An Investigation of Holographic Technologies Applied to Contemporary Art Practice

A new approach to temporal aesthetics

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Abstract

The works of contemporary art using audio, 35mm slide, video, film and computer-based technologies are commonly referred to as time-based media, since they have duration as a dimension. By looking at artworks which are classified in this category, it appears that temporal visual perceptual interpretations are mainly created through the use of the illusion of movement, which is primarily constituted by sequential images. In art holography, the light-based characteristic qualities of this medium compose a kinetic and interactive visual syntax, which are not seen in other imaging technologies, stating its unique creative possibilities. Thus, this study intends to employ holography as an art medium to explore its temporal properties in order to establish a new approach to time-based media art practice.

To review the practice and artworks created for this study, the author recognises that the characteristic qualities of a medium is key for the development of its own aesthetic culture. Moreover, the author also identifies that the combination of both the slips form of a hologram and a portable lighting device would be fundamental elements of the suggested new approach. This approach integrates the holographic image replaying process and the Chinese bamboo slips structure to create a scroll form of an artwork presentation, which suggests a viewer to observe with an unrolling activity, section by section. The role of light in this approach is essential as it not only reconstructs the image, but also acts as an intangible guide to indicate the viewing direction, which forms a directional linear temporal expression.

This study combines the suggested approach with classical Chinese poetry to create a series of experimental artworks, demonstrating that the literal and figurative meaning of the poem could possibly be elevated through the manipulation of the light source and the scroll from of the image presentation, as the former creates the holographic kinetic expression and the latter reinforces the poetic linearity. This approach could be interpreted as a time-based holographic manifestation, as it unfolds the art to the viewer over time. Furthermore, in terms of the characteristic qualities of holography, the visual expressive techniques and aesthetic features created for this study indicate that such works cannot be recreated without the use of holography. This study reveals that the irreplaceable aesthetic qualities of holography, suggesting that it could

expand and diversify the creative potential of time-based media art; and the discussion of this category would not be comprehensive unless taking this medium into consideration.

This study establishes a creative possibility of holography and expects the finding to lead to a greater appreciation for future time-based media art practice, thus enriching the temporal artistic expressions. Moreover, as it is practice-based, the process of the research is primarily expressed through a series of holographic artworks, and combined with written format of discussion, which is presented in this thesis. For comprehensive understanding, reading the thesis in conjunction with viewing the artworks in person is suggested, as the photographic reproduction of the holographic images in this thesis is only for illustration purpose.

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Chapter 1 Introduction

1. Background

In the past few decades, the rapid growth of technology has significantly changed the way people perceive and communicate information and ideas. In visual art practice, the emergence of this innovative development greatly contributes to the creation of new sensory experiences, and has considerable impact on current forms of artistic technological collaboration.

In the essay "In Plato's Cave", Susan Sontag states: "A new sense of the notion of information has been constructed around the photographic image. The photograph is a thin slice of space as well as time" (1977, p. 22). This view suggests that a moment of an event can be preserved in time and reconstructed through the use of a medium, which in this case establishes photography as a primary technique for the capture of spatial and temporal information as a result of a creative process.

From a scientific point of view, a hologram contains more information than an ordinary photograph, because, while a still image merely retains light's amplitude (light projected on the recording surface), a holographic representation is based on capturing the whole information of a light wavefront, diffracted by a subject. Based on the basic process of image making, (the Italian educator and theorist writer) Pier Luigi Capucci (2011) suggests that the realm of image capture could be divided into two groups: "referential images", namely photography, video, film and analogue holography, and "non-referential images", which are painting, sculpture, animation, and Computer-Generated Images (CGI). The latter group can obtain images without the attendance of subject matter or scene, while the former is entirely reliant on the presence of the subject matter or scene during the image making-process.

