Extension of Painting Artwork by Utilizing Structural Color Materials and Perspective Projection Simulation

構造色材料と透視投影シミュレーションによる絵画表現の拡張

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Waseda University Graduate School of Fundamental Science and Engineering

Department of Intermedia Studies, Research on Environmental Art

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Summary

My thesis mainly studies how to use new materials and Perspective Projection Simulation to provide assistance to promote the creation of new works, and how to use this technology to better assist artists to complete their own works. Throughout the 20th century, the application and fascination of modern science and technology have greatly stimulated the imagination of artists. For example, PS, AI, C4D, 3DMAX, and other computer graphics software have also brought convenience and amazing visual effects to painting. Technology has provided a more convenient way for traditional painting, and people can use some drawing software to quickly produce near-realistic the real thing. New material creation refers to the new and vigorous visual language created organically using various media materials in artistic creation. New materials include traditional water-based and oil-based pigments, as well as common living materials such as ready-made products, clay, paper, mineral colors, and wastes. It also refers to the newly discovered materials and performance techniques being developed.

Chapter 1

Introduction

1.1 Background

The development of optical equipment from the 15th century to the 19th century has often influenced the practice of painting, and the emergence of photographic technology has also brought great impact and cshallenges to the artist. The conflict between imaging technology and painting has gone through such genres as Modernism (Various avant-garde and rebellious artistic movements emerged throughout the 20th century), Surrealism (Following World War I, there was a rebellion against traditional capitalist cultural thought within the French cultural sphere), and Cubism (Throughout the history of Western modern art, numerous avant-garde movements and schools have arisen). Until the 1970s, with the emergence of computer technology, various new media technologies have been developed, and art has begun to become more diversified. The development of science and technology starts from Camera Obscura (Optical instruments play a significant role in various fields), Optical Lens (These devices are designed based on the principles of light refraction), Camera (Specialized optical equipment is used for photography purposes), Video Camera (Motion picture recording devices capture dynamic imagery) all the way to ipad, graphics tablet, programming technology, 3D technology, which has expanded the medium of painting into a new cognitive structure. The more flexible use of modern technology as a new medium for painting is also a brand-new continuation of the "image-making technology of optical equipment", which can provide painters with more favorable creative methods and techniques to solve the difficulties in creating the drawing.

This thesis mainly studies how to use new materials and ICT technology (Information and Communications Technology) to assist in creation to promote the creation of new artworks, and how to use this technology to better assist artists to complete their own works. In my experimental works, new structural color pigments

are used to apply to painting, so that people can explore the relationship and changes between angle light source and color, as well as the relationship between works and light source when watching structural color works. New projection technology and 3D technology are introduced to assist the creation and detect changes in perspective in painting to complete new creations.

In the art world, there are chemical or physical materials that appear on the market but are rarely used by artists or remain undiscovered; these are referred to as new materials. New material creation refers to the new and vigorous visual language created organically using various media materials in artistic creation. New materials include traditional water-based and oil-based pigments, as well as common everyday materials such as ready-made products, clay, paper, mineral colors, and wastes. It also refers to the newly discovered new materials and performance techniques being developed.

1.2 Related Work

A wide range of knowledge can be acquired by looking through books and literature in the process of economic development. What kind of knowledge mentioned above is the development of physical and chemical techniques, how art achieves its development, and which artists make scientific and technological achievements their own for a better creation. In addition to that, the law of creation is followed by careful research on the changes of artists from different eras, together with the connection between scientific technology and chemical techniques.

With the help of the creative experience the previous artists leave behind, contemporary artists can perfect their works and create stunning innovations assisted by modern technology and up-to-date materials. Besides, multiple scientific techniques play a consequential role in the new chapter in human profiles, pinhole imaging through an Optical Lens which impacts art in the development of physical techniques, the camera obscure painting that expresses composition and quality of the picture in subtle details, or the photography rendering the picture's quality of great

vraisemblance.

The Renaissance was the first era when painters used Camera Obscure painting whose original idea was put forward by Vermeer, a famous painter in the seventeenth century. Precisely speaking, the camera obscura painting has already been brought out, yet it received wide use in Renaissance. When the days came to the era of photography, people discovered that the principle the camera adopts was the camera obscura painting. It worked under the charge of a technique called Single-hole Imaging, which had a close connection with the so-called Scenography. Accompanying the steps into the nineteenth century, photography came into being with extensive applications, simultaneously.

On the one hand, the occurrence of photography imposes overwhelming challenges on the status of painting. On the other hand, however, a great number of painters introduce photography into painting, and a method of putting photography to good use is applied by many painters from then on. It is not difficult to see that photography effectively generates progress in popularization which in turn pushes painting ahead. As technology and chemistry advance, so does the development of art, giving rise to a variety of artistic movements.

Before analyzing the relationship between beholders and works, light source, and color with analysis of the situation when works are displayed in galleries and art museums, it is of great importance to undergo multiple experiments in composing works, which needs to mix research on historical literature with practice and to add new materials that boost the color with structurally-trapped feature to a specific work. Finally, a more convenient way to compose works can be achieved after testing a new kind of software and image projectors, it is convenient to draw sketches and modify sketches before creation.

Throughout the 20th century, the application and fascination of modern science and technology have greatly stimulated the imagination of artists. For example, PS (Adobe Photoshop), AI (Adobe Illustrator), C4D (CINEMA 4D), 3DMAX (3D Studio Max) and other computer graphics software have also brought convenience and amazing visual effects to painting. Technology has provided a more convenient way

for traditional painting, and people can use some drawing software to quickly produce near-realistic out came with the real thing. Some of my personal attempts and creations want to make use of the more advanced software to assist in creation.

1.3 Purpose of the Research

This paper aims at combining the experiments and the results to further express how well the artists can achieve a creation by putting physical and chemical techniques. It means that prior to the completion of the creation, to design a perfect work needs to do sufficient research on the law of structurally-wrapped color as well as its application with the assistance of software and projectors. What kind of connection do the physics, chemistry, and artistic paintings boost? How can they work together to promote the development of arts? Arguably, they are questions that need to be figured out.

1.4 Approach of the Research

The first step to start this paper is to broadly browse literature and books relevant to the genre of art history. Based on historical records, scientific techniques boost two divisions, one is the physical technique in terms of which the history of lenses development and the way the artists add lenses to compose unfold on the paper, and the other one is the chemical technique in which the paper involves the history of pigments development.

The very next method to continue the paper is the analysis with comparison in the part of the development of the modern arts. The comparison lies in the achievements in physics and the works of artists in the contemporary. Subsequently, the conclusion that physical and chemical developments simultaneously carry on can also be effective in supporting this paper.

Regarding the impact the chemicals impose on the development of arts, there appears a method called a case study. What the paper demonstrates in terms of case study is a set of analysis on the artists and their works, how the progress in chemics

facilitates scientists to make the occurrence of pigments, together with the profound influence on artist's works and styles by these pigments.

Last but not least, the description of experiments in creating will be included in this paper, helping to elucidate how well the artists can adopt neoteric materials and techniques to their creations.

In the experiment of painting creation: in the first stage, the experimental work “The Umbilical Cord of the Universe” series was created. This new type of pigment is mainly used to paint cars and toy models. In the first three parts, aluminum sheets were selected for painting because the aluminum sheet was closer to the car’s body surface, which was easier to color and highlight the effect. In terms of pigment selection, transparent nail polish and laser powder were tried to combine propylene and oil painting to create. The first creation was to create a complete painting on a flat aluminum sheet. The second creation was formed after the deformation of the aluminum sheet, which presented unexpected futures and effects. Under the light, pearlescent powder and laser pigment showed differences in color with the change of angle on the uneven aluminum surface. The disadvantage of creating on the aluminum sheet is that the edge of the aluminum sheet is very sharp, and the work will encounter certain obstacles in transportation and storage. Later, the researcher will try to use new structural color pigments on paper. Structural color pigment is a kind of paint material that cannot be absorbed by the paper, so propylene pigment is used as the bottom layer of the paper.

In the second stage, the disadvantage of creating on the aluminum board is mentioned above, thus it is decided to use structural color pigments on the paper. Structural color pigments cannot be absorbed by the paper surface, so it is needed to use acrylic paint as a base layer on the paper surface.

Softer sketch paper was chosen. After it was creased. A black acrylic was used as a base layer’s color and sprayed with structural color paint. In the third experimental stage, ICT technology was adopted to assist the creation. Traditional artists can start to create on a flat plane, which allows artists to draw sketches and then, revise drafts on the uneven screen, and then to intuitively preset the final effect in advance. The

projector was used to link the computer painting software and put the pictures on the uneven creative materials to make a draft. For example, it is more convenient to create sculptures and uneven pictures.

The composition in the third stage uses such software as app Scaniverse (A 3D scanning app) and Procreate (A drawing application software) together with the assistance of projectors and links in the computer.

1.5 Structure of the Dissertation

Chapter One: The Background, Related Work, Purpose of the Research, Approach of the Research and Structure of the Dissertation. It introduced the development of pinhole imaging technology from the 15th century to the 19th century, how artists used convex mirrors to create, how art has been linked with science and technology since ancient times, and how the progress of science and technology and chemical technology has promoted art progress and assisted artists to complete their creations. The application of new pigment structural color in painting makes it possible to explore the relationship and change of angle light source and color, and the relationship between work and light source when viewing structural color works. The introduction of new projection technology and 3D technology-assisted creation can detect changes in perspective in paintings and use computers to create new creations.

Chapter Two: Art and Science in the History of Painting. Imaging Technology Before the 16th Century. 17th to 18th Centuries - Relationship between the Development of Alchemy and Art Materials - Invention of New Color Materials by Alchemists, 19th Century to 20th Century - From the Appearance of Photographs to 3DCG – Pre -18th Century Photorealistic Paintings Displaced by Photography, Prompt Artists to Seek New Forms of Expression that Cannot be Captured Through a Camera.

Chapter Three: New Materials Pigments. Development of Painting Technology in the Latter Half of the 20th Century. Contemporary Alchemy. Changes Seen from the Aspect of Physical Materials. The Emergence of Current Painting Materials and Their Application in Painting. Nail Art and Painting. Development of Car Painting.

Pearlescent Pigments. Painting Technique Created by New Materials. Appearance of Structural Color Materials. Evolution of Canvas.

Chapter Four: Application of Structural Color Pigments in Art Creation. Experimental Creation of Structural Color Pigments and the Relationship between Structural Color Pigments and Light Sources. Challenges for Applying Structural Color Paintings. Overcoming Challenges in work.

Chapter Five: Development of Pictorial Expression by Introducing New Projection Technique, Changes in Perspective in Painting. Perspective in 16th Century Painting. The Influence of the Appearance of Photography on Painting in the 18th and 19th Centuries. Perspective in Cubism in the 20th Century. The Influence of Computers on Art. Effect on Pictorial Expression Brought About by Change of Viewpoint Leveraging Computer Simulation for New Projections and Summary.

Chapter Six: Combining Software with Projection Technology to Assist Painting. Projection Model for Abstract Representation. Introduction of Tracing Technique by Applying Projection Mapping. A Work Using a New Projection Method. The Advantage of Creating with New Technology and Abstract.

Chapter Seven: Results and Discussion. About an Attempt at a New Painting Technique. Selection and Evaluation of Works for Exhibition (Public Exhibition Participation). Painting “The Eye of Hell” 2022. Has Won the Youth Group” Bronze Award in the H.C. Andersen Art Award. CG Work “The Eye of Hell” 2022. Has Won the Youth Group” Bronze Award in the H.C. Andersen Art Award. The 5th Beijing Film Academy International New Media Art Triennial “BORDERLESS”. Shortlisted for the Public Exhibition “ベラドンナ・アート”. Exhibitions 『在地, 園宇宙』. Industry Insiders Comment. Art and Science Impact the Present. The Influence of Information Technology on Art in the 20th Century. Remaining Issues and Future Prospects.

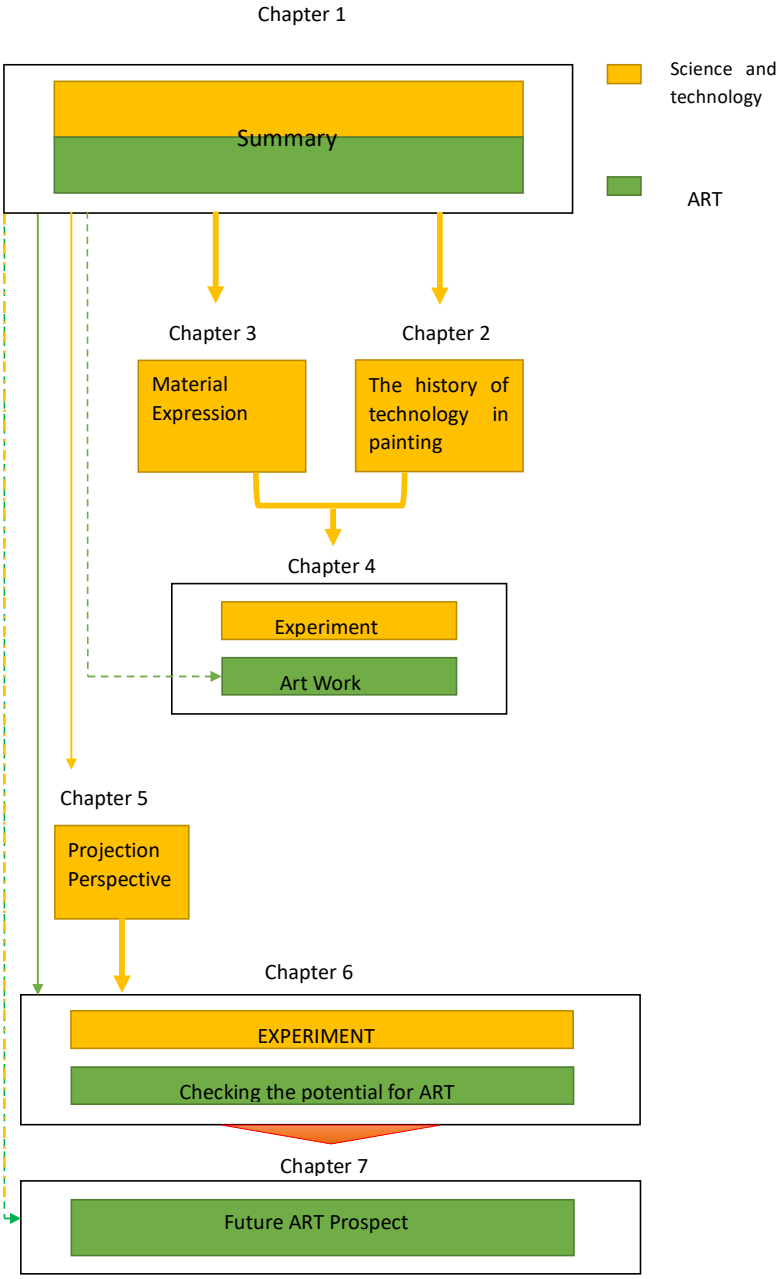


Figure 1-1: Research Idea Map

Chapter 2

Art and Science in the History of Painting

2.1 Imaging Technology Before the 16th Century

The early pinhole optical imaging principle explained the pinhole images we can see in solar and lunar eclipses, and the oldest method at that time was the precision instrument astrolabe that used pinholes for astronomical measurements [1]. BC astronomer, Hipparchus developed the theory of stereoscopic projection, and the astrolabe is an important tool for astronomers, astrologers, and surveyors. Scientist Alhazen demonstrated an instrument applied to the pinhole principle that can be placed on a blind in a dark laboratory to examine the separated light. All of the above are the starting points for pinhole imaging [2]. Scientists Odolik and Kamalal-Din al-Farisi analyzed sunlight refracting through a pinhole glass sphere to explain the rainbow principle. Roger Bacon illustrated religious creed and science in sketches of a three-tiered pinhole obscura. During the Renaissance, the architect Lippo de Ser Brunelleschi invented the pinhole perspective in 1425, known as the one-point perspective, which lead to changing the human concept of space. He used two basic optical devices, a pinhole box, and a mirror, to capture three-dimensional visions. The first diffractive camera obscura, invented by Leon Battista Alberti, was able to see a reproduced three-dimensional image through a small hole in the box [2].

Many art historians believe that the works of the 17th century the Dutch painter Johannes Vermeer were created with the aid of the camera obscura. It is said that Van Leeuwenhoek, the inventor of the microscope and expert in polishing lenses, was a neighbor of Vermeer [3]. While there is no clear evidence for this, the theory is based on research into the artwork itself. For example, according to Hockney's analysis, the bread basket in the foreground of *The Milkmaid* is out of focus compared to the bamboo basket hanging on the back wall, a change that cannot be detected by the naked eye [4]. Furthermore, if Vermeer had not been aware of the "halo" effect in the highlights due to out-of-focus, he would not have been able to paint this effect on

baskets, breads, cups, or jars [5].

As the camera obscura technology continues to develop, so does the artist's work. In the thesis research, combined with my own creation experiment, I used projection technology to assist in creation.

2.2 17th to 18th Centuries - Relationship between the Development of Alchemy and Art Materials - Invention of New Color Materials by Alchemists

Alchemy played an important role in refining the pigments of medieval times. In the practice of alchemy, red lead was artificially synthesized, a dye formed by the transformation of white lead by heating, which was called “minium” in the Middle Ages. Alchemists learned that mercury sulfide could be artificially smelted by mixing liquid mercury and odd-smelling yellow sulphur (In the ore state) in a sealed container and heating them [6]. In his own handbook, *De diversis artibus*, Theophilus claimed that this smelting process could yield pigments higher than the natural cinnabar. During the Middle Ages, people used aluminum to convert it into insoluble white aluminum hydroxide. The pigment, known as “lake”, also produces a rich blue ultramarine blue from the blue mineral lapis lazuli. The needs of medieval artists stimulated the evolution of chemical processes, and alchemy also carried the phenomenon of making use of cutting-edge technologies in the innovation of painting calendars [7].

2.3 19th Century to 20th Century - From the Appearance of Photographs to 3DCG - Pre-18th Century Photorealistic Paintings Displaced by Photography, Prompt Artists to Seek New Forms of Expression that Cannot be Captured Through a Camera

The emergence of photography technology has brought great impact and challenges to painting, especially halftone printing has changed the way humans observe the world after promoting the large-scale presentation of photos. The conflict between imaging technology and painting has led to two

differentiations in modern painting, one is towards abstraction, and the other is the implementation of Cubism, that is, replacing single-point perspective with moving viewpoints.

After World War II, the world art center was transferred from Paris to New York, and European modernist art was integrated into American contemporary art in different forms. In the 1950s, abstract painting dominated the art scene in New York; Beginning in the 1960s, Duchamp exerted a strong influence in New York as a pioneer of conceptual art, followed by the rise of Pop Art and Conceptual Art, which challenged Abstract Expressionism. Conceptualization of contemporary art, readymades, and cross-media creations became mainstream [8].

Through practice, David Hockney connected imaging technology from camera obscura, lens, camera, and camcorder to iPad and iPhone with his own painting creation and theoretical research. He tried to dialogue with the techniques of classical painting, thereby providing a solution that is conducive to solving painting problems [9].

Nowadays, digital technology has been widely used in the field of art, and with the help of these digital technologies, artists have opened up a new artistic world. In particular, the rapid emergence of new media technology has brought about the reform of stage lighting, which allows light to do almost everything. Furthermore, with the continuous improvement of innovative thinking and the development of digital technology, people's exploration of artistry will only deepen. With the support of digital technology and artistic inspiration, the assistance of lighting can form a space that is both illusory and real, which leads to the emergence of many art forms.

Chapter 3

New Materials Pigments

3.1 Development of Painting Technology in the Latter Half of the 20th Century

3.1.1 Contemporary Alchemy

The invention and production of new chemical pigments have a sustainable influence on their use in painting. Bridget Riley said: “Artists have to face two-color systems, one is provided by nature, the other is needed for art, and one is perception color, the other is picture color [10]. The painter's work not only presents the impact of color but also displays the possibilities limited by the existing chemical technology. Knowledge and implementation of chemicals in art can be used to broaden the range of pigments. Chemistry is to painting what deconstruction is to sketch, and there is reciprocity between chemistry and a significant part of art. The constant development of the modern chemical industry is also partly driven by the need for color. Synthetic chemistry made great strides in the 19th century due to the need for artificial pigmentsartart [11]. Many of the world's chemical companies started from synthetic fuel production. For example, the reproduction of color in the development of photography and printing gave rise to large technology companies such as Xerox and Kodak.

Regarding the use of colour in the 20th century, in 1897, Matisse turned to the newly invented bright blue greens and reds. Using cobalt violet, he used new cadmium red in light and purplish shades [12]. Carmine was made from cochineal in the 16th century, and the manufacture of red lakes was improved in the 19th century, but no new colorants appeared [13].

In 1910, cadmium red officially became a commercial product. Later, Bayer Chemicals developed a new technology that changed the color from orange to dark maroon by changing selenium. Matisse prefers red with a strong visual impact. Through Ogden Rood, Matisse realized that red, blue, and green can work together to

create an object similar to the hand spectrum, which inspired Matisse's work [14].

Maurice de Vlaminck is a representative Future of the Fauvist group. He extensively used palettes in his creations and designed his works using a single primary color or a secondary color. Cadmium color was used in works of barium chromate and Mars yellow. Vlaminck created “Landscape with Red Trees” using modern colors without mixing. In 1905, Fauvism came into being. The rise of this genre symbolized a new development level in pigment technology. In the same year, Matisse's “Luce, Calme et Volupte” was unveiled [15]. This work is of pointillist style, symbolizing Fauvism’s development in the direction of pointillist. Signac said, however, that the style is still limited by the rules of color contrast and complementarity. It was not until Matisse's portrait of his wife that complementary colors were completely abandoned, showing a different dissonance in which cinnabar was closely linked with purple, green, and ochre [7].

