needed. Moreover, they may be considered as original pieces, which are the definitely advantages for many artists.

Starting with the period of metamodernism and under influence of computer art, some traditional artists referring to digital effects in their works by using a traditional painting techniques. For instance, there is a woman portrait in the Figure 11 created by painter Gerhard Richter and exhibited in Leopold Museum, Vienna. The artwork called *Girl's head (blurred)* is painted with oils. The painting was created in 1965, when the author "began to create large-scale photorealist copies of black-and-white photographs rendered in a range of grays, and innovated a blurred effect (sometimes deemed "photographic impressionism") in which portions of his compositions appear smeared or softened – paradoxically reproducing photographic effects and revealing his painterly hand" (Gerhard Richter, n.d.). Not only do digital artists use traditional art for inspiration but it works vice versa as well.

Figure 11. Girl's head (blurred) by Gerhard Richter (1965).
(personal photo of the author of this thesis).

As we can see, there are many techniques both similar and totally different that are used in traditional and digital painting. This thesis will be dealing with three of them: lighting, rendering and image segmentation. The reasons for choosing these techniques are that they are corresponding with the empirical part of the thesis, those techniques are used in both digital and traditional painting and the similarity and difference in digital and traditional painting is better reflected on them.

2.1 Lighting and rendering in digital and traditional painting

Lighting is one of the most important aspects in painting enabling the artist to change the mood of the picture, and thus helping to achieve visual goals for a viewer to better appreciate a scene (Birn, 2014). An example of lighting (the play of light and shadows) in traditional painting can be observed in works of Correggio. If you look at the painting (see Figure 12) from a long distance, you will probably see only a woman sitting on the ground, surrounded by the sky. However, when you start to examine the picture, you will see the shape of a man in the cloud.

Figure 12. Jupiter and Io by Correggio (1531-1532). Reprinted from Krén & Marx (n.d.), https://www.wga.hu/html_m/c/correggi/mytholog/io.html.

The dynamics of light and shadows in digital painting is illustrated in Figure 13. This effect could be achieved by many different approaches such as specific algorithms that are used in generative digital art, when you need to program the algorithm that helps you to achieve the desired effect; or using specific filters and softwares as it is applied in interactive digital art.
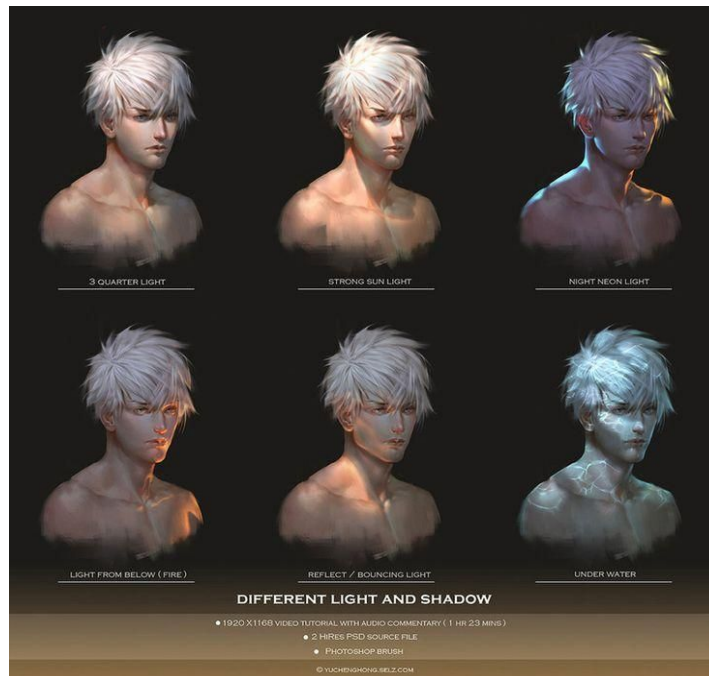

Figure 13. Different light and shadows. Reprinted from
https://cz.pinterest.com/pin/567312884285499977/

Despite using different techniques to achieve these visual goals, the idea of lighting in digital and traditional painting stays the same: to impart the mood of the picture.