A comparison of the outcomes of holography and photography establishes that resultant images feature distinctly dissimilar visual effects, which further reiterates the divergent artistic application of these image-recording techniques. However, there is one element, equally specific to both mediums, which has to be highlighted;

light information is encoded in the medium during a given exposure time, indicating that light and time for recording an image are interrelated and comparably significant for the event itself, as both of the aforementioned elements came from the original scene of the event. It means that light and time for taking an image, and light and time of an event are intertwined, which cannot separate from each other. In other words, to capture an image through the use of light-sensitive materials would require the employed medium to make its presence felt while the event happens.

Further to the above argument, holography and photography are more than merely techniques for documenting images of an event; they are actively engaged contributors to the capturing process, in a manner similar to the role of a holographer or a photographer. In this respect, the resultant images are not just a visual record of an event, a framed slice of time and space, but also evidence of being part of an event, 'being there'. As Roland Barthes suggests, "The photographer's "second sight" does not consist in "seeing" but in being there" (1993, p. 47). In an article entitled, "Simulation beyond perspective. The discourse of holography as a tool for imagery, art, media studies and science", Capucci (2011) refers to Barthes' concept "being there" in this context: he emphasises that the temporal quality has been involved since the beginning of the analogue hologram making process, and that it does not only exist in the end result.

It should be noted that the subject of a hologram can be created through the use of Computer-Generated Imagery (CGI), in which case it is commonly referred to as digital holography. However, it is the analogue form of recording that can be described not only as a contributor to the process of capturing an original scene, or a moment of an event, but also as a participant in them, since the analogue technique requires the artist's presence as the event happens, the same as photography. In other words, the holographer and the necessary holographic equipment cannot be separated from the event. This unique quality makes analogue holography an extraordinary art medium, which preserves spatial and temporal information in a more realistic and tangible form than photography, thus pushing the boundaries of the temporal aesthetics; moreover, it lays the foundations for a completely new sensory experience.

In a discussion of his relationship with art and with holography, Paul R. Newman expresses his obsession with holography:

> "There are many REASONS why holography attracts; the interplay of real and unreal, volume without density or substance, visual appearance without the reassurance of physicality, modelling in light alone, appearance/disappearance, viewer participation, interpenetration of space, the dislocation of image from medium/material, […]. These are the "many parts" but not the whole. The calculation but not the sum" (1994, p. 184).

Holographic artworks could be described as having physical dimensions, namely the measurements of height, width and depth, which are similar to traditional artworks. Meanwhile, this medium's unique characteristic qualities could also add a dimension of time to holographic aesthetic expression and unfold the temporal properties to the viewer over time. Kac (1995a) suggests that holography is time-based medium, as "time is manifested in holographic art not only as streams of images, but also as suspended clusters and discontinuous structures". The term 'time-based media' generally refers to technology-based artwork, where a distinct visual quality is revealed in relation to time, as they "have duration as a dimension" and "unfold to the viewer over time" (Tate, n.d. c and Guggenheim, n.d.). Such artworks usually use audio, slide, video, film, computer-based techniques, as well as other creative mediums for artistic expressions. In addition, time-based media is frequently presented in installation forms, which leads to the identification of exhibiting sizes being variable. To be more specific, every re-installation would need to be adapted to an individual exhibition environment (Tate, n.d. c and Guggenheim, n.d.).

According to the above list, it shows that most of the mediums in this category are lens and light-based image recording techniques, such as slide, video and film. They provide a means of making sequential images to create an impression of motion. This specific form of temporal expression or expressing time is valued as a distinct visual quality, which is shared between these mediums. In addition, as discussed previously, a physical attendance for the recording of an event is required with the use of light-

based mediums, photography and holography. The same creation process can also be applied to time-based media, those referred to as lens-based.