Figure 3-1: Landscape with Red Trees, Chatou Maurice de Vlaminck, 1907

Derived from: https://www.wikiart.org/en/maurice-de-vlaminck/landscape-with-red-trees-chatou

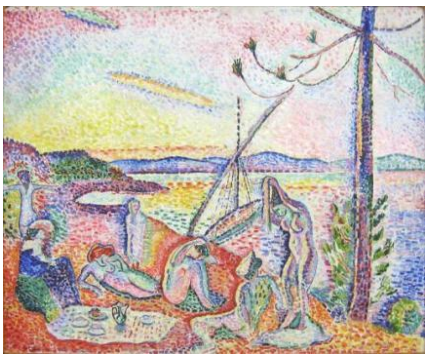


Figure 3-2: Luce, Calme et Volupte Henri Matisse, 1904

Source: https://en.wikipedia.org/wiki/Luxe,_Calme_et_Volupt%C3%A9

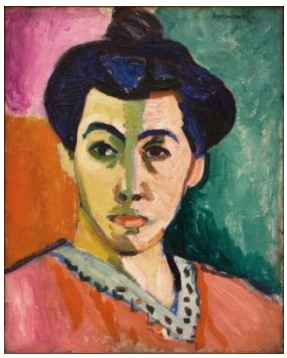


Figure 3-3: Portrait with a Green Henri Matisse, 1904

Source: https://www.henrimatisse.org/green-stripe.jsp

Since the beginning of the 20th century, synthetic binders have been used to make quality pigments. Most of Pollock's (American, abstract expressionist painter) pigments have strong fluidity. The glossy enamel paints he used were low-cost due to being mass-produced for industrial purposes. Compared with expensive pigments, paint or coating was a good choice. Mexican mural artist David Alfaro Siqueiros is

aware of the durability of these materials. When Peter Blake started using glossy enamel paints in the 1950s, British painter Patrick Caulfield also took an interest in household enamel paints encouraging a style of sign-painting without personal features, with no visible brushstrokes on the surface. Helen Frankenthaler (American painter) used acrylic emulsions. Propylene is a pigment binder that changes the optical properties of the pigment and also changes the drying time [7].

Figure 3-4: Birth of Fascism David Alfaro Siqueiros, 1936

Source: https://www.wikiart.org/en/david-alfaro-siqueiros/birth-of-fascism-1936

Figure 3-5: Mountains and Sea Helen Frankenthaler, 1952

Source: https://en.wikipedia.org/wiki/Mountains_and_Sea

Figure 3-6: The Fine Art Bit Peter Blake, 1959

Derived from:https://www.wikiart.org/en/peter-blake/the-fine-art-bit-1959

Figure 3-7: Still Life with Dagger Patrick Caulfield, 1963

Source: https://www.tate.org.uk/art/artworks/caulfield-still-life-with-dagger-t02032

Yves Klein (Promoter of Neorealist Art) was dissatisfied with the effect of the binder on the pigment when producing early monochromatic paintings in the early 1950s. He liked the richness of the dry powder, but once it was mixed with the binder

to form the pigment, the color faded, so he hoped to find a way to keep the intensity of the solid color. He turned to chemical manufacturer Edward Adam for help, and in 1955, a fixer resin called Rhodopas M60A was born, which was produced by Rhone-Poulenc Rorer and could be diluted by mixture with ethanol and acetic ether. Klein unveiled a series of blue monochromatic paintings at the "Anthropometry of the blue periodexhibition" in Milan in 1957. This new colour was patented in 1960 as "International Klein Blue" [16].

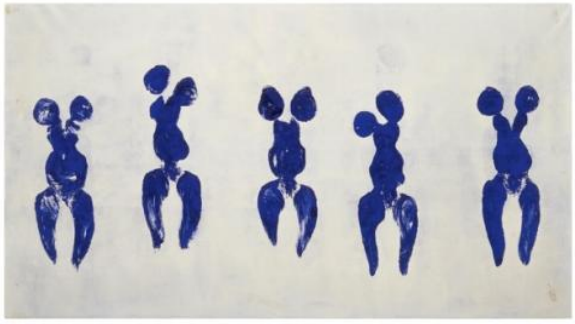


Figure 3-8: Anthropometry of the Blue Period, Yves Klein. Foto: yvesklein.com, Klein

Source: https://www.yvesklein.com/en/ressources/index?rt[]=123&p[]=1958-1960&sb=type&sd=asc&rt[]=322#/en/ressources/view/artwork/595/anthropometrie-de-l-epoque-bleue-anthropometry-of-the-blue-period?rt[]=123&rt[]=322&p[]=1958-1960&sb=typPe&sd=asc

Figure 3-9: "Untitled Blue Monochrome" by Yves, (International Klein Blue 67)

Source: https://www.yvesklein.com/en/textes-choisis/view/18/l-ikb-international-klein-blue/

Nitrocellulose is dissolved in an organic solvent and added with a resin to provide a varnish, which is a synthetic paint. When tinted with pigments, it becomes a tough, glossy, fast-drying paint, later known as enamel [17]. These characteristics of enamel paints made them popular with the expanding automotive industry, and the US-based DuPont Chemical Company began supplying enamel paints to General Motors. As a result, the time required to paint a car dropped from seven to ten days in the early 20th century to about thirty minutes in the 1920s, which was a powerful push for mass production. In the 1930s, Siqueiros began using DuPont enamels known as the Duco range. In the 1950s,

Figure 3-10: Nitrocellulose

Picture from: https://www.exportersindia.com/hengshui-yuanchem-industry-limited/nitrocellulose-hengshui-china-1731185.htm

British artist Richard Hamilton used nitrocellulose spray paint, especially in the car-themed painting “Hers Is Lush Situation. 1958.” In works about technical artifacts such as the household appliances described in “She” (1958-1961), Hamilton used nitrocellulose enamel paint. In the circle of artists, the brand of enamel paint is probably Ripolin, a French company engaged in production for domestic use since the beginning of the 20th century. Linseed oil was originally used as a binder, and when added to a resin, it will toughen and create a high gloss finish. Ripolin's reputation is entirely due to Picasso who extensively used this paint since at least 1912, apparently because of its durability [7].

Nitrocellulose has now been replaced by new synthetic resins called alkyds. These are polyester polymers that are mixed with oils to make fast-drying paint mediums [15]. The first alkyd resins were produced in 1927, and have been used as adhesives in commercial coatings in the United States since the late 1930s and in Europe since the 1950s. This alkyd resin can carry more colorant than nitrocellulose, so it can produce more intense, opaque colors. DuPont started using alkyd resins in the 1940s to replace nitrocellulose in the Duco range, and Ripolin also switched from drying oils to 367 alkyd resins. Winsor & Newton was one of the few companies that supplied artists with alkyd pigments which were only introduced in the 1980s. One inconvenience of these synthetic resin-based pigments is that, like oil paints, they must be diluted with an organic solvent such as rosin—a complex and harmful operation [7].

In 1953, acrylic emulsions appeared. Acrylic plastics, including rigid plastics such as acrylic resin, are commercially available since the 1930s. Liquid acrylic polymers are insoluble in water. However, in acrylic emulsions, the tiny particles of the polymer carrying the colorant are dispersed in water, thus preventing coalescence through soap-like substances called emulsifiers [15]. After the paint film dries, the water evaporates and the acrylic transforms into a strong but flexible coating. Once cured, this paint is water-proof. The first acrylic emulsions were architectural paints, but Permanent Pigments, USA, used the same formulation to produce a series of artist pigments called Liquitex. Artists like Andy Warhol and Helen Frankenthaler

experimented with them in the 1950s. It was not until 1963 that it was favored by artists after Liquitex modified the formula to increase the viscosity so that it became more like an oil-based paint. George Rowney & Company introduced a British version in the early 1960s, the Cryla series[7].

Figure 3-11: Liquitex

Source: https://www.amazon.co.jp/Liquitex-Professional-Pot-dAdditif-Taille/dp/B000KNJFKI

Figure 3-12: Cryla

Source: https://www.daler-rowney.com/cryla-artists-acrylic-paint/

In addition to being dilutable with water, another important attraction of acrylic emulsions is that they dry quickly: a new coat can usually be applied within an hour. It was this that prompted David Hockney to switch from oil paint to propylene in 1963, a traditional technique Hockney used in “Mr. and Mrs. Clark and Percy” [18]. In the late 1940s, American pigment manufacturers Leonard Bucure and Sam Golden collaborated with an acrylic resin manufacturer to design the Magna series of acrylic “solution” pigments for artists [19]. Magna pigments in tubes have a consistency similar to oil paints and can be diluted with turpentine, which can even be mixed with oil paints. The pigment can be loaded with a lot of colorants, so it can be diluted considerably without loss of color intensity, whereas diluted oil paints become translucent [15]. Pop artists like Mark Rothko, Barnett Newman, and Kenneth Noland as well as Roy Lichtenstein used the pigment. Working with the painter Maurice Louis, Bucure developed a bespoke version of Magna paints that fit Louis's extremely personal style. Bucure sometimes tested new Magna products, giving them free to British painters like John Hoyland, who had no access to acrylics until 1963. The Magna series ceased production in the 1980s. Sam Golden's son Mark (Now head of

Golden Artist Paints) created a similar line of acrylic paints in the late 1980s [15].

Figure 3-13: Mr and Mrs Clark and Percy David Hockney, 1971

Source: https://en.wikipedia.org/wiki/Mr_and_Mrs_Clark_and_Percy

Figure 3 - 14: Magna

Source: https://en.wikipedia.org/wiki/Magna_%28paint%29

Acrylic is an expensive material, and most household emulsion paints are now also based on polyvinyl acetate (PVA) instead. The principle is the same: PVA itself is a water-insoluble polymer that can be used to form tough plastic-s and resins, but in an emulsion, it is dispersed in water as droplets.

PVA coatings, first marketed in the 1950s, also have the advantage of fast drying. British painter Bridget Riley used them in the 1960s. The flat surface of the PVA complements her delicate, illusory-art compositions. Towards the end of the 1960s, Riley began to paint her “op art” more and more in color rather than black, white, and grey.

In the 1970s, Riley eventually turned to propylene, and later she sometimes used oil paints to make the shade dense [7].

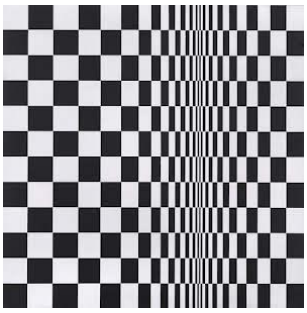


Figure 3-15: Movement in Squares bridget riley

Source: https://www.theguardian.com/artanddesign/2019/dec/06/bridget-riley-movement-in-squares

Figure 3-16: Fete Bridget Riley, 1961a

Source: https://www.wikiart.org/en/bridget-riley/fete-1989

Willem de Kooning used a variety of pigment mediums in his paintings, including oil paints and cheap enamels, sometimes enhanced by the addition of plaster of Paris [20]. Some of his works are colorful and have bright tones. In the late 1950s, Louis created his “faces” series by pouring highly diluted pigments on natural cloth [15]. Repeated applications of a range of bright colors can result in the appearance of a translucent, gauze curtain. The color is soaked into the cloth as if it were dyed. In the “Unfurled” series of the 1960s, Lewis retained the pouring technique without adding and mixing colors. He combined pouring and rubbing to direct paint into diagonal bands of color, leaving large areas of the canvas blank. He has about 20 colors on his palette, which were supplied directly by Bucure [19]. Louis remade the paints each time and carefully cleaned the machine amid the preparations of each color. However, the extreme dilution of acrylic binders means that it can be difficult to obtain a uniform pigment surface. In some of these works, there is a trace of pigment particle aggregation.

In the 1950s, a brand new colorant, organic compound called quinacridones appeared. As a true organic colorant (Based on salts of azo dyes), quinacridone colorants have been on the market since 1958, offering colors ranging from orange-red to blue-violet [21]. Many artists' pigments were colored with quinacridone. Quinacridone would be the most promising alternative to cadmium [22]. In 1983, the first patent was granted to diketopyrrolopyrroles, or DPP. In 1974, light-absorbing organic molecules from which DPP was derived were discovered. The molecule, originally a tiny reaction product, was then developed into a commercially viable compound by chemist Abdul Iqbal from Ciba-Geigy Limited Co. in Basel. DPP pigments, which range between red and orange, are still expensive. Ciba-Geigy Limited Co. produces these pigments, mainly for the automotive industry. Greater attention from the industry will eventually bring these colors to the artist's market [7].

Figure 3-17: Willem de Kooning Interchange de Kooning , 1955
Source: https://en.wikipedia.org/wiki/Interchange_%28de_Kooning%29

Figure 3-18: Faces Morris Louis, 1959
Source: https://www.wikiart.org/en/morris-louis/faces-1959

Figure 3-19: Unfurled Morris Louis, 1960
Source: https://morrislouis.org/paintings/unfurled-paintings/du361

In the early 20th century, due to the continuous development of inorganic pigments, cadmium red (PR108), molybdate red (PR104), bismuth yellow (Pucherite PY184) pigments and other high-performance composite metal oxide pigments have entered the market. In 1919, cadmium red (PY108) pigment was officially launched. Due to the scarcity of cadmium metal, the price of cadmium red was relatively high. In 1933, Schultz obtained the invention patent authorization for molybdate red (PR104). In 1935, molybdate red (PR104) began to be marketed and sold in the American market, which was used in coatings, plastics, ink, and other industrial fields. Considering the need for environmental protection, inorganic pigments are gradually developing toward the direction of zero harmful heavy metals. In 1985, bismuth yellow (Pucherite PY184) pigment began to appear on the market as a new type of pigment with bright color and no harmful heavy metals such as lead and chromium. In 1997, the French company Solvay successfully developed cerium sulfide red (PR265) pigment, which is the first environmentally friendly red inorganic pigment without harmful heavy metals lead, chromium, and cadmium, and partially replaces cadmium red (PR108), molybdate red (PR104) in the market [23] [24].

Figure 3-20: Cadmium Red Pigment red 108; Chemical Formula: Cd/S/Se

Source: https://www.alibaba.com/product-detail/Cadmium-red-pigment-red-108-PR108_60371982019.html

Figure 3-21: C.I. Pigment Red y104; Chemical Formula: xPbCrO4·yPbSO4·ZPbMoO4

Source: https://www.alibaba.com/product-detail/pigment-red-104-PR104-Pigment-red_515875145.html

Figure 3-22: Bismuth Yellow PY184; Chemical Formula:(Bi/V/Mo/Oxide)(Bi-V-Mo-O)

Source: https://img0.baidu.com/it/u=1014211212,948665057&fm=253&fmt=auto&app=138&f=JPEG?w=250&h=240

Figure 3-23: Cerium Sulfide Red P.R.265; Chemical Formula:Ce/S

Source: https://enochdye.en.made-in-china.com/product/IjhEozVAHgWi/China-Cerium-Sulfide-Pigment-Pigment-Red-265-for-Plastic-Nylon-Use.html

Figure 3-24: Copper Phthalocyanine; Chemical Formula: C32H16CuN8

Source: http://jnyxrlhg.vsp.windmsn.com/product527306.html

Hoechst has developed the “Hansa” series of yellows, synthetic yellow with good light resistance and transparency. On this basis, many yellow series of diazo-reaction with acetanilide in chemical composition are produced [25]. The second important thing is to find the most economical way to purify this metal oxide and make titanium dioxide with the advantages of non-toxicity, strong color, and complete opaqueness. At the same time, the British Chemical Industry Company developed phthalocyanine blue, which has the advantages of good transparency and good mixing. In the 1950s, quinacridone was used in pigment production to produce a series of light-fast reds, and colors from alizarin crimson to gold were developed over the next 50 years. Quinacridone itself was used as a permanent alizarin crimson. Synthetic organic pigments are constantly being developed, and the perylene series, pyrrole series, and aryl series (Such as Hansa Yellow) have all been put into production. Providing more choices for watercolor paints, they feature better color mixing, transparency, and light resistance, replacing many traditional pigments. In addition, as

the development of the automobile industry promotes the current development of pigments, the exterior car color needs to better withstand severe climate, and bad weather. As a result, many pigments with special materials, such as structural colors, have been developed [25].

3.1.2 Changes Seen from the Aspect of Physical Materials

People often associate art and science using the common creativity of human beings as a bond and observe the relationship between the two from rational thinking. Both art and science are a manifestation of human cognitive activities. Einstein's mass-energy equation is a kind of knowledge, and Picasso's presentation of characters and still life is also a kind of knowledge [26].

In 1905, Einstein proposed the special theory of relativity, which is based on the following principles: First, the principle of special relativity. All inertial reference frames are weighted, that is, the way followed by the laws of physics has no difference in all inertial parameters, which suggests that the corresponding laws of physics are the same regardless of whether it is a static researcher in a laboratory or a high-speed moving electron. Second, the principle of constant light speed. The difference in the reference frame will not affect the light speed in a vacuum, that is, photons exist in a light-like form in space-time [27].

Around 1915, Einstein introduced the prototype of general relativity in his published papers. He was fully aware of the conclusion of the principle of equivalence that gravitational mass and inertial mass are consistent. This fact can also be assumed that all objects with sufficiently small mass move in exactly the same way in the same gravitational field when the object is only subjected to gravity. At this point, gravity can be identified as a space-time effect rather than a “force” in the traditional sense [28]. The theory is that the mass of the object (Precisely, the non-zero energy-momentum tensor) can cause curved space-time, and the gravitational force generated by the gravitational source on the object is the geometric effect under the curved space-time [29]. At this time, the object will continuously perform inertial motion in

curved space-time, while the motion trajectory is a geodesic, and strictly follows the geodesic equation. It is based on the above ideas that Einstein established the general theory of relativity.

In general, the general theory of relativity is premised on the following hypotheses: Firstly, the general principle of relativity. All physical laws are presented through physical quantities irrelevant to the reference frame and are expressed in geometric language as all the space-time quantities existing in the physical laws are the metric of this space-time or the physical quantities derived from its operations [30].

Einstein's field equations provide a detailed overview of the effects of space-time substance on the space-time collection, in which the requirements related to the energy-momentum tensor cover the above content related to the equations of objects in inertial motion [31].

According to the current theoretical framework of general relativity, other hypotheses can be used to derive the equivalence principle. In general, if there is an observer G in space-time, then an inertial reference frame can be established in a specific area of the world line, but the general principle of relativity requires that the world line value of Christoffel symbols in the reference frame is 0 at G [32]. Where the most typical of these is Synge's point of view, that is, in the early creation stage of the theory of relativity, the equivalence principle played the classical role as a physics bridge, which can be called the midwife of general relativity, but the advent of general relativity ended it.

In 1905, Einstein first proposed the theory of relativity. During this period, many schools also appeared in the art world, such as Fauvism, Cubism, and Futurism. Fauvism advocated the use of color to highlight light, while Einstein identified light as the essence of the universe. Cubism created a new form of spatial expression. At this time, Einstein proposed many new theories in the field of space. Futurism not only looked at the past but also looked into the future, which coincides with Einstein's point of view. The above three schools respectively represent the three basic contents of the special theory of relativity [27].

Matisse said that color is an indispensable part of a painting, and color itself is the main purpose of the painting. Fauvism painters believed that the integrity, line, and composition of things in the frame were not static, but could escape from their colors [33]. In 1927, Hubble concluded that the universe existed in an expanding state based on the relative properties exhibited by the colors of light. Combining the Doppler effect and the light transformation equation in Einstein's theory of relativity, it can be known that when an object is observed by the light speed principle, its light color is redder. Einstein discovered through research and experiments that light is an extremely critical constituent element in the universe, so the painter raised color to the primary position in the creation of pictures [27].

Cubism appeared in 1907, Cubism primarily seeks the aesthetics produced by the construction and formal arrangement of geometric forms. The image of three dimensions is reduced to a flat, two-dimensional space. Light and dark, light and air; the misplaced placement reveals the unique perspective of cubism. Instead of looking at things from one point of view, the shapes observed and understood from different viewpoints are resorted to in the picture to express the continuity of time [35].

Georges Braque used Cubism to create artistic images. Highlighting the new space of the painting, most of the pictures are white, black, and taupe, which are the tones observable by the viewer under the state of light-speed motion [36]. Meanwhile, cubism eliminates the consistency of shadows. According to the formula of Newtonian mechanics, the shadow of an object should be on the opposite side of the light source, and all variations under this law result in questions on the correctness of absolute space, absolute time, and absolute light [37]. The current cubism does not consider the specific position of the light source and paints shadows or objects on small tiles. When painting, the light-color three-dimensional method is often used [38]. The principle of this method is that brighter-colored objects observed by the naked eye appear closer than darker ones. However, Picasso adopted a completely different approach in his paintings. In his book “The Girls of Avignon” the painter's painting canvas was dense and airtight, which made it look very flat so that the observer's line of sight could not penetrate through the picture space and reach the

back of the person. This is due to the fact that there is no background in the painting. With the continuous improvement of the artistic level, the styles of post-cubism become increasingly diversified, and painters such as Kandinsky and Malevich no longer use perspective painting [39].

In 1907, “The Girls of Avignon” symbolized Picasso's beginning to create Cubism works, but most artists created in 1911 from a non-European space and the fourth dimension. The connection between Cubism and relativity is an issue that has long been studied by artists and historians [39]. Some art historians have stated that Cubism is separate from the principle of perspective. Cubism's way of observing external things is relative, which is essentially multi-viewpoint, and each viewpoint has no authoritative position [40]. The result of the above segmentation method is that things are observed from all angles, such as top, bottom, inside, and outside. The way in which things are represented from many viewpoints raises the problem of simultaneity in the modern world. In 1905, Einstein defined the concept of simultaneity in his masterpiece “On the Electrodynamics of Moving Bodies”, and the two coincided in time, so this view was also recognized by a large number of artists [41].

Picasso's unique imagination appeared earlier than the concept of time and space, and after years of development, it presents an art form without the concept of time. Previously, regardless of expressing a specific moment or showing an eternal state, Western art covered the concept of time, while Cubism paintings did not possess the attribute of time [42]. Cubism abandoned the principle of perspective and then eliminated depth. When there is a lack of time and depth, the dimensions of Cubism works are reduced from the original four to two. Cubism makes observers refer to things with space vectors and time coordinates, while Einstein's explanation is that the observer needs to ride on the beam to observe a similar scene in the universe. Although Einstein's theory of relativity and the Cubism proposed by Picasso has not been substantially resolved, it can be found from Cubism and Einstein's formula that the appearance of Cubism symbolizes the single form of seeing things with one eye [42].

Fauvism explores the representation of light, while Cubism focuses on space, and Futurism analyzes time in depth. The focus of Cubism is to see the space at the same time, thus presenting all angles of affairs [43]. The essence of futurism is to see time at the same time, that is, to present the past, present, and future as a whole. “The Hand of the Violinist” by Giacomo Balla uses overlapping images to pour movement and energy onto the canvas [44]. Futurism expresses speed in the form of distance within a specific period. Futurism's view that speed can break static forms is consistent with Einstein's view that the number of speeds in the universe remains unchanged. It was the emergence of Einstein and futurism-related theories that completely broke the traditional concept of time and space [45].