Concerning the techniques, traditional painters generally pick up medium sized brushes that allow them to paint more details, sculpt more dimensions and make definite decisions regarding object edges, colour blends, and lighting. Digital painters can do "the same things using digital brushes but they have other options available to them as well" (Conner-ziser, 2017). Traditional painters must create highlights and shadows "from scratch" using lighter, darker and complementary colours. Meanwhile, "digital artists may rely upon those from the original photograph or add to them and enhance them as desired" (Conner-ziser, 2017).

A technique of rendering is more concerned with 2D or 3D computer graphics. Rendering in computer graphics means the process of shading, colouring, modelling and texturing of an image. Objects in the picture can be transformed in accordance with an observer's viewpoint (Hemmendinger, n.d.). This topic is widely covered in Chapter Three.

2.2 Expressing emotions through digital hardware

Art is a way of expressing emotions, you do not have to speak or understand foreign language but if you understand the language of art you may consider yourself as a multicultural person who understands what an artist wanted to tell no matter where they come from. As it is in the language (there are some dialects and slang that you may not understand or consider them as aesthetically beautiful to listen to), in art you may also find some movements and artists that are quite contradictory, despite that you will be always trying to interpret it in your own way, because art speaks through human's emotions.

Hence, how does an artist decide to become a digital artist? And is it true that computer can not express artist's emotions?

With the introduction of a computer, art was shifted to a new level, although it could be claimed that a computer has only the role of a tool in art. In fact, a computer performs more than one role in the process. As determined by Staudek (2017b), these roles are defined as:

1 *medium* – as means of recording, preservation and assistance in creation;
2 *object* – as a subject of aesthetic manifestation;
3 *tool* – as a digital physical (interactive) and abstract (computational) brush;
4 *co-author* – as a creative partner with aesthetic responsibility.

This proves that computer is not only a tool to facilitate an artist's work, but more importantly it could be your co-worker. An artist is the one who has an idea and a computer is the one which has means to embody this idea, and sometimes even in a way

the artist could not even think of. A computer gives you a variety of options that you could use while you are painting. It broadens your mind and, therefore, it is no longer a tool or an object but your creative partner. Noll (1967, p. 89) claims, "In the computer, man has created not just inanimate tool, but an intellectual and active creative partner that, when fully exploited, could be used to produce wholly new art forms and possibly new aesthetic experiences".

In order to prove that it is possible to express emotions through digital software let us make a comparison of traditional and digital paintings. Figure 14 shows an original painting *Scream* by Edvard Munch, while Figure 15 shows its digital replica by Andy Warhol.

Figure 14. Scream by Edvard Munch (1893). Reprinted from https://en.wikipedia.org/wiki/The_Scream
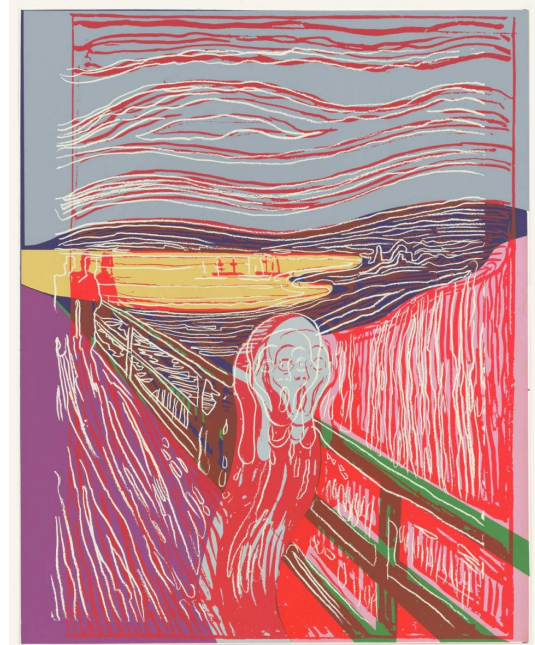
Figure 15.Scream by Andy Warhol (1984). Reprinted from https://www.moma.org/collection/works/71559?locale=

Since Warhol was a pioneer of computer art, at first sight his painting might seem to be more mechanical than the original one. He expresses the desperation and power of the scream by showing series of the repetitions of the man's face, while in the traditional painting the viewer might observe it from his facial expression and look in his eyes performed by the strokes. The difference in conveying the main idea lies in the lack of tools and techniques which were available to the digital artist at the beginning.