In other words, the image contents under this category are composed by means of the empirical scope of an event, which Capucci refers to as “referential images”. Moreover, compared to those lens and light-based mediums under the time-based category in contemporary art, the empirical scope is not indispensable in traditional art practice, because an artwork can be completed without the need to pay a physical visit to the scene or to place a subject in front of the artist. For example, painting a landscape can be fully completed in an indoor art studio, or a sculpture can be formed and shaped without a model. This suggests that the nature of the creation process in time-based media is fundamentally differentiated from other art mediums. Thus, the concept of the empirical scope or “referential images” suggests that image capturing can be signified as an act of witnessing and observing an event in the course of the recording process.

Based on the above discussion, it can be said that holography appears to fulfil the criteria of time-based media, and qualifies for listing in this category. However, it seems that holography has been excluded by the Tate and the Guggenheim, since two leading institutes in time-based media art have established their pioneering conservation departments. The Tate in London was the first museum to dedicate conservation staff to the care of its time-based media collection which was established in 1996 (Sherring, 2018). The Solomon R. Guggenheim Museum was also at the forefront of the developing field in the early twenty-first century (Guggenheim, n.d.). In comparison, the aforementioned mediums: slide, video and film, have led the trend of contemporary art over the past few decades whereas holography regrettably still seems far from the mainstream and remains less known by the general public, artists and critics.

In spite of the fact that the Hungarian scientist, Dennis Gabor, published his paper about the theory of holography in 1948, a sufficient laser light source was only developed in the Sixties, which has significantly advanced the development of

holographic technology (Coyle, 1990). Creation of holographic artwork deeply relies upon a professional laboratory; in particular, laser technology and a vibration free environment are essential for producing adequate images. In creative practice, artists have found that it is difficult to meet the level of scientific requirements, which has led to a considerable restriction for the development of holographic aesthetic culture, since the era in which holography was invented.

Due to this inaccessibility for artists, a substantial discussion of holography's creative potential was lacking during this period. It was not until 1968, (nearly two decades after Gabor's paper had been published), in the second issue of *Leonardo*, the Swedish physicist, Hans Wilhelmsson, proposed the possibility that holography could be used by artists. In the paper, "Holography: A New Scientific Technique of Possible Use to Artists", he enthused that, "The new technique offers three-dimensional images on a two-dimensional surface and may possibly lead to a revolution in the means of image presentation. […] I would like to stress from the beginning, however, that the new technique can be expected to be considerably more far-reaching and effective than photography. In fact, it adds one more dimension!" (p. 161).

The perception of holography as a three-dimensional (3D) image medium dominated early stages of the development of holographic art. However, later, the views of its creative potential shifted, as Frank Popper suggested in 1993, "in order to build an (*sic*) historically legitimate aesthetic of holography one has to detach oneself from dependence upon the photographic paradigm so important in understanding computer art. The persistence of this paradigm reveals itself especially in the overemphasised 'third' dimension of holography" (p. 37). Moreover, Kac (1995a) reflects his practical insight of the role of holography in contemporary art:

> "One of the most common misconceptions about holography is the notion that the medium's primary visual property is that of producing "illusionistic" three-dimensional pictures -- a kind of spatial photograph, with an added dimension. The "naturalistic" misconception is usually grounded on unfulfilled expectations and unproductive comparisons with other media, when not to poor or inexistent research.

> I will go as far as to suggest that those who think of holography in these simplistic terms are just unaware of some of its most significant features and directions".

Based on their understanding of the development of holographic art, there is one specific comment that has been pointed out in their writings. The France-based historian and aesthetician, Frank Popper, and the author and artist of Holopoetry series, Eduardo Kac, both clearly accent that the creative potential of holography will be limited, if the exploration of holographic aesthetics only focuses on its spatial properties or the 3D image presentation. Thus, it is important to recognise that Popper and Kac have common concerns, either from a theoretical or a practical point of view. They suggest that the further development of holographic art could weigh less on its 3D culture, and move forward to a dimension beyond these technical effects.