Figure 3-25: Violin and Candlestick Georges Braque, 1910
Source: https://en.wikipedia.org/wiki/File:Violin_and_Candlestick.jpg

Figure 3-26: The Hand of the Violinist Giacomo Balla,1912
Source: https://en.wikipedia.org/wiki/The_Hand_of_the_Violinist

Figure 3-27: The Girls of Avignon Pablo Picasso, 1907
Source: https://www.pablopicasso.org/avignon.jsp

In 1912, Duchamp used the abstract form of movement to show time and space in “Nude Descending a Staircase”. Cubism uses the form of pieces of things to show the simultaneity of space, while Duchamp compresses the time interval [46]. The work also presents the past, present, and future at the same time. “Rotary Glass Plates Precision Optics” is another representative work of Duchamp. This artwork depicts an independent propeller that rotates around a central axis on a tripod [47]. This is the first artistic work that integrates the concept of motion with true constant motion. Duchamp uses the motor to make the work come alive. However, when the motor is turned on, if one stands in the proper position where the work can be viewed according to the principle of perspective, one will find many fantasies of rotating

propellers, that is, many static concentric circles, just like an arrow target [47].

Curious about new physics, Duchamp created “3 Standard Stoppages” from 1913 to 1914, introducing high-dimensional concepts from a low-dimensional perspective. Duchamp dropped three pieces of thin metal with a length of one meter from a height of one meter, twisted straight lines into curved lines, and made them into templates [48]. Geometry does not have width or thickness, but only length, which is a typical one-dimensional Future. A thin metal with a length of one meter fits this definition. Let the thin line space fall, and as it falls, it outlines a plane. Through this artwork, Duchamp enables the observer to more accurately recognize the space of status and incorporate time, but this is not the entire purpose of artistic work [48]. The line's falling process is not straight, it is still one meter in length, but the curved shape makes it impossible to occupy a one-meter-long space. In other words, when the original line extends beyond one dimension of space-time, it will occupy less space [48].

Cubism is a form of art that emphasizes the beauty derived from the construction and arrangement of geometric forms. One of its key characteristics is the transformation of a three-dimensional space picture into a flat, two-dimensional space. This approach plays with light and dark, light, and air, and often involves the intentional misplacement of objects to highlight the unique perspective of Cubism. Rather than depicting objects from a single point of view, Cubist art seeks to convey the continuity of time by portraying shapes that can be observed and understood from different angles.

Many people agree with Duchamp's standard-stop view that human beings live in three dimensions but can delineate a fourth dimension as a personal physician, while Einstein's special theory of relativity is also a measure-related theory [48].

Figure 3-28: Nude Descending a Staircase Marcel Duchamp, 1912

Source: https://philamuseum.org/collection/object/51449

Figure 3-29: Rotary Glass Plates Precision Optics Marcel Duchamp, 1912

Source: https://en.wahooart.com/@@/8XYHDZ-Marcel-Duchamp-Rotary-Glass-Plates-%28Precision-Optics%29

Figure 3-30: Standard Stoppages Marcel Duchamp, 1913-1914

Source: https://www.tate.org.uk/art/artworks/duchamp-3-stoppages-etalon-3-standard-stop-pages-t07507

In 1917, the “Metaphysical School” was born in Italy. It was founded by the painter- Chirico. After a series of developments, the school became the later Surreal School. Chirico's works display a breakthrough in the principle of perspective that forms various forms of distorted space. Chirico's works not only distort the spatial layout but also distort time. Generally, there are mainly two ways to represent the passage of time. The first is through the interval of timing sounds, and the second is through the change in shadow size of things caused by the rotation of the earth. Therefore, the light color change and the shadow state are considered the most effective way to represent the passage of time. When analyzing Chirico's “The Enigma of a Day”, if we judge by shadow, it should be sunrise or sunset, but if we analyze based on the clock tower in sunlight, it should be noon. The depiction of sunlight in the work creates a feeling of stillness in the air, but the pennant flutters in the wind, forming a contradiction between the two [49].

Figure 3-31: The Enigma of a Day Chirico; Chirico; 1914

Source: https://www.moma.org/collection/works/80587

Figure 3-32: The Melancholy of Departure Giorgio de Chirico, 1914

Source: https://en.wikipedia.org/wiki/Gare_Montparnasse_%28The_Melancholy_of_Departure%29

Chirico treated the image in a similar way in “The Melancholy of Departure”, making observers feel an incongruous sense of time through contradictory imagery [50].

Giorgio de Chirico was the first painter to incorporate trains, clocks, and rulers as common subjects. Clocks and rulers are generally considered the basic tools for measuring time and space. In the special theory of relativity, Einstein questioned the authenticity of the measurement of clocks and rulers. He believed that when clocks and rulers were in a state of high-speed motion, they would not only change in terms of measurement values but would also change themselves. In this theory, all the examples used by Einstein are imagined based on the movement of trains [49].

Dali's series of works are based on realism, but he uses a unique artistic approach to make his work unique. All of his paintings are extremely personal, many like maps for wandering in the subconsciously eerie environment [51].

Because new physics lacks a language for three-vision representations, Dali strived to produce a set of usable icons since the beginning of his creation. “The Persistence of Memory” is one of Dali's most famous paintings. In this work, he presents two things often used to represent time, clocks and grains of sand[52].

In another work, “Galatea en creación”, Dali used graphic symbols to express the concept of time by depicting geometry in the picture. Dali's depiction in this way brings a deep sense of unease to the observer from a spiritual level, which makes it

even more impressive. Furthermore, a closer observation of the cross reveals the uniqueness of its shape: the novel cube representation of multiple cubes is an innovation in art but is a very common representation in mathematics. In this work, the shadow is one of his covert expressions. In the real world, things generally exist in three-dimensional form, and things with only two dimensions of length and width but no thickness hardly exist. Things can be thin, but they always have thickness. However, mirror images and shadows are the only two exceptions. Shadows have no thickness. If there is a fourth dimension in the world, then we must face such a question: if the two-dimensional projection result of the three-dimensional things is a shadow, then is it possible that people and objects in this three-dimensional world are "shadows" of four-dimensional objects in a three-dimensional world? Dali depicts such a scene in his work "Galatea en creación" [53].

Figure 3-33: Galatea en Creación; Salvador Dali; 1954

Source: https://www.salvador-dali.org/es/obra/catalogo-razonado-pinturas/obra/688/galatea-en-formacion

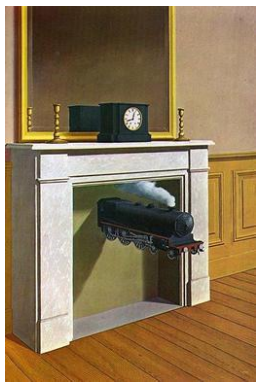


Figure 3-34: Time Transfixed; René François Ghislain Magritte; 1938

Source: https://canvaspaintart.com/rene-magritte-paintings/

As a representative of surrealist painters, Magritte calls himself a thinker who uses pictures as a tool of communication.

In 1935, Magritte created "Time Transfixed". He provides many portraits in his works, which can effectively help the observer to understand the concept of physics. He merges two images representing the course of time in the same frame [54]. In addition, in his paintings, he uses a unique treatment approach to display the effect of

upside-down lighting and the formation of mirror images in the picture. Magritte blends day situations with the night sky. If the two opposite existences of day and night are to appear at the same time, it is only possible in places where the motion speed approaches the light speed so that time changes [55]. According to Einstein's theory of relativity, we know that when the traveler's speed approaches the light speed, the space around him will get smaller and smaller, eventually making him impossible to move; [56] when the speed reaches the light speed, the space will be infinitely compressed, then the traveler can only see the back of his head when looking forward, a scene Magritte fully displays in his painting “The Glass House”.

3.2 The Emergence of Current Painting Materials and Their Application in Painting

3.2.1 Nail Art and Painting

From 1800 BC: In ancient society, nail painting was not just for women. Since 1800 BC, wealthy and upper-class men have both dyed nails to manifest their power. Finger color symbolizes their influence, whereas darker colors indicate greater influence. However, men at the bottom of society also often paint their nails, but the color is very light and shallow, mostly green. The nail colors worn by the ancient Babylonians were subtracted from natural substances, especially coal and sulfide powders, which were highly prized [57].

From 1500 BC: The traditional body art of henna nail painting in India.The pursuit of beautiful nails and hands spread to the world. At this time, henna tattoos were also widely promoted in India. Mehndi was used in body painting. For a long time, henna has been applied to the arms, legs, and feet for beautification. The raw materials for making henna come from dry shrubs and ground leaves, so as to obtain coloring paste. During the ceremony, henna is applied in a filigree pattern and used in wedding decorations. This technique first appeared in the Vedas of India [58].

Figure 3-35: Mehndi

Source: https://artplanet.cn/article/955579336264519680

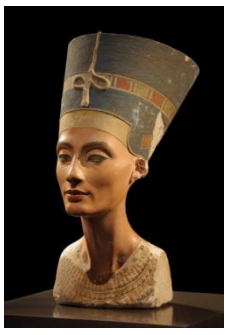


Figure 3-36: Nefertiti

Source: https://en.wikipedia.org/wiki/Nefertiti

1400 BC: Nefertiti's ruby nails. Queen Nefertiti was the consort of Pharaoh Akhenaten, and legend has it that the queen wore ruby-colored nails, the first in-

record nail polish. In this era, nail polish was mixed with blood to make the color thicker, and the color of the nails manifested her extremely noble royal status [59].

Since the 13th century, all continents around the world have been very fond of nail decoration, which promoted the orderly development and wide spreading of nail decoration. Archaeological experts have found that the Incas used sharpened knives and natural colors to create artistic nails. They applied painting tools to the nails, and such decoration was very popular on occasions of great interest. The Incas loved the vulture very much and regarded it as a sacred object. The locals recognized the bird as a divine bird and regarded it as a messenger of communication between the underworld, the human world, and the sky.

In the early 18th century, round and slender hands were favored by the world, and pyramid-shaped and oval nails with exquisite mother-of-pearl luster were extremely popular. This gentle decorative technique was even more popular among local high officials and nobles and was a fashion of the time.

In the 20th century, decorative accessories, chiffon, lace, beads, sequins, and all kinds of glass accessories brought new possibilities for fashion. The introverted and elegant manicures dominated the mainstream, and people loved rounding their nails and applying warm colors such as pink and ivory. Nitrates were born during World War I and first appeared for military needs such as making explosives. After the war, however, beauty-loving women found that combining nitrates and other ingredients could generate the shiniest, most durable nail polishes.

From the end of the 19th century to the beginning of the 20th century, Chinese nobles took artificial nails over 10 cm as a fashion item wearing these extra-long nails on their little and ring fingers. Most of these extra-long nails are decorated with frogs, crickets, and other lucky symbols. These exquisite nail artworks can now be seen at the Metropolitan Museum of Art in New York. They represent power, and only the elites are eligible to wear them, as these privileged classes are not required to

Figure 3-37: Extra-long Nails

Source: https://new.qq.com/rain/a/20200619A0QEI700

perform physical labor [60].

The earliest traditional oily nail polish. The real sense of nail polish is the first transparent nail polish on the market in 1916 after the discovery of nitrocellulose in 1838. And then Charles Chengfron and his chemist added pigments to the nail polish, making the nail polish more colorful. Limited by technology, the covering power of the nail polish was quite well at that time, but the durability was not ideal enough.

Figure 3-38: Michelle Menard

Source: https://www.facebook.com/mallofcosmetics/photos/a.1646023869029130/1987838931514287/?type=3

In 1932, inspired by paint spray in the automobile industry, Michelle Menard from Revlon created the first nail polish. The first bottle of Revlon nail polish hit shelves in a color never seen before. Since then, people no longer use dyes to dye their nails but apply nail polish instead [61].

Nail design is becoming more international. It is generally considered that the inventor of the first nail styling was Dr. Fred Slack. When he accidentally injured his nails during a dental experiment, he accidentally found a way to use dental materials. To repair his damaged nails he came up with a new idea and made a template with aluminum foil to fix the damaged nail. Then he made artificial nails with dental acrylic based on that. This artificial nail forms a protective screen for damaged nails protects them from secondary damage, and ensures healing. He was very interested in the effect of artificial nails, so he conducted in-depth research and exploration and further improved and perfected the technology. In 1955, he patented it by the name of “a device for extending nails”. Dr. Slack’s company has launched the first acrylic product for nail styling, hoping to make it easier to use and help users get the best results. Dr. Slack has achieved good outcomes in both dental materials and cosmetic manicures. His company’s product line is very comprehensive, covering products of polymers and light-activated urethanes, ensuring the rapid development of nail models in the 1970s. Between 1981 and 1989, sales of multifunctional nail

Figure 3-39: Press On Nails

Source: https://store.shopping.yahoo.co.jp/kdline/20211119140734-00010.html

products increased substantially by nearly 50%. The researchers believe that there are two main causes. On the one hand, the variety of products has increased significantly, and on the other hand, nails have also let women more confident. In 1980, Tinkerbell invented the first “bo-po” (Paint it on and tear it off) nail polish. Considering the increasingly strong nail strengthening and lengthening demands of users, there were more and more manufacturers of “Press On Nails”. The so-called “Press On Nails” refers to artificial nails that could be pasted on natural nails, which looks like increase the length and change the color of natural nails. At this stage, fiberglass, acrylic, and the first kind of gel nails appeared, matured, and were widely adopted by most nail studios. As after, nail art entered a new era: the appearance of airbrush facilitated the creation of micro-engraving works on nails by manicurists, and rhinestones, gemstones, and the variety of patterns make nail art design richer and more diverse [62].

The rough start of gel nail styling**,** In the early 1980s, the dominance of acrylic nails was challenged: American manufacturers developed gels containing photoinitiators that were easier to be applied under UV light [63].

Innovative gel nail, in the late 1990s, nail gels were innovated and entered the market with improved formulations. The improved gel has full variation, good usability, and high durability, so it was warmly welcomed by the market and has received further breakthroughs and innovations [64].

Glittery elements and stickers entered the nail market and quickly became popular. With the upgrading of nail styling technology and the improvement of related products, it provides the possibility for continuous optimization of nail art.

Traditional oily nail polish not only has a bright color, dries quickly, and lasts for a long time, but also gets more colorful by adding various color pastes, pearl powder, glitter, luminous powder, and other highly decorative materials. Until now, almost all of the nail polish market is based on the basic formula that has lasted for more than 200 years, nitrocellulose, modified resins, plasticizers, and various mixed solvents. However, the solvents that can dissolve nitrocellulose are generally volatile, irritating, and highly toxic substances, such as lipids, ketones, benzenes, and alcohol ethers.

With the popularization of nail polish and the rise of manicures in recent years, there have been more and more reports on the harm of nail polish to the human body, so the development of environmental-friendly, non-toxic, odorless and highly decorative nail polish has become the goal of chemical engineers.

Early Exploration of Environmental-friendly nail polish, in the mid-1990s, the research and development of water-based nail polish started. Due to the great technical difficulty, many such issues could not be solved. The produced water-based nail polish cannot be compared with traditional oil-based nail polish in terms of appearance, durability, and visual effect. Nevertheless, due to its non or low odor, non-toxic and environmental-friendly properties, it has been recognized and preferred by some consumers. And that is the early environmental-friendly nail polish on the market, peelable water-based nail polish. The raw material of this product mainly includes modified water-based acrylic resin. The disadvantage is that it is easy to fall off, is not glossy enough, has poor air permeability, and is hard to dry.

In the past decade, with the vigorous development of water-based nail polish, various types of products have appeared in the market, such as peelable, non-peelable, and hot water removal types. The two fatal defects of water-based nail polish are still hard to be solved completely: one is poor durability and firmness; the other is poor color storage stability. In addition, the composition of the formula is sophisticated, containing many hazardous substances. For example, the main resin of the mainstream water-based nail polish on the market is water-based polyurethane, most of which contain toxic cosolvents such as N-methyl pyrrolidone, N-ethyl pyrrolidone, and amides that are banned in Europe and the United States. There are also many unknown toxic substances in the auxiliaries, making the safety of so-called environmental-friendly water-based nail polishes worrying [65].

The components of nail polish are mostly composed of nitrocellulose, modified resin, plasticizer, and other substances. Generally speaking, nitrocellulose is easily volatilized in lipids and benzene solvents, and chemical reactions occur, resulting in

highly irritating and toxic micro-particle elements [65]. At present, the common cat's eye style (A new type of nail polish with a three-dimensional visual effect) comes from the electroplated color-changing paint layer of automobiles which is mainly composed of natural mica and synthetic substrate, and after several layers of coating, the coating thickness of various inorganic oxides is accurately controlled, so as to obtain the pigment with the best optical effect. Under the action of absorbing and reflecting light, the effect of the coating will be more vivid and achieve the layer-by-layer transformation of color. The color of this nail polish will change as the angle changes, and this special visual effect can also bring inspiration to manicurists[66].

Figure 3-40

Image from brand Russian Dance Legend nail polish NewPrism

Source: https://www.lazada.com.my/tag/danc

Table 3-1:Chemical Composition of Nail Polish

Components	w/%	Components	w/%
Nitrocellulose	14.0	Ethyl acetate	25.0
Camphor	6.0	Ethanol	5.0
Alkyd resin	13.0	Toluene	27.0
Butyl acetate	10.0	Dyes, antioxidants	

Components	w/%	Components	w/%
o-Benzyl-N-hydroxyalkyl Polyglucosamine	6	(65:35) Cellulose ethanol solution (65 : 35)	18
Butyl acetate	40	Dibutyl phthalate	4
Hexyl acetate	30	Camphor	2
Deionized water	10.0	Preservatives	0.1
Hexadiol	10.0	Siloxane defoamer	0.1
Diethyl phthalate	5.0		

The table is a component of several nail polish, and the data is from the website: https://www.docin.com/p-1643890708.html?docfrom=rrela

3.2.2 Development of Car Painting

In 1886, Karl Benz produced the first car. The cars were all painted with natural paint materials, mostly processed by pine oil, carbon black, etc. Then the paint was applied

to the surface of the car with a brush, which greatly restricted the large-scale production of cars. In 1924, DuPont innovatively used the airbrush to spray the paint on cars, which improved the painting quality and efficiency, controlled the smooth painted surface and painting time of cars within a few hours, and enhanced the mass production of cars. In addition, DuPont also has developed a nitrocellulose car refinishing paint [67].

In 1929, DuPont improved car painting and produced alkyd enamels synthesized from alkyd resins, such paints have bright colors and excellent durability. After that, DuPont produced and developed the car paint matching system to diversify the car color. Car painting achieved rapid development. In the middle of the last century, LUCITE acrylic quick-drying paint emerged, and until now, this car paint is still widely adopted in the automobile. The amino high-temperature baking paint and polyurethane high-temperature baking paint that came out in the 1960s made the gloss of the car even brighter, and the strength and durability were improved significantly. DuPont has successively developed anti-rust electrostatic coating, powder coating, and high-static coating, boosting the car painting technology to a new level. Double-layer baking paint was first popularized in Europe. It adopts the techniques of bottom coat cover and clear topcoat. Because of its high brightness and strong durability, it is favored by Europe and the U.S. and also laid a solid foundation for the later development of metallic paint and pearl paint. The new type of metallic paints and pearl paints are widely used in car production, and accompanied by a high-brightness varnish finish, the color of the car is more refined. In the 1980s, In order to protect the environment and reduce pollution and low-polluting paints were widely used, which led to the popularity of high-temperature urethane paints, acrylic urethane paints, and varnishes. The application of high gloss and clear coats results in more visible imperfections. Under such circumstances, the preparation of substrate and clean-up of the shop environment are even more critical. At the same time, the painting technology of pearl paint has improved continuously, and the use of layer coating and three-layer coating brings a more vivid and touching car body color. Entering the new century, the birth of water-based coatings marks a huge breakthrough in car painting.

At present, a large number of car manufacturers use this material, and the anti-scratch varnish is also adopted by Toyota and Mercedes-Benz because of its unique advantages [67].

As for now, more than 90% of global car manufacturing uses electrophoretic coatings, and some adopt cathodic electrophoretic coatings. In recent years, some U.S. companies have begun to apply intermediate coatings in production. The advantage of this coating is that the color of the middle and the color of the topcoat are matched, which makes the appearance more beautiful. In recent years, metallic coating has developed rapidly, pearl coating and dream coating have been launched one after another, and the color is moving toward the direction of high transparency, depth, and vividness [68].

Nanomaterials used in car coatings play a huge role in anti-aging, high toughness, bright color, sterilization, and disinfection, which are suitable for being applied in the development of car coatings. Its future development is very promising. Nano-material topcoat not only has good decoration but also has strong durability, excellent anti-interference, electrostatic shielding, anti-scratch, and other good properties. At the same time, nanomaterials can change color at different angles. Nanomaterials show strong strength under the effect of angle discoloration. For example, adding nano-TiO2 to the metallic glitter finish can make the coating more colorful. When applying nano-powder in flash aluminum or mica bead pigments in the coating system, the side light of the coating could reflect blue opalescence. The color will change with the viewing angle under sunlight [68].

Research and development on nano-glass coatings adopt the property of strong ultraviolet reflection of nano-powder material. Pouring a specific proportion of nano-TiO2 powder into the coating can better resist ultraviolet rays and prevent the passengers from ray radiation [69]. Applying such material on the surface of the car window glass, when exposed to ultraviolet rays directly, can completely decompose the contamination on the surface of the glass, kill toxic substances and eliminate bacteria through oxidation, so as to enhance the car environment, safeguard passenger health and discharge pollution and dust. Collision discoloration paint can effectively

avoid hidden dangers after a car collision. The collision discoloration paint has rich capsules filled with a small amount of powder. When the car with this substance collides with a huge external force, the capsules will break and release the powder, which will change the color of the damaged part to attract the driver's attention. The lower part of the car that is close to the ground is often hit by small stones, and that is the best part to apply a protective coating with strong resistance. At the same time, the parts of the car that are easy to wear also require low-friction paint. When nano-Al2O is added to the automotive coating, the strength of the coating surface can be further improved, the wear resistance can be increased, and the paint chip damage caused by small stones can be reduced effectively [70]. Since static electricity can cause multiple dangers, anti-static coatings should be applied for interior trim coatings and outer parts of cars. Mixing nanomaterials and resins can help cars shield static electricity. At the same time, the use of nano-oxides Fe3O4, ZnO, etc. can also generate colorful antistatic coatings. Nanomaterials have strong effect in sterilization, disinfection and dirt adsorption, so nano-particles can be used as carriers to absorb germs in cars, thereby achieving the effect of sterilization and disinfection. Nano ZnO particles can inhibit the growth of bacteria and remove odor, so it can be applied in the treatment of natural fibers to produce excellent antibacterial fibers, which can be installed on the car to purify the air in the car [70].