With hardware and software development in digital art industry, it is now possible to convey emotions in the same manner as in traditional painting. For instance, have a look at the portraits in Figures 16 and 17. The portrait on the right is one of the most famous women's portraits painted by Dutch painter Johannes Vermeer and the other one is a digital portrait by a Russian digital artist Elena Berezina. It is always difficult to convey a facial expression in a portrait painting due to a variety of human emotions. "Eyes are a window to the soul"[18] once was said. Here I believe both artists succeed in capturing the look, the soul of these beautiful ladies which represent hope, dreams, beliefs, mystery, and desire.
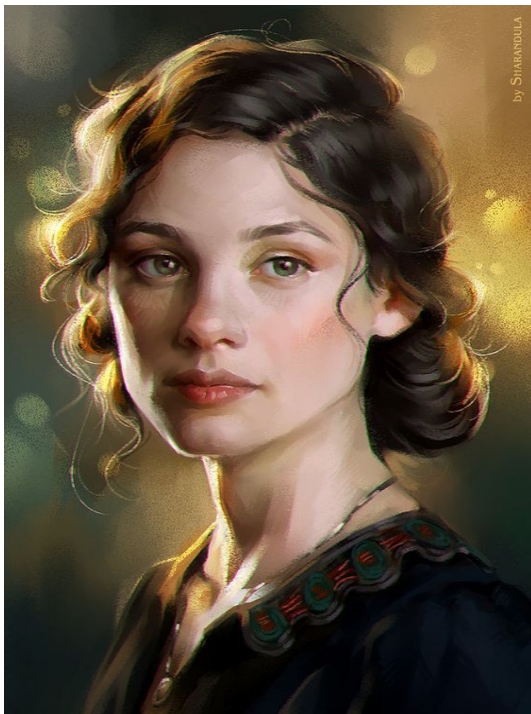

Figure 16. Astrid Berges-Frisbey (study). Elena Berezina (2014). Reprinted from https://www.artstation.com/artwork/oAxBq

Figure 17. Girl with a Pearl Earring. Johannes Vermeer (1665). Reprinted from https://en.wikipedia.org/wiki/Girl_with_a_Pearl_Earring

To conclude, art is a way of expressing emotions and as long as works of art are created by humans, by artists it does not matter what tools, techniques or help they created them with. If artists put their ideas and emotions in their work, the audience will see it.

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[18]   There is a wide debate over the origins of this quote. Its origin could be found in the bible 58 to 68 A.D., in Cicero (106-43 B.C.) works, someone even refers to Shakespeare. For more information go to https://www.phrases.org.uk/bulletin_board/41/messages/1097.html.

2.3 Psychology of image perception

The way how images are perceived by people is the matter of not only optics, but of psychology, philosophy and science as well. It is an essential subchapter for my thesis since the process of image and painting interpretation has changed within changing art movements and periods. Nonetheless, the way how to look at an image is directly connected with the aesthetics' concept. At the same time it helps to understand metamodern form of art that combines generative digital painting with traditional painting by means of image segmentation.

Durand (2002) names the pictorial cues or parts of monocular geometry that are essential for image perception: occlusion[19], size[20], position related to the horizon[21], convergence of parallels[22], linear perspective[23], shading and shadows[24], texture gradient[25] and aerial perspective[26]. In consonance with how those cues are located in the composition, our perception of the whole image could change. According to Aumont (2010), viewer never consider or perceive image as "clean" without background and contextual information. On the contrary, the vision depends on the context as well, which can be "social, cultural, technical, ideological or institutional" (Aumont, 2010, p. 8). In other words, the persistence of perception hinges on background knowledge or our understanding of visible world and allows us to assign permanent properties to its objects or to their location in space. Nevertheless, Gombrich (as cited in Aumont, 2010) claims that memory is what helps us to recognise those properties and objects. Therefore the persistence of perception is a "constant process of comparison between what was formerly seen and what is seeing now" (p. 73).