An art medium which is so often considered as an impeccable substitute of reality, its aesthetic value and creative potential could be under estimated. Taking photography as an example, this medium has a reputation for being realistic. It can be very dissimilar to the understanding of today's practice of photographic art, if photographers and artists reject any other imaginations of the creative possibility and only attempt the realistic effects. Wilhemsson's proposal in the late Sixties reflects the early expectation of the beginning of holographic art, which mirrors a similar evolutionary route that can be found in the emergence of photographic art. However, these two forms of art have developed in very different directions since then. It is intriguing to see more diversified creations, as both mediums depart from their object-oriented, and realistic aesthetic culture.

2. Summary

In art practice, an art medium can be categorised in many different ways. In terms of holography, it could be considered as part of new media art, as its technological quality could be seen in opposition to old visual arts, such as traditional painting, screen print and sculpture. Additionally, based on its materiality, holography could be defined as a medium of Light Art, since it is intrinsically involved with the use of

light. On the other hand, the immaterial and dynamic visual qualities of a holographic image feature a clear connection with Kinetic Art. This suggests that an artwork is basically constituted by the characteristic qualities of the employed medium, and the resultant artwork is viewed as the main reference when categorising it into a specific art form. This means that holography can be described as a medium of light, 3D imaging or time-based, which is primarily dependant on the visual appearance of each individual artwork. Thus, it could be said that the term "time-based media" in art holography is defined by the nature of the medium, which can create a visual impression of movement, and is not merely categorised by the technical factors.

This leads this research to focus on the exploration of the temporal aesthetics of holography, through a series of art practices to discover the creative potential within this medium. In particular, it aims to establish a new approach of depicting, interpreting, and representing time. Meanwhile, it is important to recognise that the intention of this research is to add a new expressive form for existing temporal narrative techniques. Although the aesthetic purposes may vary between individual projects, the convergence and combination of the holographic technical and aesthetic characteristics will be utilised by the author for creating experimental artworks in responding to the research goal. In addition, the materiality of individual time-based media is considerably different; each formed artwork features distinct aesthetics, which cannot be easily reproduced from other mediums. The diversified uniqueness is the basis to advance the aesthetic culture of time-based media.

Identifying the focus of this study is not intended to promote holography as a powerful technology feeding-in the use of visual art forms; its aim is far from marketing in the sense of how a photographic company would use image creation commercially to advertise their photographic products, for example. In his book, *Information Arts: Intersections of Art, Science, and Technology*, Stephen Wilson (2002) addresses his view that the role of the artist "is not only to interpret and to spread scientific knowledge, but to be an active partner in determining the direction of research".

In a similar manner, this research intends to propose a new approach to adding a dimension of time to the holographic visual expression, in order to bring attention to the temporal properties in holographic images. The core of establishing this new approach is not only to emphasise holography as a time-based medium, but also to expand and diversify the creative potential of this category. The thematic direction of the study highlights the significance of holography as an art medium and also reflects on time as a subject from an unconventional angle, by emphasising that "viewing" time could lead to more explicit temporal experience, moreover, a formation of a completely new means of creative communication. As Marvin Minsky (1999) points out, artistic representation could play an instrumental role in influencing new ways of understanding:

> "no matter what one's purpose, perhaps the most powerful methods of human thought are those that help us find new kinds of representations. Why is this so important? Because each new representation suggests a new way of understanding; and if you understand something only one way, then you scarcely understand it at all. Perhaps this is why the arts so often precede the flowerings of culture. For what, indeed, is Art itself but the Science of discovering new ways to represent things?" (p. 230).

3. Thesis Structure

The practice-based elements of this research are conducted from a centre of core concepts and key investigational aims. The practical projects within this research have developed organically, in parallel as well as sequentially, with some overlapping. This thesis has been structured to lead the reader through the most logical path of development.