Figure 3-41: Color Changeable Paint

Source: https://www.autohome.com.cn/tech/202011/1078875.html.

As the basic paint layer of car paint, the new nano electrophoretic paint developed at the beginning of this century also plays the role of anti-corrosion. Nanomaterials are currently widely used in automobile manufacturing but due to their high price, surface activity, and many other issues, the ubiquity of nanomaterials and the medium mixing strategy are still not perfect, so there are many problems in their application in automobiles. However, it is expected that with the continuous improvement of modern technology, the application technology of nanomaterials will become more

and more mature. In the future, nanomaterials will inevitably promote the innovation and development of automotive coatings by their special properties [71].

In October 2017, the paint of the Lexus LC Inspiration Series was blue, and the manufacturer named it Structural Blue, as shown below. Structural blue, inspired by butterfly wings, first appeared decades ago and is composed of natural materials with patterns that echo each other. This type of color faces multiple challenges in the process of commercialization development. The patterns required by the paint can lead to luminous reflection and diffusion. Under reflection, the coating is able to reflect nearly 100% of a specific wavelength to create a colorful, deep, and intense color. At present, the color of automobiles can generally reflect about 60 % of the light. Until now, pigment manufacturers are committed to achieving the effect of purity seen in nature [72].

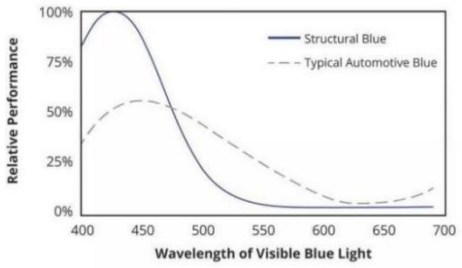


Figure 3-42 : Structural Pigments Reflect Nearly 100 Percent of Target Wavelengths.

Data from the website: https://www.sohu.com/a/304078069_100007062?referid=001cxzs00020004

Figure 3-43: LEXUS © TOYOTA PLC, BEETLE © MYN/ ANDREW SNYDER/NPL

Source:https://www.chemistryworld.com/features/structural-colour/3009020.article

3.2.3 Pearlescent Pigments

Nowadays, Pearlescent pigments are widely used in the field of art creation. As a new kind of composite material, Pearlescent pigments are made with pearls as a reference. Its core is composed of micron-scale mica flakes, and the surface is covered by a multi-nanometer-scale metal oxide film. Pearlescent pigments embody a variety of colors under direct

Figure 3-44: Pearlescent Pigments

Source:http://t15.baidu.com/it/u=1727765383,2492733893&fm=224&app=112&f=JPEG?w=500&h=500

sunlight and have the graceful soft effect of pearls, hence the name [73].

From the perspective of development history, Pearlescent pigments can be divided into three stages.

The first stage was in the 1920s. Pearlescent pigments were silver chloride Pearlescent pigments were made from natural fish scales. Although this material had been developed into basic lead carbonate and arsenic compounds successively in the following two decades, it still had great toxicity. By the 1960s when bismuth oxychloride Pearlescent pigments came out, although its toxicity was reduced, its photostability was still insufficient. The second stage was in 1963. The famous Pearlescent pigment manufacturer, DuPont in the United States, used natural mica and regarded titanium dioxide as the outer film to design mica-titanium Pearlescent pigments. The pigment was sought after and loved by consumers because of its advantages of non-toxicity, no harm, strong light stability, various color materials, and stable shape. However, Merck had occupied a huge market share through its unique technological advantages and had become the industry leader in a short period of time. The third stage was the period of the official birth of synthetic mica Pearlescent pigments. Pearlescent pigments were developing in accordance with the direction of green energy saving, and their scope of use was also increasing. In particular, at the beginning of this century, Chinese companies had mastered the core technology of synthetic mica-based products, and companies represented by Kuncai had shown their skills on a global scale. In addition, products based on glass flakes, silicon oxide, and other raw materials had come out one after another, which symbolized that the quality of Pearlescent pigments had been greatly improved, making the industry enter the high-end market [74].

Figure 3-45: Pearlescent pigments

Source: https://world.taobao.com/item/36594712918.htm

Compared with traditional pigments, Pearlescent pigments have made breakthroughs in the following two aspects. On the one hand, compared with the traditional color-forming principle of pigments, Pearlescent pigments innovatively introduce the color-forming principle of the light interference effect. In other words, when white light hits the surface of the Pearlescent pigment, the light will be reflected several times. However, the coating material of the variable oxide can obtain a variety of hues, and this imaging principle can effectively avoid the occurrence of fading. On the other hand, Pearlescent pigments not only have the characteristics of green, non-toxic, healthy, and environmentally friendly, but also bring together the advantages of high-temperature resistance, low density, resistance to electrical conductivity, and stable physical and chemical properties. For the above reasons, Pearlescent pigments have developed rapidly in a short period of time, replacing traditional organic pigments and metallic pigments, thus occupying the dominant position in the market. At present, Pearlescent pigments are widely used in the leather market, construction equipment, plastic coatings, and many other fields [74].

According to different usage, Pearlescent pigments are divided into industrial Pearlescent pigments, automotive Pearlescent pigments, and cosmetic Pearlescent pigments. In comparison, Pearlescent pigments in the automotive and cosmetic industries are higher-end than industrial pigments. As far as specific applications are concerned, industrial Pearlescent pigments are generally used in coatings and inks, covering all aspects of the construction of building materials. Automotive Pearlescent pigments are mainly used in the coating of vehicle surfaces represented by automobiles and passenger cars. Cosmetic Pearlescent pigments are commonly used

in a series of cosmetic products such as lipsticks and foundation make-ups. The downstream of Pearlescent pigments can be applied to industries such as agricultural production and electronic products. To sum up, Pearlescent pigments not only have broadened applications in traditional industrial fields but have also achieved breakthrough development in the beauty and cosmetics, and automotive industries, which has played an important role in improving the market penetration of Pearlescent pigments [74].

Pearlescent pigments usually require five base materials, of which mica-based accounts for as high as 80%. Depending on the quality of base materials, Pearlescent pigments can be divided into natural mica-based, alumina-based, glass flake-based, and other base materials. The difference leads to a huge difference in the color effect, resulting in different security levels. Generally speaking, the safety level of synthetic mica-based is slightly better than that of natural mica-based. At the same time, it can show stronger adhesion and brighter luster, but oxides and glass substrates often have important applications in high-end industries. However, in most cases, industries such as cosmetics and automobiles use synthetic mica-based and glass-based, and natural mica-based, which often cannot meet the health needs of cosmetics [74].

The properties of Pearlescent synthetic mica often surpass those of natural mica, among which the performance of cosmetic synthetic mica is more significant. The advantages of synthetic mica are as follows. First of all, in terms of the maximum operating temperature, the maximum temperature resistance of natural white mica and bronze mica is 450℃ and 600℃ successively, while the maximum temperature resistance of synthetic mica is higher than 1000℃, so the latter has a stronger high-temperature resistance ability. The second is excellent insulation. The average surface resistivity of synthetic mica is significantly stronger than that of bronze mica, and the resistivity of cosmetic grade and Pearlescent mica is better than that of industrial natural mica. The third is the purity and the content of harmful substances. The elemental composition ratio of synthetic mica is close to the theoretical value, and it has significant advantages in purity and quality. However, no cadmium element is detected in cosmetic synthetic mica, and the content of a lead element is only

0.05×10-6, which is significantly lower than that of Pearlescent mica and industrial mica. Finally is the higher whiteness. It can be found that the average whiteness of synthetic mica is 99.02%, which is significantly higher than that of phlogopite and natural mica. Among synthetic mica, the whiteness from high to low is cosmetic grade, automotive grade, and industrial grade [74].

Titanium tetrachloride is an indispensable raw material for Pearlescent pigments, and the titanium dioxide coating obtained by its conversion has a direct decisive effect on the color of the pigment. Titanium tetrachloride is not only an important raw material for making Pearlescent pigment product but also a component of metal oxide coatings. Nowadays, the method for neutralizing titanium tetrachloride with alkali widely used in the industrial production of Pearlescent pigments is as follows. First of all, it is necessary to pour mica flakes and deionized water solution into the test tube according to a specific ratio, and accurately control its temperature, PH value, stirring speed, and so on. If the above indicators are controlled within a reasonable range, the hydrolysis reaction of titanium tetroxide will occur, and carbon dioxide will be generated in a layered structure and suspended on the surface of the mica substrate. Secondly, TiCl4 should be dissolved in water to make a TiCl4 stock solution, which will generate titanium oxychloride under the action of a chemical reaction, and titanium dioxide will be obtained after in-depth hydrolysis. Therefore, the deposition effect of the coating layer produced by titanium oxychloride or titanium tetrachloride is the same. The increase in the deposition amount of titanium dioxide makes the Pearlescent pigments show changes of silver, orange, red, blue, and green respectively [74].

The properties embodied by Pearlescent pigments match the needs of coatings and can help coatings show unparalleled decorative effects. On the one hand, Pearlescent pigments can be fully dissolved in water and can play a role in a variety of solvent-based coatings; On the other hand, due to the weak conductivity of Pearlescent pigments, it is suitable for electrostatic spraying process, which can effectively avoid the damage of electrostatic sparks. Finally, the high-temperature resistance of Pearlescent pigments has led to their widespread use in baking and anti-

corrosion paints. In addition, Pearlescent pigments can be matched with transparent pigments of various colors, showing beautiful colors and a three-dimensional sense. Therefore, compared with ordinary pigments, Pearlescent pigments have excellent decorative properties, plus the substitutability of traditional pigments, It can bring more creative imagination to the artist [74].

Figure 3-46 : Pearl Eye Shadow

Automotive Pearlescent paint can have a decisive effect on the color and gloss of the vehicle, which is usually used in the production of high-end vehicles. The ordinary vehicle paint layer is divided into four layers, namely the electrophoretic layer, middle coating layer, color paint layer, and varnish layer, with a cumulative thickness of about 100 microns. The painted color effect is the true effect of the reflection of the color paint layer. Ordinary paints, metallic paints, and Pearlescent paints are usually in the market. Among them, the mica used in Pearlescent paint does not have aluminum particles sprinkled on the paint, and some paint bases innovatively use mica Pearlescent pigments made of titanium dioxide and iron dioxide. When sunlight hits the mica particles, the color of titanium dioxide and iron oxide will appear. Then under the action of refraction, the difference in the angle will show different colors, so the Pearlescent paint gives people a feeling of novelty and various color forms. At the same time, Pearlescent pigments show great antioxidant power and are widely used in high-end vehicles [74].In the field of cosmetics: Pearlescent color products have significant advantages, and there is a huge space for development in the field of color cosmetics.

The characteristics of synthetic mica-based Pearlescent pigment can meet the

practical needs of the cosmetic industry, resulting in it becoming a powerful driving force for the development of color cosmetics. The surface layer of synthetic mica-based beads tends to be covered with metal oxides, which are characterized as follows. The first is that the product has bright colors, large density, and large luster, so it can form a variety of colors. Secondly, it is resistant to high temperatures, has no radioactivity, and has low impurity content. Thirdly, its production process is safe and pollution-free with non-toxic and heavy metal substances, which will not cause damage to the skin, making it an important substitute for organic pigments. Fourthly, the application of white synthetic mica-based Pearlescent pigments with other types of pigments can present a variety of visual effects. In downstream practice, cosmetic Pearlescent materials are widely used in beauty products such as eye shadows, hair creams, and hair sprays, and have even greater potential for future development [74].

3.3 Painting Technique Created by New Materials

3.3.1 Appearance of Structural Color MaterialsM

Professional researchers also take structural colors as the primary reference elements in the practice of photonic structure design [75]. The colors in nature are diverse and are mostly expressed by organisms and animals, in which the color of organisms is affected by pigment color and structural colors. Here is the physical color, representing the corresponding color produced by the light and the wavelength of light in the structural matching state.

Structural color is color based on microscopic structure relevantly related to the optical process. The mechanism of structural color is divided into the following five; (1) thin-film interference, (2) multilayer interference, (3) photonic crystal, (4) diffraction grating, and (5) light scattering [76]. Although it was originally thought that these kinds of colors result from “surface color”, Lord Rayleigh proposed the alternative idea of the “interference color” [77]. The debate between surface color and interference color was terminated by the invention of the electronic microscope. Sponge-like structure in a specific bird and periodic structure in the scales of the

butterfly was observed, and that supports the idea of the interference color [78,79]. After that biologists discovered many microscopic structures revealing structural colors. For example, structural colors in butterflies and moths: “All butterfly scales and moth scales have the same basic structure, but various elements of this structure are in the scales that exhibit the structural colors [80]” and scarabaeid beetle exocuticle as an optical analogue of cholesteric liquid crystals: “cholesteric liquid crystals and lamellate cuticle have helicoidal structure, their optical properties depend primarily on the pitch of their helicoidal architecture[81]”. Once the notion of photonics was established, structural color is studied by many researchers and is rapidly developed [82].

The structural colors we touched are closely related to the optical principle, that is, under the action of refraction and diffraction, structural colors are produced, and it is also under the influence of optical effects that the external world is gorgeous. In other words, structural colors lead to the existence of multiple colors. For example, the colorful feathers of birds and the colorful wings of butterflies are related to the refraction of light; The peacock's head has light blue spots, the blue of the tail is deeper, and the multi-level presentation effect of color is caused by the scattering of light, which is the presence of the skin granular layer, resulting in a large amount of melanin being fully absorbed. According to the difference between spatial orientation and structure, the structural colors can be divided into one-dimensional, two-dimensional, and three-dimensional photonic crystals [75].

3.3.1.1 One-dimensional Photonic Crystal

Interference Colour

Figure 3-47: Multilayer Structure on the Surface of Beetles

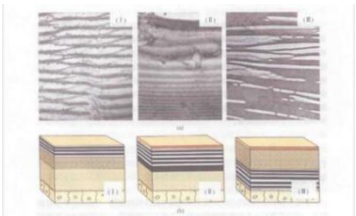


Figure 3-48: Three Representative Multilayer Structures

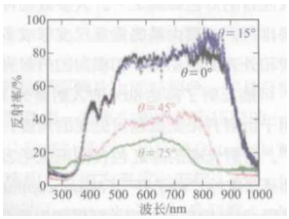


Figure 3-49: Diffraction Grating

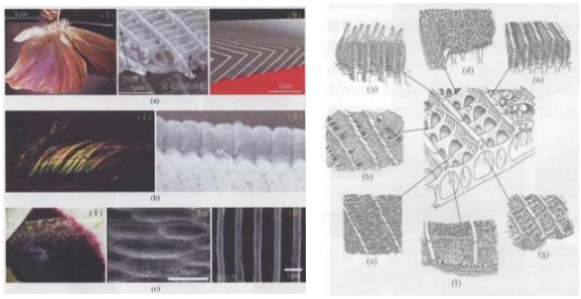


Figure 3-50: The Scales of the BigButterfly b Hair ofSeed Shrimp c Petals of Wild Watermelon Seedlings and Tulips

The above picture material is from “Structural Colors materials”

3.3.1.2 Two-dimensional Photonic Crystal

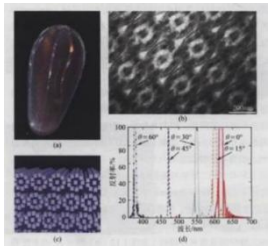


Figure 3-51: C Ctenophore

b : Tenophore scanning electron micrograph

c : Schematic diagram of cilia clusters

d : Reflection diagram of cilia

The above picture material is from “Structural Colors Nanomaterials”

Figure 3-52 : Green Peacock Feather Structure Diagram

a Green peacock

b Microscopic picture of tail fin

c Cross section of green small feather wing

d Larger enlarged kohane wings

e Cross section of small brown wing

f Planed surface of small feather wings

The above picture material is from “Structural Colors Nanomaterials”

3.1.1.3 Three-dimensional Photonic Crystal

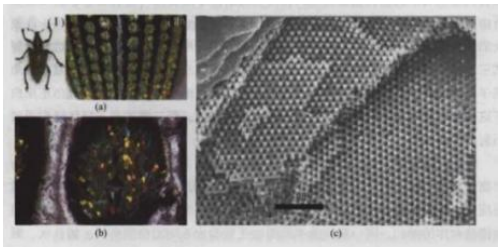


Figure 3-53: Entimus Imperialis Wing Structure Diagram

a Entimus imperialis specimen

b Back concave and convex scales.

c Scale electron scanning microscope photo

The above picture material is from “Structural Colors Nanomaterials

3.3.2 Evolution of Canvas

Before canvas was invented, painters usually painted on walls or wooden boards and the materials required for oil painting were hemp seed oil and pigments mixed in specific proportions. As a support of the painting, wooden boards are more special than walls [83]. When it comes to small paintings, it is easy to find a suitable wooden board. On the contrary, it is not easy to find a suitable wooden board that meets the standard for large-scale paintings. At first glance, it is feasible to nail pieces of wood to the back side of the wooden board to expand the area, but the board is easily out of shape due to the influence of the external environment. Taking basic material and primer material into account, therefore, this material is not the first choice.

In the 13th century, the first person to use canvas for artistic works was Arezzo, a pioneer of the Renaissance. Some people believe that the earliest cloth used for painting were those painted with plaster priming portraits on coffins of ancient Egyptian. Artists from the Venetian School took canvas as the cloth used for painting. Initially, this canvas was designed as the sail for sailboats, which adopted the woven method based on shapes of herringbone and argyle, so that the woven material has the advantages of exquisiteness, durability, and low ductility with the result of a high application rate. There is the inherent disadvantage of high moisture and humidity, though it is durable. So at last, the canvas was replaced by linen during the

period of great prosperity of the Venetian School [84].

Figure 3-54: Linum Usitatissimum L

Source: https://www.chemicalbook.com/NewsImg/2015-05-21/2015521993175108.jpg

Figure 3-55: Linen

Source: https://img0.baidu.com/it/u=2892901414,2090553746&fm=253&fmt=auto&app=138&f=JPEG?w=667&h=500

After years of dissemination, Linum usitatissimum L. (Common Flax), which first appeared in West Asia, has finally been planted in countries around the world. Dating back to ancient Egypt, people cultivated common flax, more specifically, fiber flax, oil seed flax, dual-use flax, and other types. It is widely used in the creation of oil paintings because there are such strengths as durable texture and strong corrosion resistance for linen made of flax fiber. Linseed oil, which is produced from oily flax, is seen as the first choice for the creation of oil paintings dependent on its colorless feature [85].

Hemp, ramie, and cotton can all be used as cloth for painting apart from linen. The pigment of oil painting is highly corrosive, so the painter should first apply glue preparation instead of painting directly on the cloth when painting. Gluing can not only effectively avoid the phenomenon of corrosion between the pigment and the cloth, but also maintain color stability. During the development of human history, the colloids used were first extracted from plants and animals. In the industrial period, with the development of advanced science and technology, the coated cloth produced by large machines greatly raised the painting efficiency and offered convenience for the artist's creation, so they had no need to apply the primer by themselves [86].

In addition, there are the following stages in the evolution of the cloth used for painting: Generally speaking, the cloth used for painting does not need to be bleached and dyed. Otherwise, its strength and durability will be seriously damaged, except for special requests. Common flax: Flax has the following features, high strength, deformation resistance, corrosion resistance, mildew resistance, dirt resistance, and short moisture dissipation time [87]. Due to its relatively fixed size and last storage period, linen is regarded as an excellent basic material for painting cloth traditionally. When people make and extract hemp fiber, there are bright yellow warm water retting (Retting by soaking in water) and blue-gray dew retting (Retting by wind, rain, frost, and dew in nature) according to different methods. Because the texture is rough and easy to produces fuzzing and pilling, it is not suitable for spray painting (Atomize the paint through the spray gun) [87].

Figure 3-56 : Corchorus Capsularis L

Source:https://img1.baidu.com/it/u=704587463,2030258824&fm=253&fmt=auto&app=138&f=PNG?w=689&h=448

Figure 3-57 : Jute Cloth

Picture from: https://img.tukuppt.com/png_preview/00/36/53/GgVyGp3kRd.jpg%21/fw/780

Corchorus capsularis (Jute): Its color is tawny and it has traditionally been used as an oil canvas. Due to its thick and hard fibers, jute is only suitable for regard as thick canvases. Because the texture is rough and easy to produce fuzzing and pilling, it is not suitable for spray painting [88].

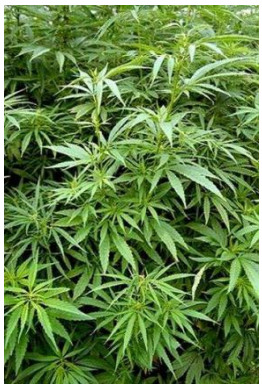


Figure 3-58 : Cannabis sativa L.

Source:https://bkimg.cdn.bcebos.com/pic/ae51f3deb48f8c5405d7053337292df5e0fe7fa2

Figure 3-59 : Cannabis sativa L.

Source:http://baike.texnet.com.cn/view-18948.html

Figure 3-60 : Boehmeria nivea (L.) Gaudich.

Source:https://baike.baidu.com/item/%E8%8B%8E%E9%BA%BB/470973?fromModule=lemma_search-box

Figure 3-61 : Ramie cloth

Source:https://bkimg.cdn.bcebos.com/pic/d52a2834349b033ba28687031bce36d3D439bdd9

Cannabis sativa (Hemp) and Boehmeria nivea (Ramie): The color is white and yellowish white. As one of canvas types, hemp, and ramie has such properties as stability and durability. Because the texture is rough and easy to produce fuzzing and pilling, it is not suitable for spray painting [88].

Figure 3-62 : Gossypium

Source:https://p1.ssl.qhimg.com/t01c9ad887672e5d386.jpg

Figure 3-63 : Cotton cloth

Source:https://img0.baidu.com/it/u=735079915,3988663998&fm=253&fmt=auto&app=138&f=JPEG?w=340&h=300

Cotton: In times when fabrics were not readily available, if painters wanted to paint by hand, cotton canvas, which was tight and not easily worn, was often used as the painting cloth. However, it resulted in a lot of trouble for painters because it is perishable, easy to mold, difficult to dry upon getting wet, and looser and looser. The texture is great when sprayed or printed on cotton canvas. Since the canvases used for printing paintings have been treated with anti-corrosion, there are no phenomena such as rot, moisture, and mildew [89].