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[19] According to Birn (2014, p. 91), "occlusion is shading technique that simulates the blocking of the light". It is mostly used in 3D painting.
[20] The proportions of the object relatively to the dimension they are in.
[21] How the objects are placed relatively to the horizon. It can affect the size of the objects.
[22] Objects that appear to the eye shrinking and parallel lines and planes converging to infinitely distant vanishing points as they recede in space from the viewer (Perspective, n.d.).
[23] A system of creating an illusion of depth on a flat surface. Meaning that all parallel lines (orthogonals) in a painting or image converge in a single vanishing point located on the composition's horizon line (Blumberg, n.d.).
[24] The way of enhancing particular object in the image.
[25] There are certain object in each image with fine and more or less regular structure, which is called visual structure (Aumont, 2010).
[26] *Encyclopedia Britannica* (2018) defines aerial perspective as "a method of creating the illusion of depth by a modulation of colour and tone".

While the most images represent a part of reality that meets the requirements of monocular geometry and corresponding with our background knowledge, abstract images, on the other hand, express the certain distance from the reality and cannot be explained in terms of described above features. As a result, abstract images along with computer images (both based on geometry) are perceived according to image area, colour scale, value scale (from black through shades of grey to white) and structure of the composition (Aumont, 2010). Due to the fact that it is not attached to "existing" reality anymore, abstract art opens up possibility for the imagination, considering that all art is subjective. It contemplates the vision from the psychological point of view (impersonal vision that disregards personal perspective or as Cézanne (as cited in Aumont, 2010) described "vision of the world that existed before we look at it" (p. 273). The transformation of the painting's perception is switched from "I" to "It".

The above described features regarding image perception show us that the way how people perceive the image, the painting and art in general depends on many different issues such as context, our memory, foreshortening, linear perspective, colouring, composition, lighting and shadowing (previously described in Chapter 2.1), texture gradient, etc. Therefore, the perception of the painting over the years has changed from the personal perspective to impersonal one. And nowadays, it oscillates back and forth in terms of digital painting and creates something new with elements of former originality. As for an aesthetical side, the way of image perception has always been in dichotomy of beauty and ugliness. This means that aesthetics in image could not only represent something beautiful, but also something that is not, if it conveys the artist's message. This confirms another fundamental pattern that a perception of the art and art itself are subjective.

2.4 Image segmentation in digital and traditional painting

Image segmentation is the basic technique that is used for the empirical part of this thesis, the *Stylize* editor working principle built on this technique, which is why it is

crucial to describe it here. Although the image segmentation is related to digital painting technique to a greater extent, it is possible to find equivalences in traditional art as well.

Since in the previous Chapter 2.3 the perception of the image was covered, this subchapter is dedicated to how the image could be redesigned in accordance with key features of the perception. Due to the fact that the process and techniques of image segmentation hinge on those features such as colours, texture, value scale, etc.

Generally, what is meant "by segmentation of image is a transform permitting to extract the 'objects' contained in the image" (Dokládal, 2000, p. 5). The aim of image segmentation, according to Anjna and Kaur (2017), is simplification; the image is divided into small elements or segments. The application areas of segmentation vary and they are often used for medical purposes, where the processing of the whole image is insufficient (for instance, MRT[27], X-ray diagnostics, ultrasound diagnostics, etc.). However, for my thesis the image segmentation will be considered from the artistic point of view.

There are several digital techniques in the image segmentation process that work with different image's features such as gradient, structure, edges and regions, shapes of the object, position of the object in space (what is located in background and what is in foreground) and others. Those techniques are subdivided into: region based techniques[28], edge detection based techniques[29], thresholding method[30], clustering based techniques[31], watershed based techniques[32], partial differential equation based method[33] and artificial neural network based techniques[34] (Anjna & Kaur, 2017). The way how each type of segmentation is achieved depends on algorithms specific for each type. More detailed information on segmentation algorithms can be found in Chapter 3.2

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[27] MRT refers to Magnetic Resonance Tomography.

[28] The segmentation process is based on similar characteristics of the pixels (Anjna & Kaur, 2017).

[29] Pixels on the edge (or edge points) can be derived from the image function and mainly work with intensity level (Anjna & Kaur, 2017).

[30] The image pixels in this method are detached with the help of level of intensity with the aim of separation foreground objects from background ones (Anjna & Kaur, 2017).