In Chapter 1, the author provides an extensive discussion of holography as an art medium, in order to gain an in-depth insight of its individuality and creative potential. In the discussion of a visual representation of time and space, the author investigates the underlying similarities and differences in the materiality between photography and holography, producing a foundation for a further exploration of holographic aesthetics. Moreover, the author addresses that the discussion of time-based media

art would incomplete if not to take holography into the consideration. In particular, the optical properties of holography would enable this medium to develop its own visual culture, which could be seen as a bold artistic identity from other time-based media, as well as a key feature to diversify the temporal expression.

Chapter 2 discusses the interrelationship between an art medium and its aesthetic culture. The author addresses that an artistic expression could be modified as a society evolved. For instance, the movement of a social structure, or the progression of science and technology, those factors could greatly influence themes and techniques artists employ in their work. In addition, by studying the various descriptions of time-based media, it leads the author to recognise that the medium assigned to this category is primarily based on its visual effect, which is the phenomenology of the moving image. This means that a medium can produce the aforementioned outcome which could be defined as time-based. In other words, the expression of the fourth dimension could not be limited by the use of sequential images, currently the main approach used by Tate and Guggenheim defined time-based media. Moreover, to understand how the temporal expression can be practically created by holography, the author refers to several artworks, indicating different interpretations and creative approaches.

In Chapter 3, the author identifies that this study is practice-based. As the artwork creation is the basis to identify if other practitioners could adopt a possible approach to successfully completing pieces of artwork, despite the technical demands of working with this medium. Thus, the practicality of exploring the new approach is the main concern of this study, which leads the author to employ Denisyuk single-beam hologram as the main method to develop a series of experimental art projects. In particular, the characteristic qualities of a medium and the process of making artwork would significantly affect the resultant artwork. The Denisyuk scheme requires a relatively achievable operational process, allowing practitioners o access and familiar with this technology. Moreover, the artworks created through the progression are seen as the outcomes of different phases of the study; it would

engage observation and reflection to be used to inform or extend the author's understanding of this medium and its practice.

To gain more practical experience in art holography, the author starts with making the single-beam reflection hologram to develop her skills. Chapter 4 presents the early stages of her art practice. Considering 3D printing could provide numerous creative possibilities and rapidly fabricate a concept into a solid form, the author decides to employ this technology to create her own subject matter instead of using the conventional ready-made objects. The 3D printed objects are purposely designed in a thin and flat form, in order to study the 3D image representation of holography and its interaction with light. The resultant artworks show that colours and shadows presented within the hologram would change as the viewing or lighting angle shift. In other words, the multitude of viewpoints or the movement of the illumination could lead an audience to view a holographic image unfold over time, which is considered as the important manifestation of time-based art.

Chapter 5 continually looks at the creative potential of the temporal expression of holography; especially, the connection between the three-dimensional representation and multiple viewpoints. In terms of traditional linear perspective, a single viewpoint corresponds a point in time. However, the nature of viewing an object-oriented hologram could provide an experience which is similar to perceive an object in real space. The audience could walk along the hologram, forward or backward, the movement of viewing position relates to different points in time. To gain an in-depth understanding of this interrelationship, the author employs the principles of mirror anamorphosis to create a distorted skull hologram, which can only view this object's undistorted image from the reflection in a cylindrical mirror. This work uses the anamorphic object to stress that its different sides of appearances are created by the different viewpoints; the change of the appearance means the shift of the viewing position, which interrelates with time.

In Chapter 6, the author shifts the focus to another creative potential of temporal expression, the movement of illumination. To investigate the connection between the

image replaying process and the presentation of a holographic image, the project of Holographic Script uses Chinese calligraphy as a basis to create a hologram and encourages the audience to view the image by holding a torch. The intention of moving the light source is primarily to reflect the nature of handwriting, which is relatively less static than a printed text. Meanwhile, the suggested lighting technique could reinforce the poetic linearity of this work, and its created kinetic effect could be interpreted as a manifestation of rhyme and rhythm. Additionally, the image is designed to be viewed as the light hits the right side of the plate, which is the same direction as reading classical Chinese poetry. This project identifies that the role of light is key to activate the text-based holographic artwork, and also a guide to reveal the traditional Chinese writing layout. The graphic and poetic meanings of Holographic Script are unfolded by the manipulation of light to the audience over time.