Figure 3-64 : Chemical fiber (Polyester)

Source:https://img0.baidu.com/it/u=979707141,3795425466&fm=253&fmt=auto&app=138&f=JPEG?w=751&h=500

Figure 3-65 : linen cotton

Source:https://img0.baidu.com/it/u=3208856127,2834528169&fm=253&fmt=auto&app=138&f=JPEG?w=395&h=343

Chemical fiber (Polyester): On the one hand, it has good properties as a canvas, on the other hand, it has bad properties of being embrittled in the future and without the texture that the painter loves. It is suitable for oil painting printed and spraying [90].

Linen offal and cotton blend (Linen Cotton): Its color is white with grayish yellow, the surface is matt and is covered with dense black, brown, and brown dots. It is characterized by low strength and is easy to lose. The quality of this kind of cloth is rough and the price is low, appearing in the market in recent years. The above discussion is the main evolution in cloth used for painting from the mid-and late twentieth century to the present.

In the research of this dissertation, some of the experimental creations I have done have abandoned the traditional oil painting cloth and used aluminum plates instead. The painting tools are also changing with the changes of the times. At present, artists can use various materials as their own drawing boards, to break through some restrictions on traditional painting cloth.

Chapter 4

Application of Structural Color Pigments in Art Creation

4.1 Experimental Creation of Structural Color Pigments and the Relationship between Structural Color Pigments and Light Sources

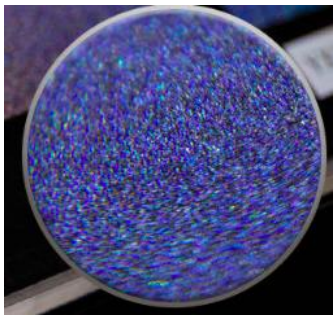


Figure 4-1: Structural Powder

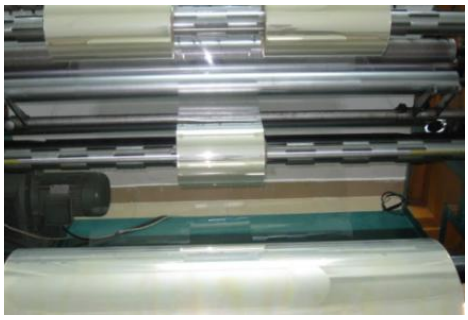


Figure 4-2: Polyester Film

Source: https://img1.baidu.com/it/u=1524162295,2320971873&fm=253&fmt=auto&app=138&f=JPEG?w=640&h=430

Traditional laser powder, glitter powder, commonly known as sequins, gold flakes, silver flakes, gold dots, silver dots, glitter powder, glitter flakes, gold, and silver powder, is generally made of PET (Poly Ethylene Terephthalate) metalized film. The thickness of traditional laser powder is generally greater than 12 microns, depending on the thickness of the PET base film. Because the traditional laser powder has a PET base film, and the thickness of the structural powder is 2 to 3 microns without a PET base film, the application is different. In terms of particle size, the particle size of traditional laser powder monomer is generally 200-3000 microns (Diagonal), and the size of the structural powder is much smaller. Traditional laser powder, glitter powder is mechanically cut powder, with good consistency in shape and specifications, usually square and hexagonal. The structure powder adopts the method of powder mixing, screen classification, or specific gravity extraction, and the particle shape is random and irregular. Structural powder and laser powder are priced by weight, but traditional laser powder is with PET base film. The structural powder does not have a base film, the process flow is more, the input and output of finished products of the same raw materials are much less, and the production capacity is low. The price and

production cost of the structural powder is higher. This effect is made by the material structure itself, such as optically variable paint, optically variable ink, optically variable pigment, etc. This specific nano-optical material is mostly made of nanoscale thin film structure compounded and stacked, and this structure forms strong optical effects such as interference to light, which can realize dynamic color changes and metallic luster. The general material attachment process is vacuum coating, spraying, and so on. The structural color of optically variable paint is different from that seen from different visual angles.

The process of vision: the light is emitted or reflected from surrounding objects, then projected by the lens of the eye onto the retina, and finally transmitted by the retinal nerve to the brain.

The physical form of an object is determined by its boundaries. Other objects are usually not considered to be characteristics of the physical form. The perceived form of an object changes with the location and surroundings of the object. Visible forms interact. The form we perceive is the result of the interaction of three elements, which are the object to be recognized, the light of the transmitter of information, and the main component of the nervous system of the audience.

Figure 4-3: Structural Color Paint Brand Show Up Store Shooting

Structural color materials and selection of drawing board tools

Figure 4-4 : Show Up Custom Color Series, Nail Polish

Figure 4-5: Pearl Powder

Figure 4-6: Laser Powder

Figure 4-7: Aluminum Plate 45 x 45

Figure 4-8 Black Spray Paint

Figure 4-9: Spray Gun

Production of work :

Figure 4-10: Creation Site

The first experimental stage of creation lets the painting show structural color characteristics: Use traditional oil paint to paint on the aluminum sheet, wait until the oil paint is completely dry, then use laser nail polish and laser glitter mixed with transparent nail polish to paint for the second time. After the color is completely dry, crumple up the aluminum sheet.

Figure: 4-11 The First Experimental Stage of Creation

Author: Lin Feng

Work: “The Umbilical Cord of the Universe” Series

Size: 20cm x 30cm

Year: 2022

The second experimental stage of creating is the change of Pearlescent powder on the screen under the light: Use black spray paint to spray the aluminum sheet black, and use transparent nail polish mixed with laser powder to make part of the base color. Adopt oil paint for painting, then use nail polish mixed with laser powder mixed with oil paint for painting. When the painting is completely dry, crumple up the aluminum sheet and then polish the surface with pearl powder.

Figure 4-12 : The Second Experimental Stage of Creation Normal Light Source

Author: Lin Feng

Work: “The Umbilical Cord of the Universe” Series

Size: 20cm x 30cm

Year: 2022

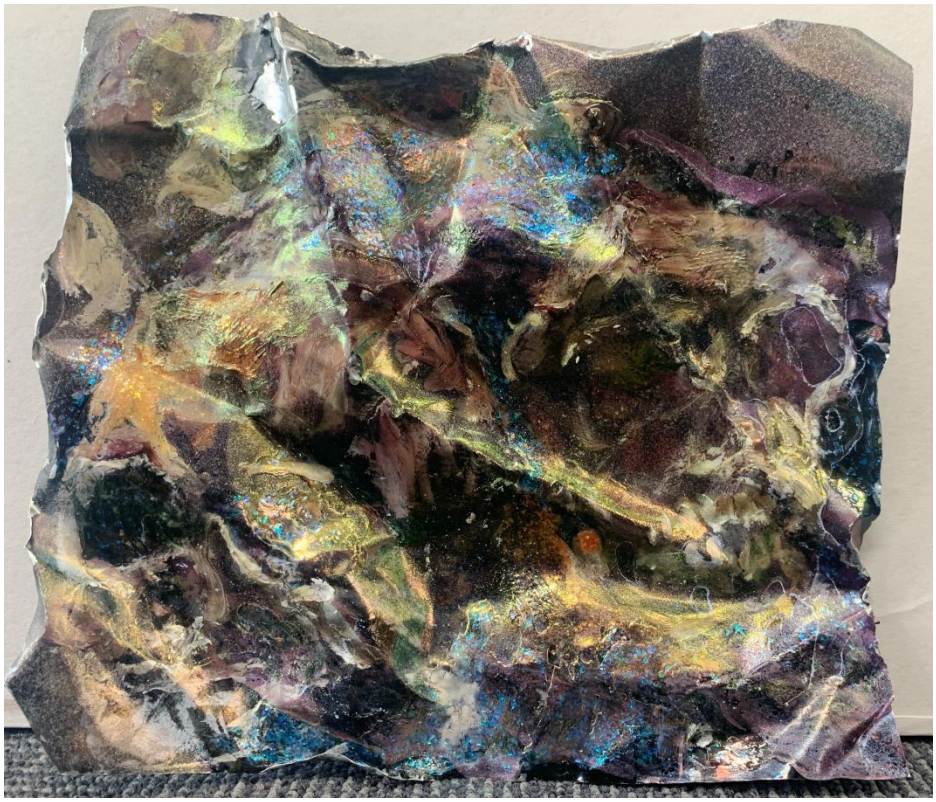


Figure 4-13 : Works in Bright Light

Author: Lin Feng

Work: “The Umbilical Cord of the Universe” Series

Size: 20cm x 30cm

Year: 2022

The third experimental stage of creation Changes of structural color and Pearlescent powder in the picture: black spray paint is used as the background color, then pearl powder is used to polish the surface, and then pearl acrylic paint is used to draw. After the creation is completed, the aluminum sheet is crumpled, and then the deformed bulge and recess parts are polished with pearl powder.

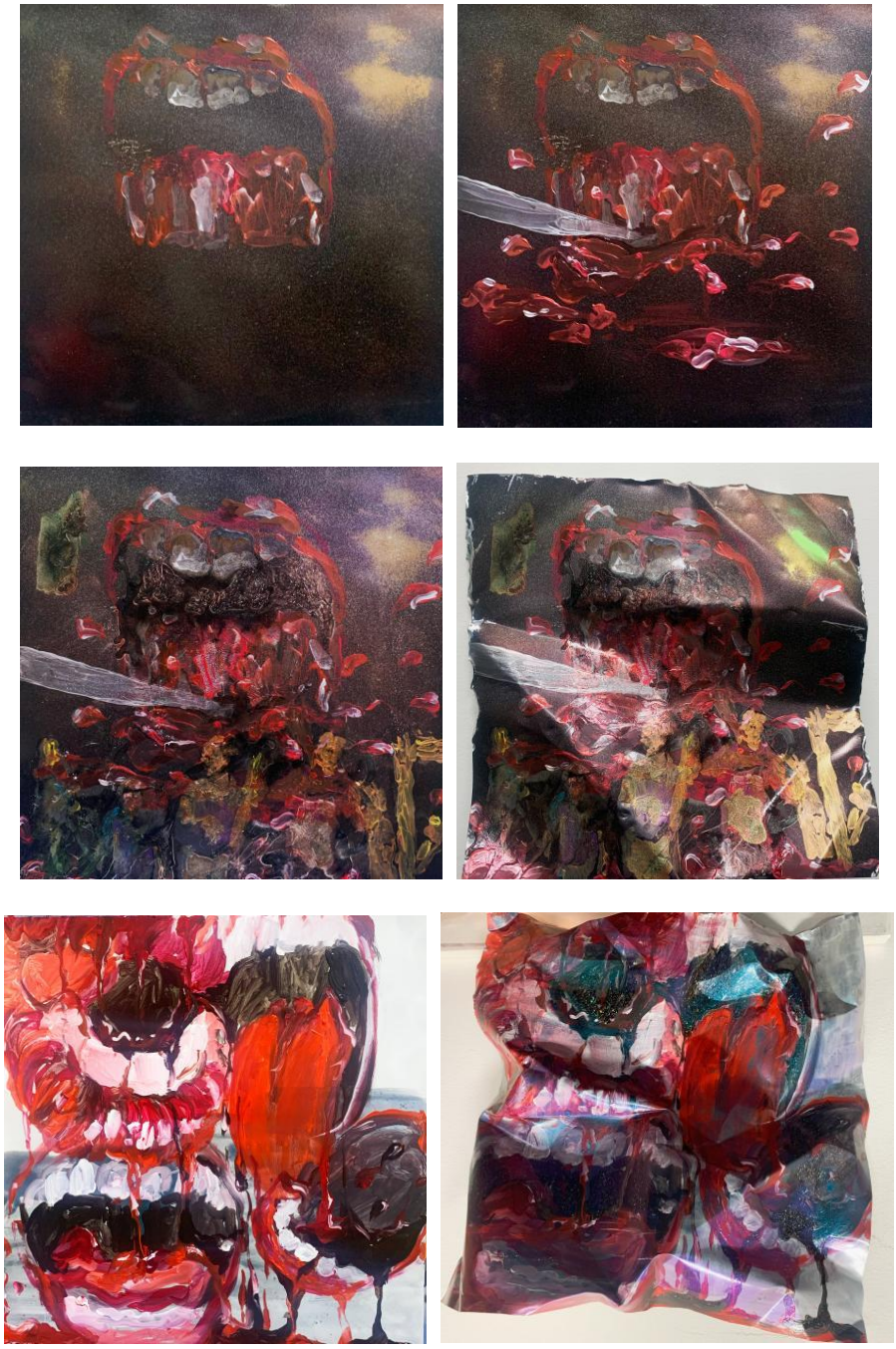


Figure 4-14 : The Third Experimental Stage of Creation

This new type of pigment is mainly used in car painting and toy model painting. In the first three stages, chose to paint on the aluminum sheet because the form of the aluminum sheet is closer to the automobile, which is easier to color and produce effects. This study mixes transparent nail polish with laser powder, combined with acrylic and oil painting. The first creation is a complete painting on a flat aluminum sheet, and then the deformation of the aluminum sheet is equivalent to the second creation. Under the light, the color of pearl powder and laser pigment will be different with the change of angle on the uneven plane.

Figure 4-15: Pigments Used in the Silver Part of the Work

The fourth stage of the creative experiment is the harvest of creating on the deformed aluminum plate: try to crumple up the aluminum plate first, then paint it with spray paint and structural color pigment, and then recreate along the arched part of the aluminum sheet.

Figure 4-16: The Fourth Stage of the Creative Experiment

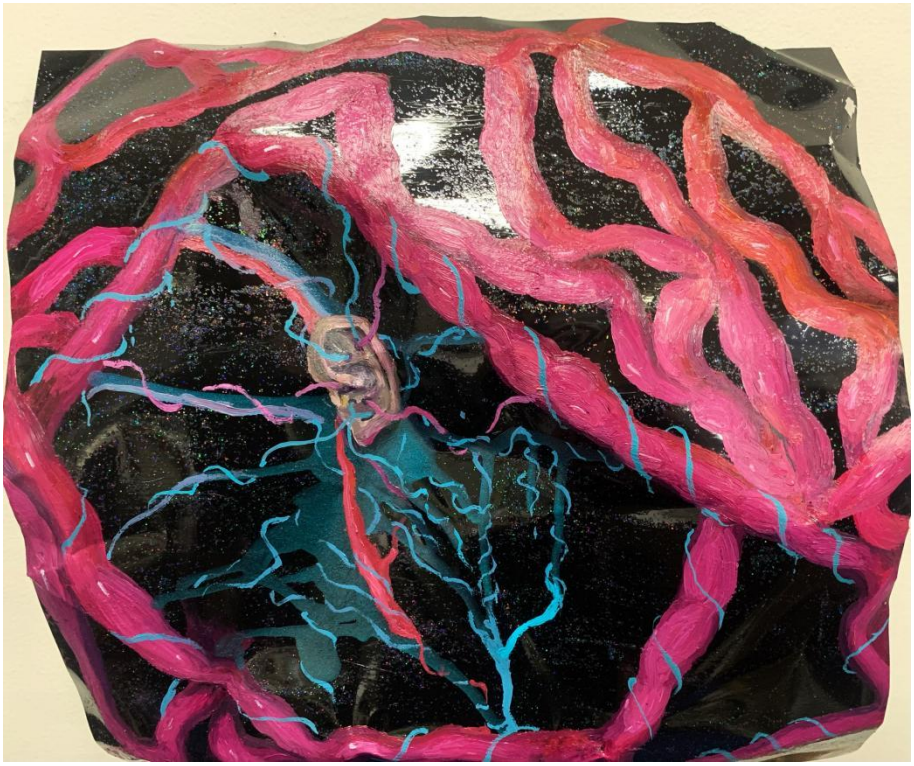
Author: Lin Feng

Work: “ The Umbilical Cord of the Universe ” Series

Size: 20cm x 30cm

Year: 2022

Different angles, the color change of the middle part of the structural color pigments at different angles, from purple to green.



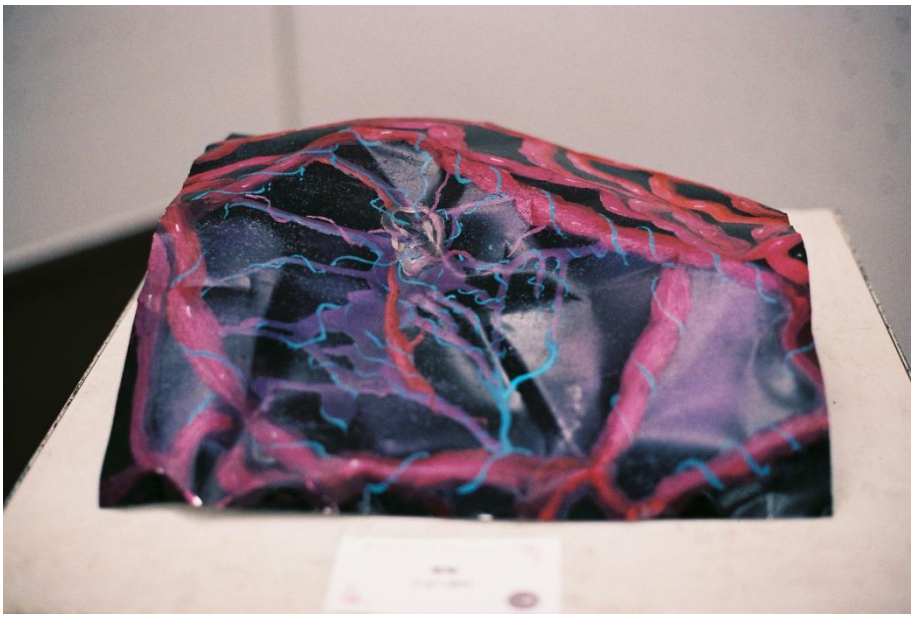


Figure 4-17

Works Displayed at the Tokyo Metropolitan Art Museum

Author: Lin Feng

Work: “The Umbilical Cord of the Universe” Series

Size: 45cm×45cm

Year: 2022

The characteristic of structural color pigment is that the color will change with different angles and light intensities, which can give artists more creative space and

audiences more space to imagine when watching the art piece.

Color change from left to right of the same aluminum sheet fully painted with structural color pigment.

Figure 4-18: Effect Picture of Structural Color Pigment Experiment

The distance between the same aluminum sheet with structural color pigment and the light from top to bottom changes from far to near.

Figure 4-19: Effect Picture of Structural Color Pigment Experiment

The visual connection between the shape, color, viewing position of the work, and the light source to the audience

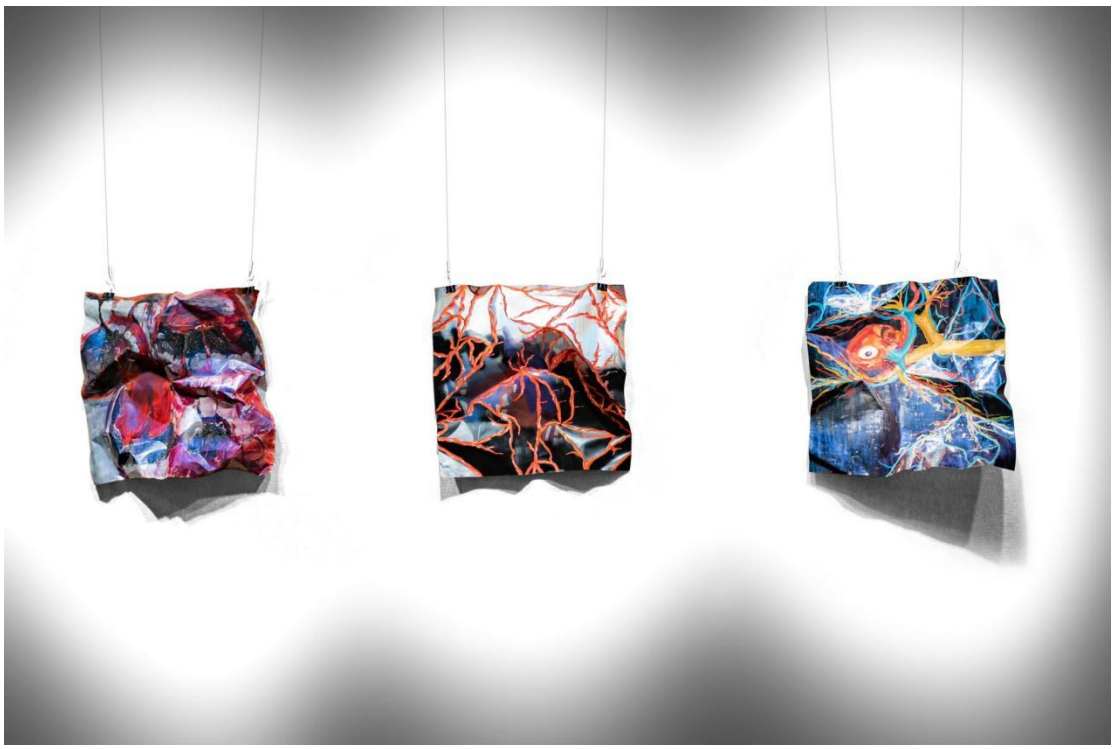


Figure 4-20: Waseda University Gallery

Author: Lin Feng

Work: “The Umbilical Cord of the Universe” Series

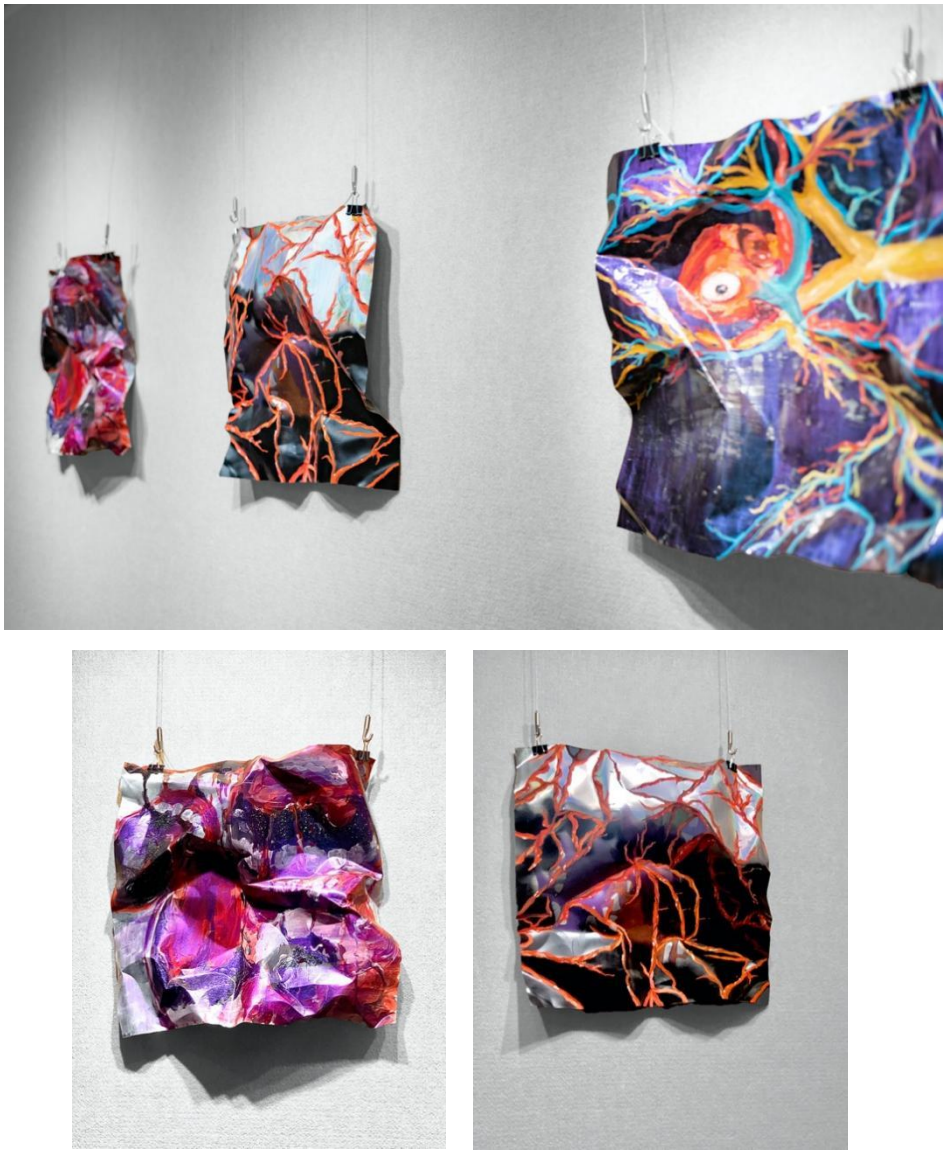


Figure 4-21: Waseda University Gallery

Author: Lin Feng

Work: “The Umbilical Cord of the Universe” Series

Normally, light is impenetrable except for transparent things. In addition, light travels in a straight line, so its projection can only correspond to the surface of an object that is in line with the eyeball. In all respects, these works of art are different. We do not observe the shape of an object by its projection on our retina at a certain time. A Creative image is formed by the transformation or combination of specific media attributes and the observed object's own characteristics [91].