[31] Similar to region based techniques, the clustering segments divide the image into clusters of pixels with the same characteristics (Anjna & Kaur, 2017).

[32] The aim of watershed method is to find the regions of high intensity gradients that divide adjacent local minima. The technique is mainly used in gradient of an image (Salman, 2006).

[33] The fastest way of segmentation that helps to achieve blurred edges and boundaries, which can be possibly shifted by using close operators (Anjna & Kaur, 2017).

[34] This method used mostly in medicine for separation the required images from background. The working principle consists in stimulation the learning strategies of human brain for the purpose of decision making process (Anjna & Kaur, 2017).

Stylize Editor: Working Principle, where those algorithms are described on practical examples.

Traditional art, on the other hand, uses image segmentation in both different and similar sides. The difference, for instance, contains in tools and techniques of image segmentation in traditional painting, there are no computer algorithms. However, there is work with layers, edges, lighting and shadowing on already completed artwork. Some of the famous artists such as Vincent van Gogh, Francisco Goya and even Leonardo da Vinci painted their new pieces over existing ones. Figure 18 shows the painting *Patch of grass* performed by Vincent van Gogh and the Figure 19 represents the hidden portrait of the woman underneath the famous painting discovered by scientists using fluorescent X-rays. The reasons for that, however, were not artistic, they were mainly economical, since most of the artists were not wealthy and the canvases were extremely expensive.

Figure 18. *Patch of grass* by Vincent van Gogh. Reprinted from https://krollermuller.nl/en/vincent-van-gogh-patch-of-grass-1
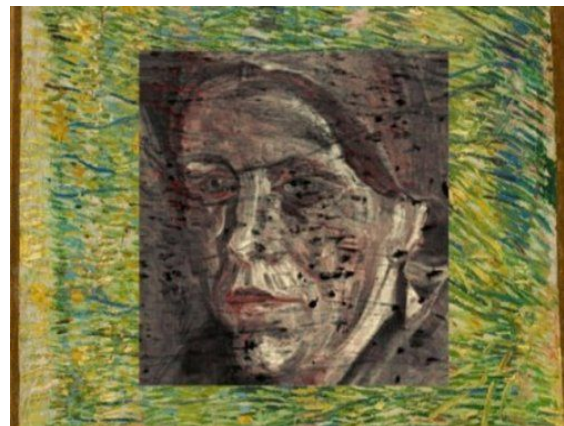
Figure 19. Hidden portrait of a woman. Reprinted from http://www.bugaga.ru/interesting/11467 52568-top-10-spryatannye-izobrazheniy a-obnaruzhennye-na-izvestnyh-kartinah. html

Despite the reasons for their way of image redesign, it required an essential amount of efforts to paint over already existing painting and to cover it fully without any visible signs. This effect could be accomplished by using certain types of brushes, extra amount of paint, etc. There is also a particular technique in traditional painting, which is called glazing. Glazing is the technique, where you apply the paints over already finished painting in order to enhance more essential objects or elements (exactly what

segmentation in digital art sometimes does). In order to glaze your painting you will need a "transparent layer of colour contained within oil or acrylic glaze medium" (How to layer colours: 5 glazing essentials, n.d.). If applied correctly glazing creates interaction of bright, clear colours that can be fascinating to the eye, in which each layer contributes to the total visible effect.

In the Chapter Two I described basic differences and similarities of digital and traditional art. Those features gave us an idea that not only traditional art has not fully transformed into digital one, on the contrary, now they are co-existing in useful symbiosis, where one draw an inspiration from the other. This symbiosis is represented in techniques, ways of expressing art vision and ways of how this vision is percepted. All of which were supported by the practical examples. In the following Chapter Three, you will find out how to create from digital image something more similar to traditional art on the grounds of image segmentation techniques that were described above.

3 Digital painting tools and techniques

It does not seem so long ago when the personal computer was introduced, yet technology has evolved rapidly since then. Nowadays we have a notebook, Macbook, tablet, iPad, graphic tablet, smart phones and others. All these devices can be implemented in digital painting. Nevertheless, it is more a question of technical requirements than a brand or a type of devices that are used (which is question of one's preference). The devices that are appropriate for 2D and 3D graphics (interactive digital art) have to meet strict technical requirements, however, in case of generative digital art, those requirements are not that solid. All you need is an average notebook with enough memory to install necessary software for the certain type of programming.