To extend the discussion of the poetic linearity and holographic temporal expressions, Chapter 7 further investigates the creative potential of this combination. The author suggests that the layout of the traditional Chinese bamboo slips could emphasise the linear temporal aesthetics of classical poetry; moreover, the scroll of bamboo slips is commonly read section be section, unrolled to the viewer over time. Thus, as Li-Bai's work could be activated by the use of holography and the manipulation of image replaying process, the concept of transforming a piece of hologram into the slips would elevate its poetic linearity. The composition of Chinese characters in "Thought in the silent night" could be seen as a composition of a music notation, the act of viewing the holographic slips is similar to read a poem as well as to play a music, which is also time-based.

Chapter 8 reflects the process of the study and artworks created through the inquiry, as both are equally important to lead the author to further the exploration of the holography's creative potential. This chapter also provides an overview to explain the connection between artworks, which indicates the nature of the practice-based study, as the development of artistic project is commonly informed by its previous progression. In terms of the investigation of the new approach, the author proposes a

broader view to look at holography as an art medium, which not only considers its functionality as an imaging technology, but also its materiality, a solid medium coveys an image; as both are interrelated. In the conclusion, this study suggests that employing a hologram as an imaging medium and a glass subtract could establish a new approach to add a dimension of time to holographic aesthetic expression.

Chapter 2 Holographic Aesthetics

1. Visual Representation

From an artistic point of view, there is an intrinsic link between the mediums, methods of presenting works, and aesthetic intentions. Each medium, especially the technology-based, has a different scientific or technological nature, which could have a direct impact on the formation of the quality or texture of an image it produces. An artist views the selected medium as a kind of extension to connect with audiences, and a conceptual aesthetic message can be translated into a visual form through the use of the medium. Moreover, the decision-making involved in the choice of mediums and the means of presenting the final works are interrelated. Through a certain arrangement of employed mediums, the scientific and technical factors within them can be converged and combined, thus generating the impact of artwork creation, as Tate (n.d. c) states, "Artists make very specific decisions in their choice of media and the way in which their work is presented. [...] Specific technology places a work at a particular point in history and may convey ideas about the spirit in which the work was made".

Although aesthetic messages or purposes within individual artworks could vary, a common ground for technological art creation is primarily constituted by an artist who would manipulate those features that are "unique in the nature" of the chosen medium (Greenberg, 1973, p. 68). In holographic creative practice, an artwork is embraced by the optical characteristic qualities of the medium. A hologram is comprised of a holographic image within a plate or a film, representing and imitating the characteristics of the specific materials; the creation process would also include the particular techniques which are used to control these materials.

The optical properties within the medium and the related visible spectral colours could be seen as scientific and technological factors; at the same time, both could also be viewed as a form of expression used for an artistic activity. To be more specific, the principle of colour representation in holography is fundamentally different from the properties of the natural pigments used for traditional colouring or

painting practice. In this context, it would be justified to consider holographic art practice as a new expressive genre, as it bears unique optical qualities.

In this study, the artistic creation is deeply dependant on the application of holographic technology. Thus, it is important to understand the optical properties and principles behind this medium, in order to succeed in the development of holographic artwork. However, the discussion in this section is not aiming to provide a full explanation of the technological principles and processes of recording and reconstructing a hologram. A number of highly respected sources have provided detailed information, for example, *Holography Handbook* by Fred Unterseher, Jeannene Hansen and Bob Schlesinger; *Practical Holography* by Graham Saxby.