Figure 4-22: Waseda University Gallery

Author: Lin Feng

Work:“The Umbilical Cord of the Universe” Series

Size: 45cm×45cm

Year: 2022

Figure 4-23: Waseda University Gallery

Author: Lin Feng

Work: “The Umbilical Cord of the Universe” Series

Size: 45cm×45cm

Year: 2022

In a vast space without the influence of external forces, spatial orientation provides a reference structure for the position of an object. We can only rely on our vision for our frame of reference and environment.

In addition to the coordination of the retina and the surrounding visual field, the movement of the human body refers to the coordination of the muscles and ears of the human body. This means that no matter how our body, head, and eyes change, we can feel the presence of gravity. In the daily activity sense, the sense forms a harmonious relationship with the peripheral visual structure.

There is not only one picture that visualization can receive, but also three similar factors, namely, the composition of the visualization around the object, the image of the object projected to the brain, and the structure of the sense of gravity own body perceived by muscle sensation and the balance organ of the inner ear through

kinesthesia. The orientation of the whole visual is determined by the main axis.

The function of the frame of the painting is actually composed of the trusses and walls around the altar in the Renaissance era. At that time, in order to separate the plane from the wall and create a specific depth of field, it was necessary to draw a clear boundary between the interior entity and the studio. The absence of frame constraints allows for greater flexibility in displaying the artwork: it can be framed or unframed, the shape can be adjusted, and it can be presented by hanging it on a wall or positioning it on a display stand, it represents only the boundary of the composition, not the boundary of the place to be expressed.

Aluminum panels can produce textured, uneven surfaces that introduce a sense of tension to the artwork, giving it a more dynamic and powerful appearance. Even in oil paintings and line paintings, concave, and convex do not only appear on the contour lines of the plane but also on the spatial effects produced by crumped deformation.

Painting itself mostly appears in the state of the plane so its three-dimensional space can only be copied indirectly through the side feature points, and this interruption will weaken its intuitive effect. The other is to change the size, shape, spatial distance, and angle of objects to achieve better results. This method has brought a strong impact on two-dimensional media and images.

Deformation is a phenomenon produced by the change of all spatial connections in the overall form (Or local). Change always involves a contrast, that is, a contrast between its current form and its original form.

Illumination is also a substance that acts on the objective brightness and color of surrounding objects through illumination. Illuminated objects can maintain constant brightness and color, while shadows and bright parts are grouped into a light gradient series with a simplified structure.

Figure 4-24 :

Author: Lin Feng

Work: “The Umbilical Cord of the Universe” Series

Size: 45cm×45cm

Year: 2022

In the gallery, studio, or stage, in order to prevent the rough local effect caused by the exposure of light, is used various combinations of light sources to make the color change. When multiple rays meet, they form a unified radiation, or each radiation itself has a luminous step. The overall lighting creates an organized visual effect. But different light sources can also influence each other, either enhancing or weakening each other, so that people can not understand their form and space. In order to make these different light sources cooperate with each other, photographers need to arrange these lights together in physical space, which is caused by the influence of light.

4.2 Challenges for Applying Structural Color Paintings. Overcoming Challenges in Work

The disadvantage of creating on the aluminum sheet is that the edge of the aluminum sheet is very sharp thus potentially hazardous for the audience when exhibited in the gallery. In addition because of its fragile nature, there will be some difficulty in handling and storing the artwork. In the case of using structural pigments on paper. Structural color pigment is this kind of paint material that can not be absorbed by the paper, so the acrylic pigment is used as the base color on the paper.

It was chosen as a kind of relatively soft sketch paper, after pleating, use black acrylic on the background color, and then spray structural color pigment was.

Figure 4-25: Different angles of the same sheet try different colors

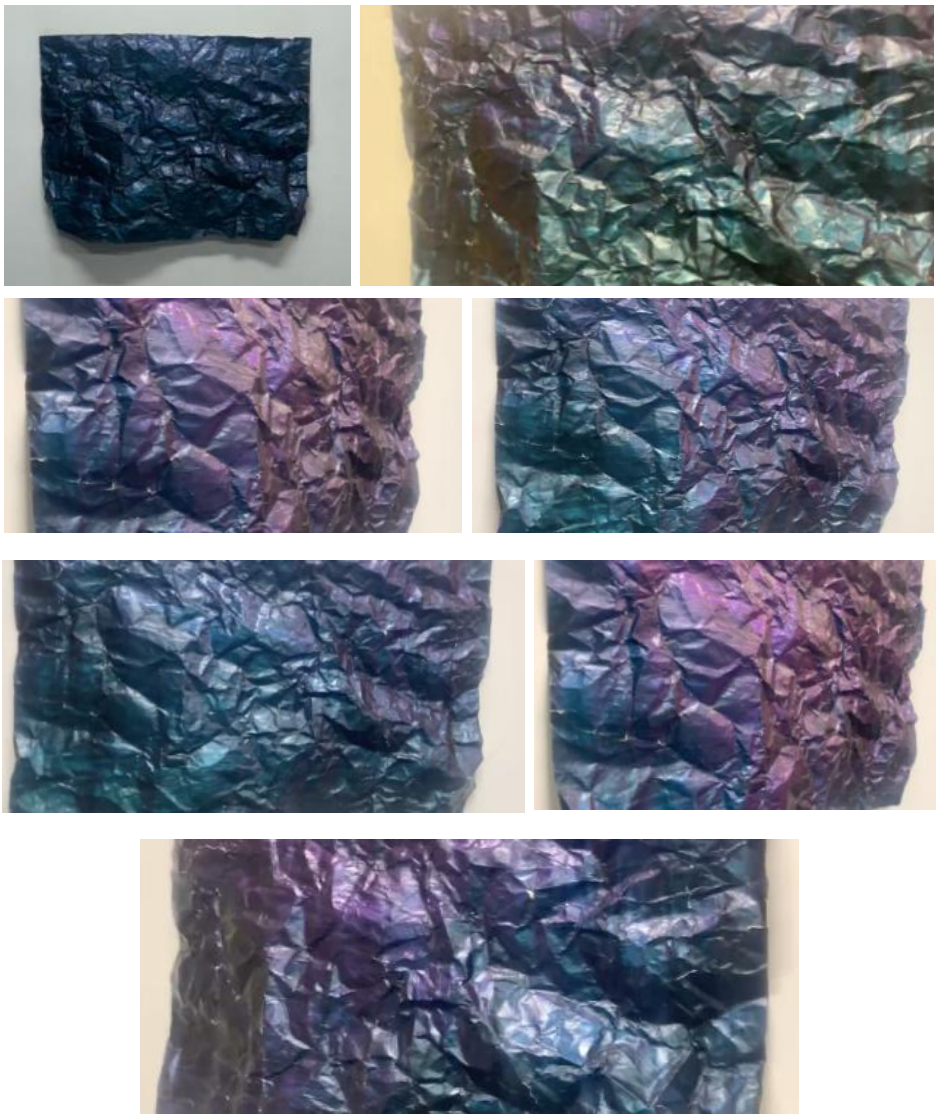


Figure 4-26: Different Angles of the Same Sheet Try Different Colors

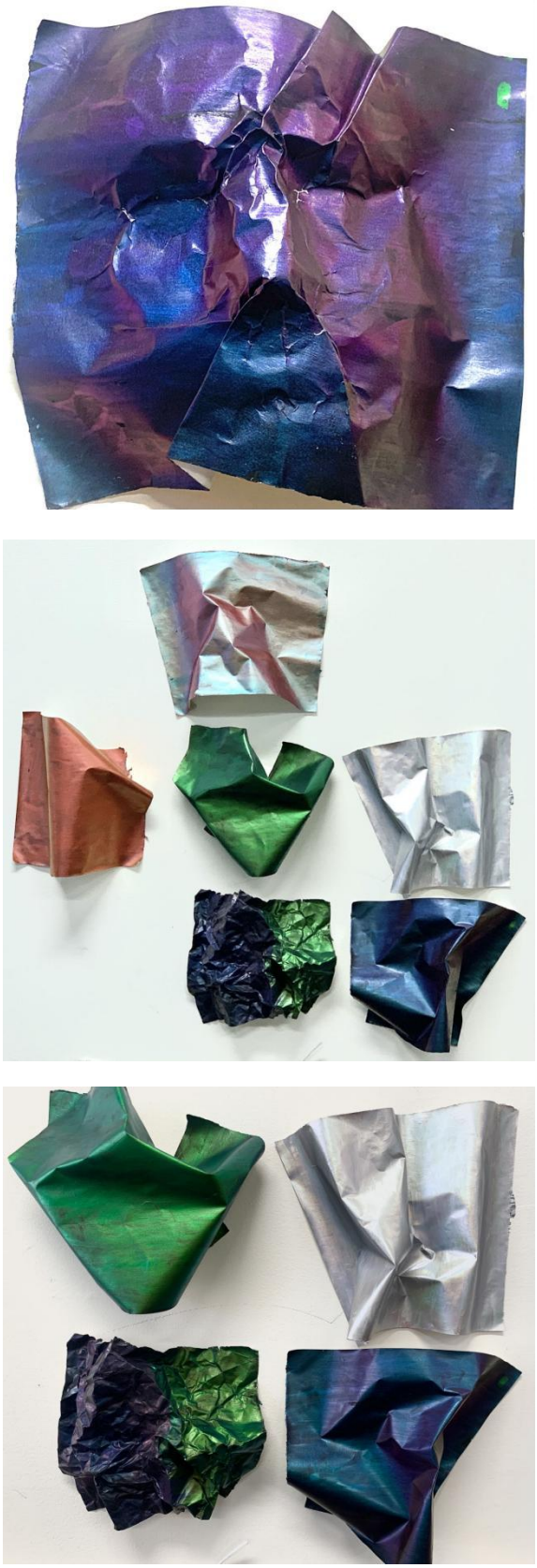


Figure 4-27: Shape of the Human Face with Structured Colored Paper

Because the material of the structural color pigment is spray paint liquid and has high transparency, the structural color pigment does not have the capability of covering colors and cannot be dipped by a pen to directly paint on a plane, so it is really difficult to do brush paint with it. Through the use of the pigment, the material can be sprayed and mixed with acrylic paint, and in addition, a three-dimensional object can be molded through plane paper, as the structural color pigments show different colors at different angles and under different lights.

4.3 Work

Figure 4-28 Work:

Author: Lin Feng

Work: “The Umbilical Cord of the Universe” Series

Size: 45cm×45cm

Year: 2022

The constituents of artistic creation, namely nature, organs, and fetuses, are not concrete objects but rather manifestations of linguistic transformations. My predilection for such themes may be attributed to my inherent distaste for rigidity and banality in objects, as well as the mundane realities of this world, which tend to.

Within “The Umbilical Cord of the Universe” series, there exists an implicit correlation between the human body's internal harmony and the harmony of nature and the cosmos. How should contemporary humanity perceive its relationship with itself and the world?

The movements of the sun and moon, the lunar phases, and even Jupiter's revolution around the sun all embody the close relationship between humanity and the cosmos. Everything in the cosmos is a microcosm of the interplay between humans and nature.

In today's world, people experience restlessness, anxiety, and pessimism due to the impact of the pandemic and rapid development. This phenomenon is particularly prevalent in China, where economic growth has been rapid, but spiritual development has lagged, and only a small number of individuals have undergone ideological awakening. In this restless era of entertainment and pleasure, we should strive to regain inner calm and introspect on our present relationship with the world. The emphasis on the present moment is crucial because the past and future can only be linked through the current time and space.

The disintegration and recombination of human organs manifest in a manner that defies the conventional logic of nature and reality. What is the significance of this mode of combination?

Concerning the recombination of human organs, I am not fond of concrete objects. If presented with a normal object, I prefer to distort it, such as by growing eyes on top of the heart or adorning the blood vessels with eyes. The fusion of human internal organs with nature is portrayed in soft or strong, gloomy colors, featuring ambiguous facial features that are in constant conflict with each other, both evoking pleasure and unsettling emotions. In the realm of reality to create more possibilities.

The human body is in a state of perpetual flux. How do we perceive these transformations? In the end, all that we confront in our physical bodies is death. As we mature, we lose more and more, not just our loved ones and friends, but our bodies as well, which slowly deteriorate due to calcium loss, osteoporosis, and declining immunity. I have even developed a herniated disc. For me, the essence of life is growth, and this growth is spiritual. Wisdom may be the only thing that one can carry with them after death if one believes in the soul. Human cognition is finite, and scientific inquiry is circumscribed. Is the world that we see with our naked eyes truly what it seems to be? Perhaps not.

Chapter 5

Development of Pictorial Expression by Introducing New Projection Technique, Changes in Perspective in Painting

5.1 Perspective in 16th Century Painting

According to Alberti's research, architect Filippo Brunelleschi found that the perspective principle was not implemented in words. In 1435, Alberti formally put forward the perspective theory for the first time in “oil painting”, and perspective has influenced the development of painting in Europe and even the world since then. By the 16th century, perspective was widely used [92]. For example, in Raphael's “The School of Athens”, where the floor tiles and the lines of the vault follow the principle of perspective, giving a real sense of space. The whole background and composition of “The School of Athens” is like a stage space, and the audience is facing the painting as if he/she were in the theater.

Figure 5-1: The School of Athens; Raphael; 1511

Source: https://www.epochtimes.com/b5/22/3/28/n1367859 3.htm

David Hockney said in the book *Secret Knowledge*:

“We know that there was a significant technological change in the early 15th century, namely the invention of linear perspective. This technology enabled artists to depict the illusion of depth and to arrange objects in proportion as they would appear from a specific viewpoint [9]. However, linear perspective alone did not aid the artist in accurately drawing the folds of clothing or the glimmers of armor, which could be achieved with the assistance of optical equipment. It is commonly believed that knowledge of such equipment was not available or not yet mastered during that time.”

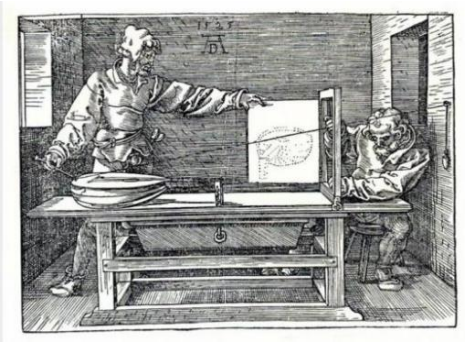


Figure 5-2: Albrecht Dürer 1525

Source: Secret knowledge

Figure 5-3: Hans Holbein (The Ambassadors) in 1533

Picture from: Secret knowledge

David Hockney compared Albrecht Dürer's woodcut in 1525 with a painting by Hans Holbein “The Ambassadors” in 1533 and concluded that the most difficult thing for linear perspective is the curved object like the ancient Pipa. The woodcut by Albrecht Dürer in 1525 shows that artists use some technical means to solve this problem. Hans Holbein's images are full of curved and spherical objects that are hard to draw with the naked eye, but whose shortened perspective is extremely accurate. It is possible that Hans Holbein could have used Albrecht Dürer's sketching machine to draw the ancient lute on the lower shelf, depicting it from an angle similar to the viewing angle in Albrecht Dürer's woodcuts. It is almost impossible to draw with Albrecht Dürer's sketch machine. The accuracy of still life and projection is likely to be achieved with the help of optical instruments.

Italian painter Andrea Mantegna painted “The Dead Christ” to show the human body with shortened perspective. In the late 15th and early 16th centuries, the copper layout of the German printmaker Albrecht Dürer (Albrecht Durer) was also influenced by Andrea Mantegna [93]. He devoted himself to instruments for describing perspective drawings He put forward the theory of perspective by using the compass and the method of measuring

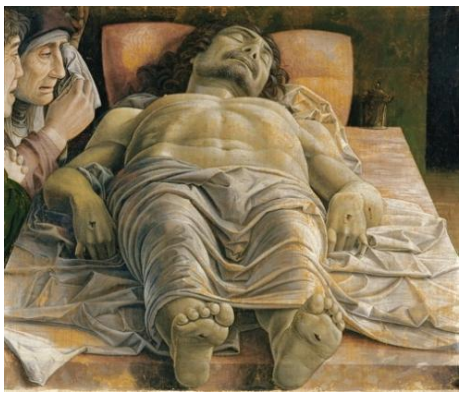


Figure 5-4: The Dead Christ, c.1480-90 (Tempera on canvas)

Source: https://www.meisterdrucke.jp/artist/Andrea-Mantegna.html

straight lines to make mathematical futures and applied geometry to the theory of perspective. His perspective method was called “Durer's method”. In 1525, Albrecht Dürer wrote a book entitled “Measurements of the Round and Straight Ruler”, which was very influential in the history of the study of perspective. Chamberlain, France proposed a method of calculating distance, which improved the diagonal grid futures (That is, the arrangement of points was obtained by the distance point method).

During the period of perfecting and expanding the application of basic perspective theory, perspective theory gradually became popular after the Renaissance and was constantly enriched from the 17th century to the 19th century. In 1630, the Dutch painter De Voss used the grid and an imaginary horizon to seek the vanishing point on the horizon and obtain rules. Perspective was also developed in Russian realistic painting in the 19th century. Vinetzianov briefly described the law of perspective painting in painting practice and theory. In particular, the role of Renaissance perspective theory on painting had a great influence on the later Baroque period, Realism, and Classical.

5.2 The Influence of the Appearance of Photography on Painting in the 18th and 19th Centuries

Photography (The process of recording images using some specialized equipment) was born when L.J.M. Daguerre’s daguerreotype was announced to the world on 19th August 1839 at the joint meeting of the Academy of Sciences and the Academy of Fine Arts in France. It not only extended our vision but also made the moment eternal [94].

The development of photography is mainly composed of the development of photosensitive materials and cameras, which derives from movies, television, digital photography, etc. The era of image culture is the third era in human history, after the era of totems and words. Its realism has had a significant impact on the classical realism of western painting art, the mainstream of “imitation”. Before Daguerre announced the daguerreotype, western painting art had always been classical realism

with “imitation” as the mainstream since ancient Greece and Rome. Especially in the Renaissance period, the three masters of the Renaissance represented by Da Vinci and others applied the knowledge of human anatomy, perspective, and color to their paintings in pursuit of realistic and nature copying including Da Vinci's oil painting “Mona Lisa”, Raphael’s oil painting “Comment parler de Raphaël aux enfants”, and Daguerre's contemporary French painter (J.A. Ingres1780-1867), Ingres' oil painting “Le Bain Turc”, “Valpinçon Bather”, “La Source”, etc., which reached the peak of classical realism painting with “imitation”. Therefore, photography has shaken the mainstream to some extent.

The realism of photography also impacted the “modernist” art (Symbolism, Fauvism, Expressionism, Cubism, Constructivism, Dadaism, Surrealism, Geometrical Formism, Tahiism, Pop Art, etc) of the West at the end of the 19th century. The modernist art trend basically appeared before and after Impressionism, with Post-impressionist painter Paul Cézanne as the “father of modern art”. Modernism emphasizes the self and emphasizes “venting” which is a protest against the restraint of the self by Western mass production and a refutation against the lack of emphasis on individuality in social production relations. In advocating conscious design and the elimination of unnecessary judging in painting standards, it has long been thought to be represented by the work of lesser photographers to appreciate the remarkable achievements of photography. They managed to go beyond the mechanical nature of the camera to the standards of art with effort.

Photography prompts modern painters to rethink, to conduct new explorations and creations in terms of tools, techniques, and subject matter, shifting to seeing and depicting the real world to the modern spirit. “The achievements of modern art include Impressionism, Cubism, and Surrealism, which are all related to photography.”

After the advent of photography, Realism, and Romanticism reached a peak in the 19th century when artistic creation techniques have been fully explored. In the onslaught of confrontation with photography, new schools of art have also emerged. With the development of science and technology (Photography) and modern social thoughts, human thoughts have become more careful, complex, and comprehensive.