This chapter will be focused on the non-photorealistic rendering technique, *Stylize* editor that works on principle of image segmentation and it will provide a manual for digital artists (beginner level).

3.1 Non-photorealistic rendering: Definition, evolution and software

Referring to the movements and styles in art and suitable digital techniques for each of them, this subchapter will deal with an abstract style, since there is slightly less detail and less time is required to learn how to do it. Once, these techniques are learnt is possible to proceed to more complicated artistic styles.

As described in Chapter Two, a *rendering technique* is concerned with the process of colouring, shading and texturing of an image. One of the possible outcomes of the rendering could be an abstract stylisation of the image. It first appeared in lithographic posters – a general category of printed 2D artwork designed to be affixed to a vertical surface, which is now used by painters, printmakers, art publishers, cultural organizers, politicians and propagandists, as well as commercial firms, PR and Advertising Agencies (Poster art, n.d.). Back in 1891 rendering was used in posters by Henri de Toulous-Lautrec, Jules Chéret, and later by Alphonse Mucha announcing

particular events in cultural life (the example is shown in Figure 20). The main concept as well as the marketing strategy of poster art is focusing on the front object and leaving the blurred background without too many details so that it could catch the eyes of viewers (or the potential consumers/audience) and let them use their own imagination to complement the image (or to come to the show in order to see what will happened next).

Figure 20. Jardin de Paris, Fête de Nuit Bal by Jules Chéret (1896–1900). Reprinted from https://en.wikipedia.org/wiki/Jules_Ch%C3%A9ret

Regarding digital painting techniques, the poster art concept is used in term of *non-photorealistic rendering* (hereinafter referred to as NPR), which is an area of computer graphics that focuses on enabling a wide variety of expressive styles for digital art. NPR unlike classical computer graphic is no longer interested in photorealism, it is inspired by artistic styles such as painterly rendering, pen-and-ink illustration, technical illustration, cartoon shading or abstract stylisation of an image (Pfenning, 2002). According to Green (1999), rendering in computer graphics referring to the process by which the representation of a virtual scene is converted into an image for viewing. It helps to imitate work of artist and simultaneously enhance the level of aesthetic value of the picture.

The reason why it is an object of interest in this thesis is that it is a one of the closest techniques to traditional painting. It could be appreciated by users who are

interested in taking bigger part in creating an image due to a variety of interactive and generative techniques in NPR. In generative form NPR is represented by the algorithms that transform a photo into an image similar to the painting by working with texture, for instance, adding a grid of brush strokes. The image after rendering will look more like abstract painting, it will be still seen that the image is performed by digital media and this is exactly what is meant in metamodernism by adding something new to the previously known.

In this thesis, I will cover the NPR algorithm that transform source photo into painted image in abstract style. Layered painting represents the painting algorithm, which takes as input a source image and a list of brush sizes (Hertzmann, 2001). The size of brush are given as radii $R_1...R_n$. The initial canvas is a constant color image and the algorithm proceeds by painting a series of layers, one for each radius (from largest to the smallest).

Hertzmann (2001) indicates that for rendering algorithms should be used the following style parameters.

• Approximation threshold (T) represents how closely the painting will approximate the source image. Higher values of this threshold mean "rougher" paintings.

• Brush sizes is defined by the smallest brush radius (R1) and number of brushes (n).

• Curvature Filter (f_c) is used to restraint or highlight stroke curvature.

• Blur Factor (f_σ) controls the size of the blurring kernel. A small blur factor allows more noise in the image and by that more abstract image is produced.

• Minimum and maximum stroke lengths (*minStrokeLength, maxStrokeLength*) are used to control the stroke lengths.

• Opacity (α) specifies the level of paint opacity between 0 and 1. Lower opacity can result in a washout effect.

• Color Jitter represents random factors that can be added to the to hue (j_h), saturation (j_s), value (j_v), red (j_r), green (j_g) or blue (j_b) color components.