A more in-depth investigation of the aesthetic side of holography should start with Gisèle Freund's standpoint (1980) who postulated that every period of time in history finds its own artistic expression reflecting social or political atmosphere, intellectual interests, tastes of the era. According to her reflection on the development of specific forms of artistic expression, art cannot be detached from the social structure of the time, and its every change would be in response to a relevant movement in society, which would influence the theme and techniques artists adopt in their creative process. "It is the product of well-defined conditions that characterise the social structure at each stage of its evolution. [...] A change in social structure influences not only the subject matter but also the techniques artists use in their work" (Freund, 1980, p. 3).

In art practice, for instance, the techniques of interpreting the phenomenon of light have been developed in a variety of painting applications. For example, in the seventeenth century, Dutch artist Rembrandt Harmenszoon van Rijn is known for his use of chiaroscuro (light-dark), a theatrical tonal contrast technique in interpreting light and shadow, in order to suggest the volume and modelling of the subjects depicted (The National Gallery, n.d.). A later development, impressionists established a new method to capture the impact of light which were influenced by a scientific colour theory introduced by a French chemist Michel-Eugène Chevreul in

1839. Afterward, the applications of complementary colours gradually became an essential part in the nineteenth century art, (especially in the development of impressionism, post-impressionism and fauvism) (Roque, 2011). Furthermore, the most fascinating part of engaging technology into art practice is that impressionists used Chevreul's law of contrast of colour to achieve Newton's research of the colour wheel: to depict the changing effects of light through a material substance. While the principles between two theories are intrinsically different: mixing all colours of light results in white, and blending all colours of paint results black (Tate, 2014).

In the development of computer graphics, there is a great range of image editing software available, functioning to imitate the distinct characteristics of traditional art mediums such as oil paintings, watercolours, pastel drawings or pencil sketches into digital artworks. On the other hand, inspired by this tendency, artists also experiment with new ideas in reproducing the unique features of digital imagery through a use of those traditional fine art materials, for instance, recreating a pixel painting in watercolours. Paradoxically, this phenomenon indicates that the relationship between new and old mediums in art practice could be seen as a two-way influence. One can be an inspiration for the other; meanwhile, each individual does not intend to be used as a substitute for the other.

In creative practice, Margaret Benyon's career as an artist could be an example to reflect the thinking path of the development of holographic visual expression and the impact from the two-way influence. As is stated in her 1973 paper, "Holography as an art medium", during 1963-1964, she was using the graphic interference pattern on which holography is based, "in order to question the abstract expressionists' assumption that the criterion of excellence in a painting was that it should be treated as a flat surface" (p. 4). She further explained that her purpose of employing such a pictorial element was that it provided "'a means of altering the picture plane spatially without reverting to Renaissance space, perspective and traditional illusionism" (p. 4).

After Benyon's entry into holography in 1968, she developed a series of holographic experimental artworks responding to her curiosity in questioning and re-figuring a number of contemporary assumptions about the nature of visual art such as, reconstructing three-dimensions within two-dimensional surface (Coyle, 1991). From Benyon's point of view, holography as an art medium "is close enough to the traditional forms of painting and sculpture", she creates a series of holographic still lives to provide a viewer "with images of familiar objects, in order to present the 3D properties of holograms in a commonly known art genre, without the encumbrance of new ideas", which means to familiarise the viewer with less "abstruse subject matter" (1973, p. 4) (Image 1). Her another artwork *Picasso* (1969) is made of a 3D model of a landmark painting in Cubism, *Les Demoiselles d'Avignon*, which is used as a comment on "the way holography automatically achieves the aim of Cubism to show three dimensions on a two-dimensional surface" (1973, p. 4) (Image 2). As Rebecca Coyle (1991) comments, "Cubism provided an important starting point in this area and she responded to Cubist attempts to render three-dimensional materiality without recourse to traditional painting techniques of perspectival or colouristic logic" (p. 70).