Modern art came into being. The development of photographic technology is a part of science and technology, which has changed from black and white, from static to dynamic (Film and television technology), from film to digital for the realistic representation of objective scenes, playing an irreplaceable role in the reconstruction of modern Western art concepts.

5.3 Perspective in Cubism in the 20th Century

Paul Cézanne, the father of modern painting, created a self-justifying "anti-perspective method" [95]. The objects he painted were very strong, which provided new ideas for the pursuit and performance of "Cubism", and also inspired later artists.

Reverse perspective, also known as counter-perspective, is the deliberate defiance of the conventional rule of perspective, which dictates that objects appear smaller when farther away and larger when closer. In the realm of painting, this unconventional approach is attributed to Paul Cézanne, who is often hailed as the "father of modern art." Rather than adhering to the linear perspective that had been prevalent in art since the Renaissance, Cézanne pioneered a distinctive "reverse perspective" method. Instead of inviting viewers to step into the painting, Cézanne's technique created the impression that the depicted objects and figures were emerging and moving toward the viewer. His primary focus was not on conveying the three-dimensionality of objects but on expressing their structure, interrelationships, and colors. Cézanne's objective was to achieve a sense of artistic authenticity that could be apprehended through intellectual understanding rather than purely through visual perception.

David Hockney once said that seduction is an interesting topic that hasn't been discussed enough in the last 100 years. The last great discussion was in 1907 about Cubism, a topic now excluded for the sake of photography, but Cubism is indeed a "Technique of perspective" and based on the experience of studying perspective, Hockney made a series of famous photographic collages, saying emphatically

["Perspective needs to be reversed."][1]. He constantly challenges the perspective of focus. He believes that the focus perspective enables viewers to see the overall situation from a fixed angle, but people don't see the world like this. The focus of human eyes is constantly moving, so he hopes to break this fixed single-point viewing mode in his works. Compared with naturalism, the subjectivity of artists is more important. He thinks that many realistic painters draw with the help of black boxes, such as Vermeer.

From the 20th century to the present, some examples of modern painting have turned to the pursuit of subjective psychological space factors, intentionally using deformation to emphasize or abandon objective physical space. Knowing the science of perspective makes some modern art schools explore, surpass, or get rid of the law of perspective. In contrast, other schools, such as Optical Art, use perspective in a novel and hallucinatory style. In order to break the previous concept of space, some Surrealist and Avant-garde artists make full use of the special and strong three-dimensional space effect generated by the law of perspective and make exaggeration and compound of perspective. With the help of modern photographic techniques, special attention is paid to the material properties of the object, creating a more precise and detailed effect than perceived, in order to achieve "extreme realism". A "real" visual effect is created by complex light reflection and illumination.

Figure 5-5: Cubism, The girls of Avignon, Pablo Picasso, 1907

Source: https://www.pablopicasso.org/avignon.jsp

The expansion of the application of perspective theory is best illustrated by the performance of the effect of the design. Both hand-painted and computer-generated renderings in the computer age show the leading role of the perspective application.

[1] ["Perspective needs to be reversed."]: Break this fixed single-point viewing mode in his works

5.4 The Influence of Computers on Art

With the development of the third industrial revolution marked by computer and information technology, contemporary society has been increasingly influenced, transformed, and even dominated by digital technology. Digital technology has fundamentally and profoundly changed people's production, lifestyle, and perception. Digital technology has also brought about very various developments in art history for Contemporary art creation: Digital art is a type of art that is created and practiced with computers as a tool, including photography modified by digital technology, digital film, computer art, Network art, Interactive art, Virtual reality art, etc. Today, these different cart types are still enriching and expanding the realm of Digital art – deepening and developing internally, while continuing to permeate other art types.

Those abstract arts that influenced early Computer art have a common feature: they all belong to Structuralism, ranging from Cubism, Futurism, Constructivism, and Supremacism to later Light effect art. And they focus on structure, order, rational analysis, and calculation. The foundation of computers is calculation, which is the great crystallization of scientific rational thinking. Almost all the people who engaged in Computer art practice in the early days were mathematicians with a natural sensitivity for structure and order, who were easier to accept and understand the structuralist abstract artworks with mathematical thinking, and thus would be influenced by the abstract artworks at the beginning. computers are very precise and efficient in realizing the abstract images of Structuralism through calculation and even produce more mathematical beauty and order than abstract painters. But it also exposes the problem of early Computer art from the opposite side: It cannot express expressive abstract art. With the technological advancement of computers, although this problem has changed from a data point of view, [“since any form and color element can theoretically be processed by a program, computers can handle many styles”][2].

[2] [“Since any form and color element can theoretically be processed by a program, computers can handle many styles”]: The tasks of a computer as a processing tool are all computational tasks, and the processing object of the program is data (Such as numbers, text, graphics, images, sounds, etc.) or information (Using data as a carrier and

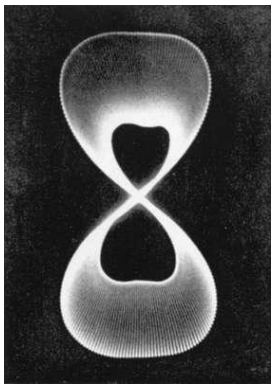


Figure 5-6: Oscillon No. 10 (Electronic Abstraction)

creators:	Ben F. Laposky
title:	Oscillon No. 10 (Electronic Abstraction)
year:	Around 1952
material:	Photograph, b/w 17.5 × 12.5 cm
artwork :	Photograph

Figure 5-7: Oscillon No. 27 (Electronic Abstraction)

creators:	Ben F. Laposky
title:	Oscillon No. 27 (Electronic Abstraction)
year:	Around 1952
material:	Photograph, b/w 25.4 × 20.2 cm
artwork	Photograph

Source: http://dada.compart-bremen.de/item/agent/253

Benjamin Francis Laposky (1914–2000), the founder of electronic abstraction, was an early pioneer of Digital art [96]. His artistic practice has important implications for the later development of Computer art. He is a mathematician, draftsman, and artist from Cherokee, Iowa, USA. In 1952, Laposky exhibited a series of his abstract works at the Sanford Museum in Cherokee, Iowa, USA, which he officially titled "Electronic Abstraction." Laposky intentionally made a connection between these works and the abstract art tradition of modernism. When interpreting his own works, he quoted and praised a group of modernist abstract painters including Marcel Duchamp, Mondrian, Malevich, Naum Garbo, and so on, which actually highlighted the Structuralism of abstract art developed from Autocubism, Futurism, and continued the development of "electronic abstraction" through new media technology in the 1950s.

Today's Computer art is open, interactive, integrated, etc., but it changes with the development of the times, and finally shows more and more artistic creation forms,

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having a definite meaning). Processing rules are actions and steps used to process data or information, such as arithmetic operations, logical operations, relational operations, functional operations, and various actions and steps such as sequence, judgment, and loop.

and then reaches any combination between art.

Creation with a computer requires the interaction and comprehensive application of multi-disciplinary knowledge, not only limited to traditional painting but also more likely for the demand of comprehensive application ability with multi-dimensional knowledge.

5.5 Effect on Pictorial Expression Brought About by Change of Viewpoint Leveraging Computer Simulation for New Projections

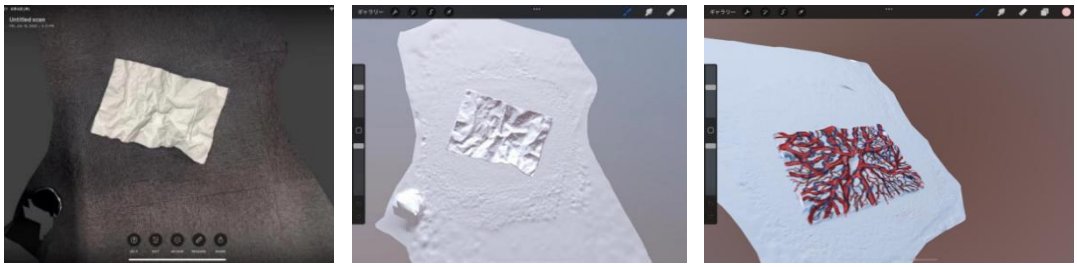
Making use of current computer software to handle the work for making a draft, can let it more convenient for artists to carry out next-step second creation in actual surface and concave-convex things.

Scaniverse software can capture, edit and share 3D content. Use laser radar to establish a three-dimension model. You only need to scan. The reconstruction algorithm handles original laser radar data as a pattern 3D model, which can directly edit control, cut and twist scanning, adjust exposure, contrast, and acutance just like editing photo, can output three-dimension formats, such as OBJ and FBX, and can adapt to most three-dimension construction software and game engine. The constructed model can watch according to actual size, and can also shrink according to ratio.

Use Scaniverse software to output the scanning mode in “obj” format, and open with procreate software, and can also paint directly on the picture scanned by three-dimensional.

Below is the experimental process:

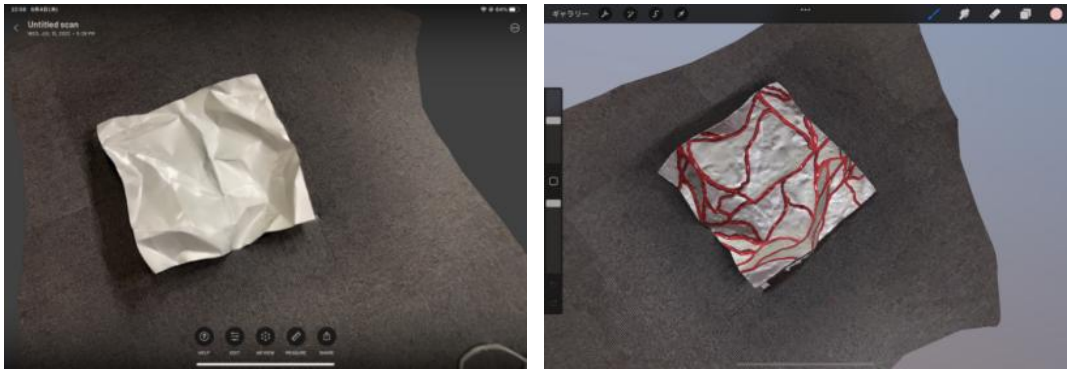
First case: Scan a crumpled white paper, then export the 3D model, then sketch the model, as picture (1), (2), and (3).



（1） (2) (3)

Figure 5-8: 3D Scanning Image

Second case: After scanning the uneven aluminum sheet after being spray-painted with white paint, directly map the original object and draw a sketch on it. as pictures (4) and (5).



（4） (5)

Figure 5-9: 3D Scan Export Modeling and Painting

Third case: Scan the plaster head future and the surrounding environment, then export the 3D model, then sketch the 3D model, as pictures (6), (7), and (8).

(6) (7) (8)

Figure 5-10 : 3D Modeling and Painting

5.6 Summary

Science and technology have been accompanying and influencing the development of art. From David Hockney's question of whether artists have used imaging technology to assist painting, it can be seen that with the progress of technology, artists' painting skills have become more and more exquisite, and artists have been using the progress of technology to assist their own creations. Throughout the 20th century, the application and fascination of modern science and technology have greatly stimulated the imagination of artists. For example, PS, AI, C4D, 3DMAX, and other computer graphics software have also brought convenience and amazing visual effects to painting. Technology has provided a more convenient way for traditional painting, and people can use some drawing software to quickly produce near-realistic the real thing. Some of my personal attempts and creations want to make use of the more advanced software to help artists overcome difficulties in reality and present their works better. Artists can combine software with technology and painting and can be applied to more art industries.

Chapter 6

Combining Software with Projection Technology to Assist Painting

6.1 Projection Model for Abstract Representation

The software this study chose for the experiment is called Scaniverse, which can capture, edit and share 3D content directly from a mobile phone. Using LiDAR and computer vision, it built a 3D model with high fidelity and small details.

It is understood that “Scannerse” is a 3D scanning application launched by Niantic, which can be used to build high-precision models of objects, rooms, buildings, or outdoor environments. iPad and iPhone devices that were previously only supported with LiDAR sensors can now be used on non-LiDAR iOS devices.

Use Detail Mode for objects, people, and small spaces. In Detail Mode, the photogrammetric processing of “Scaniverse” can be used to obtain high-quality scanning results comparable to those of LiDAR-enabled devices, even without LiDAR.

And use the Area Mode for rooms, buildings, and large spaces. Devices without LiDAR rely on visual cues to determine the depth, so it is recommended to avoid being too close to blank walls and featureless surfaces that are difficult to determine the depth [97].

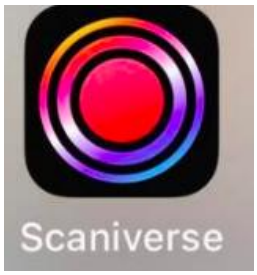


Figure 6-1: APP: Scaniverse

Figure 6-2: Scan Paper

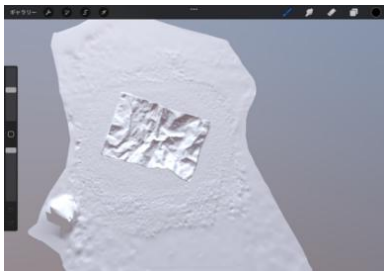


Figure 6-3: Export OBJ Format Model

6.2 Introduction of Tracing Technique by Applying Projection Mapping

In this experiment, the projector is connected to an iPad, which has an HDMI or VGA interface, while the iPad only has a lightning interface. In fact, it only needs a portable green link multi-function video converter, which has the function of USB to HDMI/VGA. Operation method, use HDMI cable or VGA cable to connect the projector and green multi-function converter use the iPad data cable to connect the iPad and the converter and connect the power cord to use. Whether it is an HDMI line or a VGA line, the iPad screen will be directly mirrored to the projector after being connected. The following is the Figure 6-4.

Figure 6-4: iPad Link Projection Onto Sculpture

6.3 A Work Using a New Projection Method

Step 1: Scanning plaster image with Scaniverse software to derive plaster model

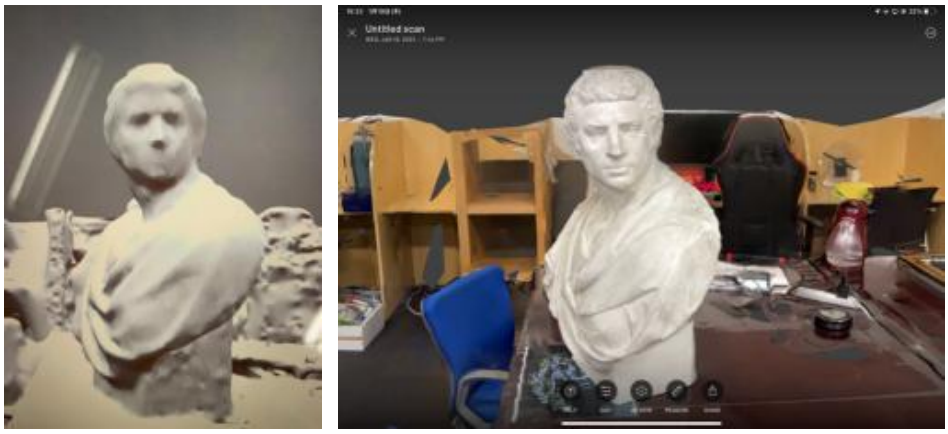


Figure 6-5: Software Scaniverse Export Plaster Renderings

Step 2: Open the exported model or image with the painting software Procreate

Figure 6-6: Procreate

Figure 6-7: Software Procreate

Import Procreate

Step 3: Project the iPad-linked projector onto the plaster for painting creation

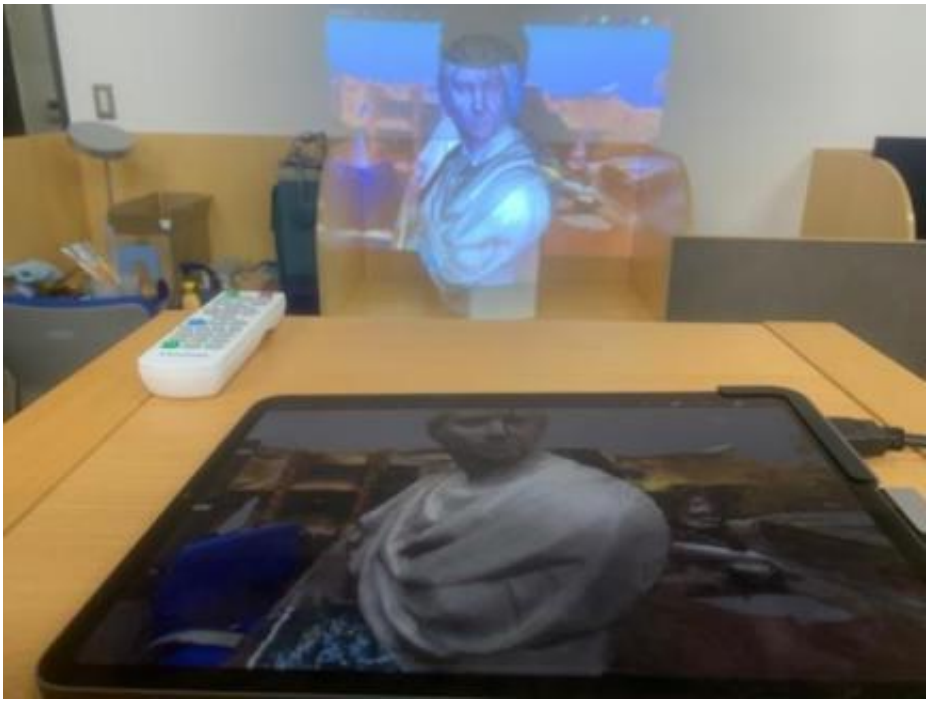


Figure 6-8 : Effect After Link Projection

Figure 6-9: Draft the Rendering on the iPad

6.4 This Advantage of Creating with New Technology

In the past, artists used projection technology to draft on a flat canvas, which solved the limitation of drafting only on a flat canvas. These previous works were created on uneven and irregular aluminum sheets. This technology can make it easier for artists to draft, see the effect of creation in advance, and then modify it in time. In addition, this technique can also be used for the creating of three-dimensional works, or sculptural graffiti painting, allowing artists to see the effect of their creation in advance on the work in a three-dimensional space, and modify it if they are not satisfied. It is beneficial to cast the projection directly on the three-dimensional object for sketching and modification before formal creation.

6.5 Abstract

Projectors are now widely used in painting. Since the 15th century, many Western painting artists have used the method of projection tracing, and the invention of lenses has created the peak of Western classical realistic painting. The second and fifth chapters of the dissertation, it is written about the development of the camera obscura technique and the use of the camera obscura technique by artists to assist painting, as well as the changes in perspective in the genre of artists. Realistic painting has occupied an important position in the past few centuries. Can projector technology make painting progress today? In the future that the innovative use of projection technology combined with software has certain research value in today's society with diverse art.

Chapter 7

Results and Discussion

7.1 About an Attempt at a New Painting Technique

Traditional techniques of the past will also be reborn. Painting techniques have become ever more sophisticated with the development of technology. Whether lenticular or chemical, has pushed art to a deeper level. In today's society, the development of computer technology has given rise to art forms such as holographic projection and metaverse, giving art another qualitative upgrade in visual terms. The integration of technology and art also presents a certain complementary effect on artistic creation. It can be seen that the development of technology can revive old events and traditional techniques from the past. This is because technological advancements can enhance artistic expression and make it more adequate.

In the present day, many artists collaborate with talents from various fields to create new works, such as engineers, biologists, mathematicians, etc. The diversity of art in the age is not only in the single technique of painting but also, more importantly, in innovation.

This paper is based on the research of new structural colors of materials and the use of computer software and projection techniques to assist the creation. Computer technology and projection techniques make it easier for artists to complete their works.

Some of the artist's creations are not just limited to flat surfaces and canvases. This technique allows the artist to work on irregular objects as well as sculptures with ease and speed.

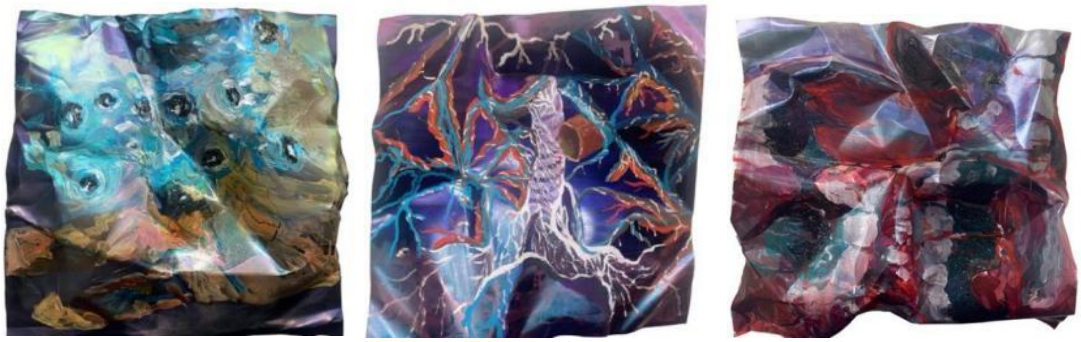


Figure 7-1: The Works Created by the Thesis Research: “The Umbilical Cord of the Universe” Series

7.2 Selection and Evaluation of Works for Exhibition (Public Exhibition Participation)

7.2.1 Painting “The Eye of Hell” 2022. Has Won the Youth Group” Bronze Award in the H.C. Andersen Art Award

Figure7-2: Work: “The Eye of Hell” Series

Figure 7-3 : Certificate of Award

Author: Lin Feng

Work: “The Eye of Hell” Series

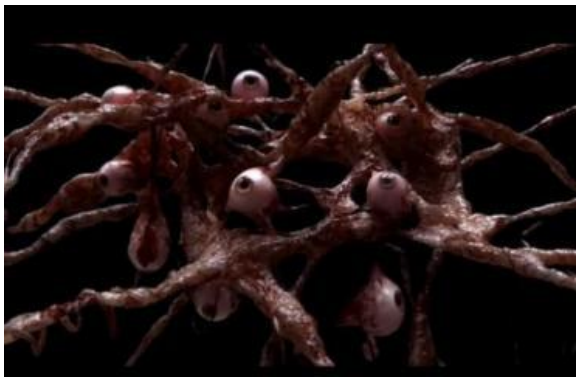
Size: 45*45cm

Time: 2022

Medium: Aluminum Plate, Electroplated Paint, Pearl Powder, Nail Polish, Glitter, Acrylic, Oil Paint

H.C. Andersen Art Awards is established by Denmark H.C. Andersen Culture & Art Committee at Odense. It is co-organised with Denmark H.C. Andersen Samfundet Copenhagen and China to award international artistic creation.