When those parameters are setted (the process of analysis) then the algorithm is run and the process of synthesis finishes the implementation of applied filters and the image is transformed.

The area of usage of NPR covers 3D animation, drawing cartoons, making special effects in movies, video games, digital painting, posters for advertisements, etc.

3.2 Stylize editor: Working principle

In this thesis I am focusing on image segmentation and non-photorealistic rendering techniques of abstract stylisation of the image. For this and many other reasons described in Introduction, the *Stylize* editor was chosen. *Stylize* is an excellent editor for those who want to become digital artists, even if they are not good at traditional drawing or painting. It combines described rendering and image segmentation techniques and it is designed for abstract stylisation originated from the poster art. One of the obvious advantages for beginners is that an art creating process is simplified by using a photograph as the base for painting. Thus, you can practise your painting skills and get yourself ready for painting or programming from the scratch, which requires more complicated software without any background help.

The *Stylize* editor can be considered as graphical filter since it is plug-in module in *Elephant* editor. This is a plug-in type 3, i.e. with a graphical interface (GUI) supporting preview function and interactive tools. The shape of the plug-in module is chosen in order to use the *Elephant* blending layer tools and a possible combination with other modules (filters). The specific features of the *Stylize* editor include:

- layer preview of each layer and easy switching between them on the visual display;
- automatic (and possibly manual) settings of analysis and synthesis parameters;
- intuitive tools for layers manipulation comfortably controllable by mouse;
- direct authoring input into the process of abstracting an important image structure;
- preview of the processing results before the final synthesis (Cetkovský, 2005).

Dynamic library *Stylize* is written in language Object Pascal and was created in the Borland Delphi development environment (Borland Delphi 6 Enterprise). The program consists of *Stylize* project file (*Library Stylize*) and from the Settings units

(Unit *Settings[35]*), HystThreshSettings (Unit *HystThreshSettings[36]*), RunEDISON (Unit *RunEDISON[37]*), Filters (Unit *Filters[38]*) and Compose (Unit *Compose[39]*). Each of those units are represented by specific commands that perform exact action in segmentation process.

Automatic settings are given by the script and reflected in the showup window while performing some of the segmentation procedure and for the RunEDISON unit they are represented as follows: SpatialBandwidth = 7; RangeBandwidth = 6.5; MinimumRegionArea = 6750.

Is is sufficient to mention an image as the object for rendering in the *Stylize* editor, the input image should meet the following requirements:

- *depth of the structure:* the image should have a clear passing perspective, the depth of the field is maximally large (the entire scene must be focused);
- *clear hierarchy:* the dominant objects are in the foreground, with the distance of other objects their importance is decreasing; at the same time, there are not too many objects, especially with the same level of importance;
- *life:* people or animals enrich or revive otherwise colder image and character's stylisation provides great opportunities for abstraction (Cetkovský, 2005).

To achieve better results a digital photograph should be picked; acceptable formats are JPEG and BMP (TrueColor, 24 bits). The photo could be colour or monochrome. The rest of the photo characteristics is subjective, although for my thesis it is essential as well to choose photo represented the metamodern concept (see Figure 21).

To simplify a basic working principle may be described as following: Upload any picture or photography (preferable) into the editor and while using different settings, render the image by blurring the edges and making the photo look more like

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[35] Defines record types for storing settings and the segmentation layer mask (*TSegmLayerSettings*), the edge detection settings (*TEdgeLayerSettings*) and *TSettings*.

[36] The unit consists only of the *THystThreshDialog* class that shows a dialog for more detailed edge detection settings. It contains definitions of all controllers and methods for their maintenance. After confirming the entered values, the *OKButtonClick* procedure changes the edge detection setting.

[37] The unit provides communication with *EDISON* system and contains procedures for generating input data and analysis scripts.

[38] The unit defines the *TFilter* class and implements its only method *SmoothRegions* for smoothing the boundaries of regions in the input bitmap (*RefImg*) by the size filter specified as a parameter of this method.

[39] The unit *Compose* contains procedures for all levels of image synthesis.

abstract painting. It is a good application to begin with, though, in order to succeed the artist should be familiar with settings and capabilities of that editor.

3.3 Stylize editor: Manual for beginners

The procedure of rendering in *Stylize* editor could be described in the following fourteen steps.

Step 1. Install the editor. It is better to create a folder where all of the follow up programmes will be easy to find later.

Step 2. Choose the digital image for rendering. It could be any photo of your choice, but try to find photograph that contain clearly seen objects in the foreground that could be enhanced.

Step 3. Run the *Elephant* programme.

Step 4. In the opened window select *File - Open.* Then choose the photo and upload it to the programme.

Step 5. After the photo is uploaded, select *Stylize* option and press the button *Filter Settings.* It will redirect you to the *Stylize* command window.

Step 6. Select the first layer of segmentation in the bar and then press the *GO!* button to start the process of segmentation. The analysis is called by Edison programme and could be tracked in newly appeared dialogue window. There are automatic settings that are normally enough for the first and following layer segmentation. However, for more advanced users it is possible to change them. As the result of Step 6 you will gain the segmented, extremely blurred image.

Step 7. By pressing the "+" button at the right top corner add the second segmentation layer. Then press the *GO!* button. As the results here, the image will become more drawn.

Step 8. Repeat the Step 7 until you will be satisfied with the results. It is possible to go up maximum to the sixth segmentation layer.

Step 9. Now go to the *Edges* section. Then press the *GO!* button in the section EDISON edge detection. By that the edges of your image will be detected.

Step 10. Now have a look at all segmented layers and pick the structure that you want to highlight. It is better to start from the second layer and go to the higher layers. In the *Segm/Edges* edit tools pick the *Green brush* and fully mark the areas you want to highlight in the obtained image. If you want to erase some of the marked areas use the *Red brush*. By pressing the *Preview details* you could track how the areas are cut.

Step 11. Go back to the window *Elephant*, open *Filter - Apply* and wait. The processing may take a few minutes, the time is depending on the size of the picture.

Step 12. If in the obtained image there are some issues that you are willing to correct. Go back to the *Stylize* and make necessary changes.

Step 13. Do not forget to save your image by clicking *File - Save As*. You can choose from two formats JPEG and Bitmaps. Choose the JPEG format for the convenience.

Step 14. Enjoy your masterpiece!

References: in Figure 21 there is a source photo taken by photographer Dina Khusainova and Figure 22 contains the image after segmentation in *Stylize* editor.

Figure 21. The source photo.

Figure 22. The image after segmentation in the *Stylize* editor.

The obtained image is very similar to the traditional abstract painting. The unexpected position of the characters in the picture and the technique in which the image is created gives the right to call it metamodern artwork.

Conclusion

In this bachelor's thesis, metamodernism was established as the leading concept of contemporary art in which the digital art has evolved in the unique branch, the aesthetic side of which is inseparably connected with nature and science. The growing influence of information technology in art has made the change in perception of an image, which has also affected art development. The differences between traditional and digital painting, however, are not too strict regarding the expression of emotions. The reason for that, as claimed in the Chapter Two, lays in non-importance of means by which the artwork is performed, but in how the message that artists put in their work is delivered. It is essential to highlight here the role of computer in a creating process, which shifted from medium and tool to co-author of the paintings who assist in the process and help to accomplish new unpredictable results that will lead to the progress in art and science.

The actual differences in techniques of traditional and digital art are shown in Chapter Two in the examples and concern mostly shadowing, lighting and image segmentation. Those techniques could be achieved by different use of paints, brushes, strokes, the way how to mix the colours and how to apply them on the canvas in traditional art. And by the special algorithms that imitate those actions and apply them on the screen in digital art. In the Chapter Three I introduced a concept of the non-photorealistic rendering that helps to transform the digital picture into the abstract painting and represents the metamodern movement in art. After the working principle and algorithms for that were described, I tried the *Stylize* editor on practice and wrote down a manual for artists who want to keep up with digital era or for programmers who are interested in art.

To sum up, the objectives of my thesis (to frame the concept of digital painting, describe its historical development, discuss differences between traditional and digital painting techniques and lay down the requirements for computer graphics hardware and software) were successfully fulfilled. Furthermore, I came to the conclusion that art develops in its own unpredictable way yet always in one direction with nature, science and technology that represent the useful symbiosis of 21st century.

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