7.2.2 CG Work “The Eye of Hell” 2022. Has Won the Youth Group” Bronze Award in the H.C. Andersen Art Award



Author: Lin Feng

Video Works

The Eye of Hell

Time:W2021

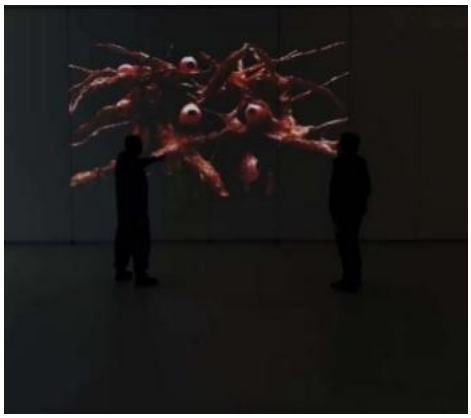
Length: 1m30s

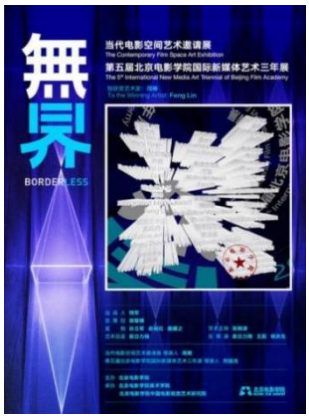
Figure 7-4

7.2.3 The 5th Beijing Film Academy International New Media Art Triennial “BORDERLESS”

2021: Video work “Eyes of Hell” is exhibited at The 5th Beijing Film Academy International New Media Art Triennial “BORDERLESS” Won the Integrated Media Award.

The Beijing Film Academy International New Media Art Triennial, sponsored by Chinese artist Professor Liu Xuguang, is held every three years at the Beijing Film Academy.





Author: Lin Feng

Work: Eyes of Hell

Time: 2021

Medium :Video works

Place: Beijing Film Academy, Beijing, China

Certificate of Award

Figure 7-5

7.2.4 Shortlisted for the Public Exhibition “ベラドンナ・アート”

The Art Association “ベラドンナ・アート” holds a national art open-call exhibition every April at the Ueno-Tokyo Metropolitan Museum of Art. As a fine art exhibition for women artists of the pioneering era, it is a fine art group full of individual female writers gathered from all over the country.

Launched in 1987 as Belladonna Art, the association established the Belladonna Art Exhibition in 2005 as a national art open recruitment group for women artists expressing “freedom of soul”. Since 2012, it has moved its venue to the Tokyo Metropolitan Museum of Art, opening up a venue for more women writers to make their mark.

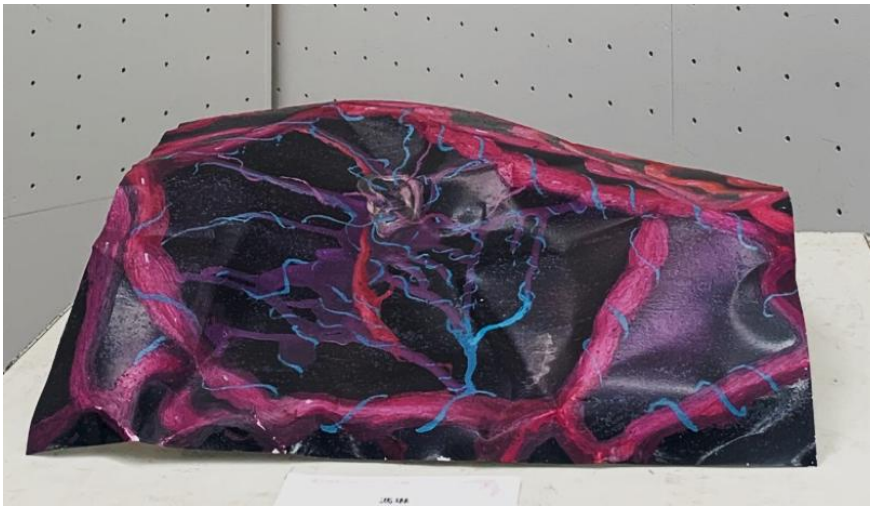


Figure 7-6

Author: FengLin

Work: “The Umbilical Cord of the Universe” Series

Size: 45*45cm

Time: 2022

Medium : Aluminum Plate, Electroplated Paint, Pearl Powder, Nail Polish, Glitter, Acrylic, Oil Paint

Place: Tokyo Metropolitan Museum of Art

7.2.5 Exhibitions 『在地, 園宇宙』

Figure 7-7:『在地, 園宇宙』

～在東京中国人アーティストによる現代アート展～

ワセダギャラリー

The exhibition was planned by the senior sister of our research room, and the works of five Chinese artists in Japan were exhibited.

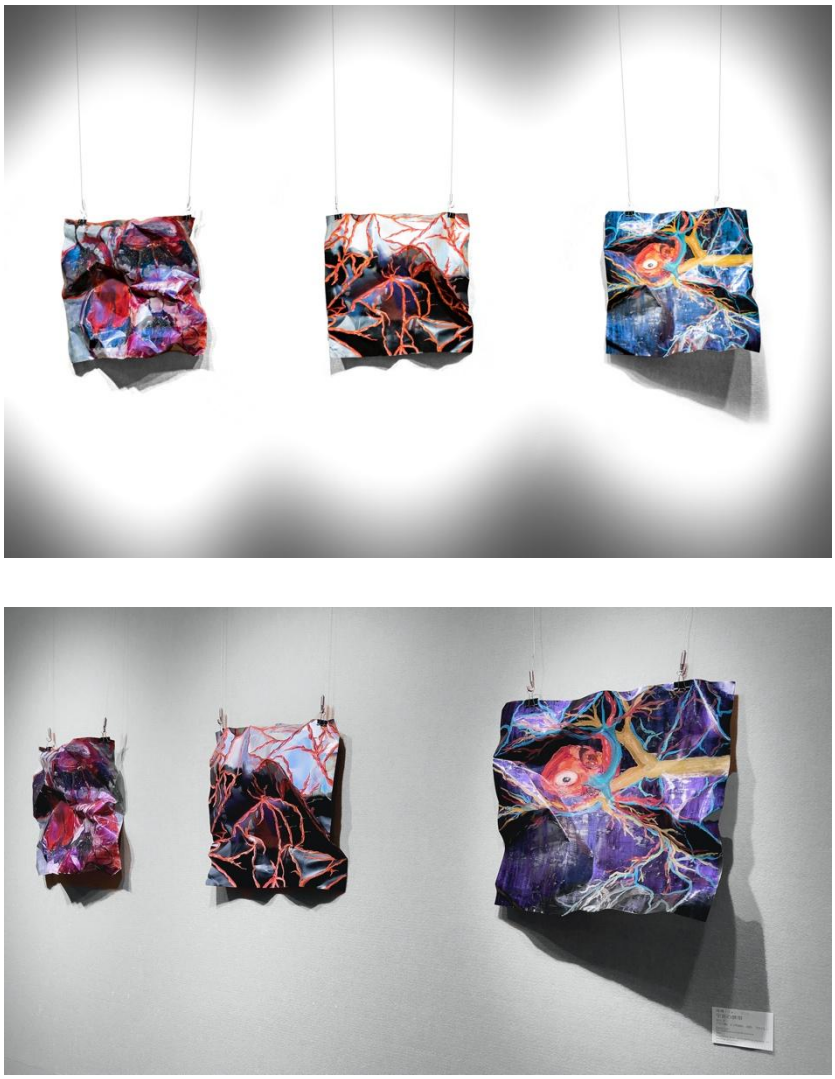


Figure 7-8

Author: Lin Feng

Work: “The Umbilical Cord of the Universe” Series

Size: 45*45cm

Time: 2022

Medium: Aluminum Plate, Electroplated Paint, Pearl Powder, Nail Polish, Glitter, Acrylic, Oil Paint

Place: Waseda Gallery . Tokyo

Figure 7-9

Author: Lin Feng

Work: Eyes of Hell

Time: 2022

Video works

Length: 1m30s

Place: Waseda Gallery. Tokyo.

7.2.6 Exhibitions Meta-Curation 16/N丨 在地、園宇宙@ VENEZIA

Figure 7-10: Poster of Individual Exhibition

The 1st Annual Metaverse Art@VENEZIA is a research exhibition organised by the University of Venice in collaboration with university students and teachers and artists from all over the world.

In this Venice Biennale peripheral exhibition, “On Earth, Round Universe@VENEZIA”, the participating artists are young people living and working in Tokyo, who, from the perspective of their identity, are people living in “another world”. Under such circumstances, they contemplate the aesthetic problems of the metaverse, objectively and subjectively placing themselves in a different space.

This exhibition in Venice is a conceptual presentation of their further reflection on the metaverse.

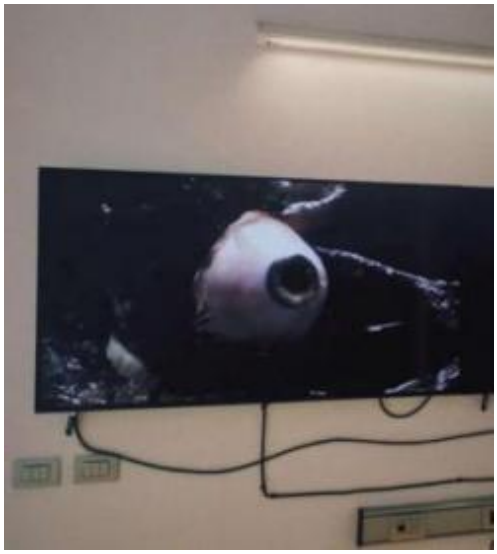


Figure: 7-11

Author: Lin Feng

Work: The Eyes of Hell

Time: 2022

Medium: Video works

Place: Arsenale di Venezia

7.2.7 Industry Insiders Comment

馮淋にとっては、人間存在とは何よりもその「内部」(それも漠然とではなくて「内部器官」という意味での「内部」)に他ならない。だからこそ人間は「宇宙」と繋がり得る。そして、少なくとも彼女にとって「内部器官」のなかで中心になっているのは「知覚」、とりわけ「視覚」である。ただ美術家だからというのではなくて、「知覚」の中核に「視覚」があると考えているようなのだ。事実、諸感覚を統括しているのはどうやら「視覚」らしい。例えば日本語には「めぢから(眼の力)」という語があるし、「眼は口ほどにものを言う」という言い方もある。

《THE EYE OF HELL》というCGヴィデオ作品は眼球の連鎖から成り立っている。また《宇宙の臍帯》という絵画作品にも眼球の連鎖は出てくる。《宇宙の臍帯》の他の作品では、個々の人間の出発点である「臍帯」、その連鎖から成っている。「脳のシナプス連合」という用語を借りるなら、人の命の成り立ちは「臍帯というシナプス連合」で形作られる、そんな連想に誘われる。そうやって形づくられた命が、赤子となってこの世の中に生れ、しばらくして眼を開ける。人間はそこから始まる。

千葉成夫 (日本の美術評論家)

2022

『在地, 園宇宙』

～在東京中国人アーティストによる現代アート展～

ワセダギャラリー

私は馮琳の作品を北京電影学院のアトリエと北京での個展で見ている。その時は非常に身体的な感覚の強い表現だと感じた。自らの体の中の世界が、特に臓器自身が小宇宙を形成し自立した感覚器官となって、彼女の腕と筆を伝わり画面へと繋がっている様だった。今回の馮琳の表現は、基底材にアルミ板を用いた絵画や暗黒の宇宙に飛び出した生命体(臓器)の CG 映像表現へと展開している。

坂口寛敏(東京藝術大学名誉教授 、美術家)

2022

『在地, 園宇宙』

～在東京中国人アーティストによる現代アート展～

ワセダギャラリー

7.3 Art and Science Impact the Present

Since the Renaissance (14th century - 16th century), art has been very popular and dominant and later generalized into the basic principle of all art theories (Including literary theories), namely the “theory of reproduction”. It is believed that nature and human life are the objects of literary depiction and that the task of the literary artist is to reproduce them using different media (Language, canvas, color, lines, notes, etc.). Art is like a mirror, with which the world (Nature) is illuminated so that art reflects the world truthfully. The essence is “truth conformism”.

Science and art play an equally important role in the development of human society, especially in today's era of rapid technological development, the combination of the two has more important significance. Therefore, understanding and handling

the relationship between science and art, giving full play to their creative thinking, will increase the speed of progress of human civilization. The art of history has a great influence on the art of today, and the art of today will have a certain influence on the art of the future, but the development of the different categories and disciplines of art is based on history.

In the research process and creation process of the thesis, the subsequent discipline of art can be more closely integrated with science and technology, and explore the interdisciplinary fields between disciplines.

7.4 The Influence of Information Technology on Art in the 20th Century

In the 20th century, with the invention of computers as the hallmark of development, mankind entered a new era - the information age, in which the most extensive and profound impact on human society is derived from information technology.

Since the 20th century, human society has once again faced a new revolution. The culture of the Post-industrial era has withdrawn from the mainstream form, and information and Digital art have taken their place as the mainstream of the new culture.

Information technology has transformed the way art is made and the tools used to make it. In the traditional painting process, the painter only needs the support of the easel and the embellishment of the brush and ink, while in the digital era, the painter only needs a computer with various drawing software and retouching tools installed to start the painting creation. The emergence of computer hand-drawing and printers also has an impact on traditional painting. Depending on the artistic effect to be pursued, we can choose different printers to form different imaging textures. Science and technology can also serve as a vehicle for the communication of the artist's spiritual world and the transmission of social and cultural connotations. Based on the guidance and support of digital technology, this multi-modal carrier expresses the design intention in an all-round, multi-angle, and vivid way by integrating various means of expression, such as text, pictures, animation, sound, and video, which truly

achieves the effect of combining graphics, text, sound, and image. Digital art is a combination of art and technology, constitutes a new art form with a high degree of integration between science and art, and forms a new aesthetic tendency.

Influenced by information technology, art is a new product of the combination of the rapid development of contemporary digital technology and art. Compared with other art directions, art presents practical, contemporary, interdisciplinary, and composite characteristics. It is necessary to have new thinking and understanding of the need for art under the influence of information technology, and it is crucial to research and explore technology art set and its related fields for the development of Digital art. As digital information is disseminated more deeply and comprehensively, the core of the combination of art and technology lies in aesthetics. The times have given them different connotations, and the creation of new tools has brought corresponding new production methods and aesthetic standards: depth and breadth, shape and color, contrast and coordination, softness and rigor, light source, and shadow. The artistic connotation needs to be expressed through the external form of art. The increasingly adjustable operating functions of computer software have led to a dramatic change in the aesthetic form of art as well. Moreover, the integration of electronic technology into the art field has resulted in digital technology that continues to shorten the distance between the artist and the admirer, even realizing the interaction of human-computer dialogue.

7.5 Remaining Issues and Future Prospects

In the series “The Umbilical Cord of the Universe”, structural colors were utilized to create the work. This material has flaws in its own application, such as being toxic. Given that the work is created on aluminum, there is a possibility of damage to all the works during transportation. The current problem is how to mount the works more scientifically to protect the original color of the works in the exhibition This is the next step that I need to explore further.

In the process of research, language in a sense determines the way we think and

express ourselves, and different linguistic structures reflected in the way of thinking will produce different results. Therefore, it can be said that a certain language structure determines a certain way of thinking. In computer technology, it is necessary that we consider how to generate a mesh that represents the material characteristics of an object by controlling the basic coordinates and finding the right way of mapping. Basic concepts such as color and shape still exist, and they are realized in different ways, which indicates a shift in their way of thinking.

It is always known that art and science and technology are two different ways for people to understand the world. In the creative process, these two aspects are interpenetrating. The progress of science has changed the role and place of art in human activity. computers can link science and art together, while it links the tradition and future of artistic creation, changing people's perception of art. The development of science and technology provides art with new means of expression and expands the space for artistic expression. Technology and art are closely related. Most artists today start to use technology as a means of creation. The combination of technology and art can bring more artistic expression and interactive cross-field characteristics. The expression form and content are more interactive, and the cross-field creation leads to a more diversified and open development.l

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Education (Educational history after enrolling at high school with indication of attending / graduated / withdrew etc.,)

High School	Jining No. 1 Middle School, Shandong Province	2005	Year	9	Month	enrolled
		2008	Year	6	Month	Graduated
University	Department of ministry of education/Major in watercolor painting, School of Guangzhou Academy of Fine ArtsUniversity, Country	2009	Year	6	Month	Enrolled
		2013	Year	9	Month	Graduated
			Year		Month	※Please select.
			Year		Month	※Please select.
			Year		Month	※Please select.
			Year		Month	※Please select.
Graduate School/Master Program	Master's Program in Department of Fine Arts, Graduate School of Beijing Film Academy, Postgraduate course in New Media Art, Beijing Film Academy University, China .Beijing	2016	Year	6	Month	Enrolled
		2018	Year	9	Month	Completed
Graduate School /Doctoral Program	Doctoral Program in Department of Intermedia Studies, Graduate School of Fundamental Science and Engineering, Waseda University, Japan.Tokyo	2019	Year	4	Month	Enrolled
		2023	Year	3	Month	Completed

Master's degree you have obtained	**Name of degree**	Postgraduate course in New Media Art, Department of Fine Arts	**degree date**	2018/06/26
	Name of University	Beijing Film Academy		
Doctor's degree you have obtained	**Name of degree**		**degree date**	yyyy/mm/dd
	Name of University			

Academies you belong to & social activities									
2017	Year	11	Month	～		Year		Month	Feng Lin's solo exhibition "The energy of magma "was held in Beijing Yangmei International Gallery
2021	Year	12	Month	～		Year		Month	Participated in the Beijing Film Academy International New Media Art Triennial
2022	Year	8	Month	～		Year		Month	" The Eye of Hell ", a video work, will be exhibited at the Venice Biennale Outreach Event: Meta-Curation 16/N On Earth, Garden Universe@VENEZIA

Awards	
2021/12/06	**Work"Interlocution" 17 series Creative Arts Award 13th Exhibition -Tokyo Museum of Art**
2022/12/13	**" Eyes of hell" The 5th Beijing Film Academy International New Media Art Triennial "BORDERLESS" Won the Integrated Media Award**
2022/06/15	**"Interlocution" 2022. Has won the youth group" Bronze Award in the H.C. Andersen Art Award， CG image "The Eye of Hell" 2022. Has won the youth group" Silver in the H.C. Andersen Art Award**

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◯Articles in refereed journal（peer review）	“On the Integration of Sense and Reason in the Relation Between Science and Art—Take the Influence of Mathematical Form on Art Design as an Example”. Art and Society:ISSN 2709-9830 . Vol. 1 No. 2, [2022] P1-10 ,FengLin.
Articles in refereed journal （no peer review）	《关于作品中的场性研究》/ “Research on the field in works of art”. Beijing Film Academy International New Media Art Triennial Exhibition.ITERATION&BLENDING . collection of essays. China Film Press .2018.1 ISBN 978-7-106-04438-1. P105-112 . 馮琳/Fenglin フラットベッド型ハイパースペクトルスキャナの試作と絵画 の分光報の計. 映情学技報, vol. 44, pp. 311-312, 2020年3月.ISSN:Print edition: ISSN 1342-6893 Online edition:ISSN2424- 1970 . 岩崎遥 坂井滋和 馮琳(FengLin) ハイパースペクトルスキャナを用いた各種画像の分光計測とその比較. 研究報告人文科学とコンピュータ（CH）巻:2022-CH-128号:5. P .1-2 2022-02-12. ISSN:2188-8957.榎本翔悟 坂井滋和. 馮 琳（FengLin）
◯Painting	“The Umbilical Cord of the Universe” series Shortlisted for the public exhibition "Fantastic Art” The National Art Center, Tokyo.2022.3.12 "On Earth, Round Universe” Five-person exhibition～在東京中国 人ア ーティストによる現代アート展～ワセダギャラリー 2022.3.19 Shortlisted for the public exhibition "ベラドンナ・アート" Tokyo Metropolitan Museum of Art.2022. 4.19.
◯Video	“The Eye of Hell” The 5th Beijing Film Academy International New Media Art Triennial "BORDERLESS” . 2021.12.11 "On Earth, Round Universe” Five-person exhibition～在東京中国人ア ーティストによる現代アート展～ワセダギャラリー 2022.3.19 Side exhibitions of the Venice Biennale: Meta-Curation 16/N｜On Earth, Round Universe @ VENEZIA.2022.8.20
◯Painting	“Interlocution" series Group exhibition "2016 Fragment Reconstruction Genes" Central American International, Beijing,

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Video	China; 2016.10.15 "Dialogue" group exhibition at Chung-Ang University, South Korea 2017.5.30 Beijing Film Academy International New Media Art Triennial Painting　Unit- Dongyue Art Museum-Beijing . 2017.12.10 FengLin Solo Exhibition-The Energy of Magma(Beijing Film Academy International New Media Art Triennial, Postgraduate Teaching Achievement Unit, Curated by Ursula Pan Hansen, Professor and Curator of Kassel University) International Gallery, Central Academy of Fine Arts, Beijing .2017.12.10 Jialilili | 2018 Qinhuangdao • Dimensional structure of Haibitai Art　Festival—The field of contemporary art　Qinhuangdao .　2018.5.13 Image Inspection-Nantong University Art Academy Art Museum.2019.11.1 Thirteenth Xiucai Exhibition——Tokyo Metropolitan Art　Museum.2021.12.6 Exhibition“くうなんアート”，北海道教覚寺 2021.12.17 Shortlisted for the public exhibition "New Soprisha Exhibition". The National Art Center, Tokyo.2022.2.20 Shortlisted for the public exhibition "Once In Lifetime”　Tokyo Metropolitan　Museum of Art.2022.3.3 Shortlisted for the public exhibition "The 27th アートムーブコンクール". Osaka.2022.5.10 “mileage” participated exhibition-The 2nd Chongqing International Image Biennale-a high rise from the ground.2017.4.28 "Dialogue" group exhibition at Chung-Ang University, South Korea.2017.5.30 Entered the college unit of the first Hechuan Diaoyucheng International New Media Art Festival. 2017.11.15 Talents China University Alliance Joint Exhibition-Beijing Quanyechang-Beijing. 2017.12.23