Image 1 Margaret Benyon *Still Life* (detail), 1969, Laser transmission hologram, 20 x 25cm

Image 2 Margaret Benyon *Picasso*, 1969, Laser transmission hologram, 20 x 25cm

2. A Medium and its Manifestations

In the nineteenth century, Cubists developed a revolutionary approach to represent visual reality in painting, instead of following the conventions of perspective, such as modelling, foreshortening, or inheriting the concept that art should imitate nature (Rewald, 2004). By fracturing and simplifying objects or figures down into its geometric forms and bringing these together into the same canvas plane, the resultant painting exhibit the fragmented components that denote a multitude of perspective all at once. Compared to the linear perspective creating an illusion of space on a flat surface from a single vanishing viewpoint, Cubists provide a new approach to suggest a new reality on a picture plane through the use of multiple viewpoints (Tate, n.d. a; Moma, n.d.). Although, the depiction of three dimensions seems the central element for both systems, this makes it even more important to clarify that the goals and principles behind both systems are fundamentally different. Since the former creates an illusionary depth to represent space and reality, the viewpoint within this condition is single and fixed; the latter combines geometric planes with compressed space to present a new reality that consists of different viewpoints or angles (Rewald, 2004).

If one considers that a single viewpoint represents an equivalent to a point of time, bringing multiple viewpoints together into the same space seems to propose that the concept of reality for Cubism is more temporal rather than spatial, implying that this representational system has time as a dimension. The previously mentioned Benyon's works demonstrate the possibility of applying this view in art holography practice. Her experimental series directly and perceptually delivers the sensation of multiple viewpoints, which indicates that the experience of viewing a holographic image is formed in a very similar way as viewing a 3D object in reality. Both consist of multiple viewpoints or angles, suggesting the inclusion of time as a dimension. "Holography is a more direct medium than painting, "to experience a hologram one needs no special art education. This illusion is self-evident" (Benyon, 1973, p. 4).

As mentioned in the first chapter, the art term of time-based media denotes a work that has physical, spatial and temporal dimensions, and based on Tate and Guggenheim's descriptions, the majority of this category is moving-image based, using a sequence of still images or single frames to display in rapid succession in order to create an illusion of movement. Unique to experience and appreciation this form of art is to "watch it unfold over time according to the temporal logic of the medium as it is played back" (Tate, n.d. c). Besides, in the discussion of the digital moving image as distinct from other forms of cinema, Gene Youngblood (1989) describes cinema as "the phenomenology of the moving image" rather than conceiving it as a particular medium or technology. He emphasises:

> "For us it is important to separate cinema from its medium, just as we separate music from particular instruments. Cinema is the art of organizing a stream of audiovisual events in time. It is an event-stream, like music. There are at least four media through which we can practice cinema --- film, video, holography and structured digital code --- just as there are many instruments through which we can practice music. Of course each medium has distinct properties and contributes differently to the theory of cinema, each expands our knowledge of what cinema can be and do" (p. 27).

Youngblood's opinion on holography as a time-based medium is based on its holographic temporal manifestation, rather than the scientific materiality. His comment is similar to Tate and Guggenheim's decision of defining the term time-based media, which is based on the conceptual and perceptual experiences that are delivered. This suggests that the presentation of a holographic image is the critical element to define holography as a time-based medium, since the nature of holographic properties is the basis to constitute its unique spatial and temporal expressions. In other words, employing holography to explore the creative potential of time-based media could possibly expand the current understanding and visual syntax of Youngblood's "cinema".

Based on the discussion above, moving image seems a significant feature of time-based media, which leads this study to take a further investigation of this visual

expression though the use of holography, in order to create a new approach to adding a temporal element or dimension to artwork. In art holography practice, the illusion of movement not only can be generated by the use of sequential images; either a physical movement of an audience, a light source or artwork could also create a similar experience. Additionally, it is important to recognise that the aesthetics of moving images created by holography could be more complex than the traditional successive still images, for instance, a work of video or film is normally edited in a clear linear timeline with suggested opening and ending; the temporal narrative of a hologram could be generated by the audience' engagement. While the viewpoint or lighting moves, the appearance of the image or colour could be changed, relative to one another.

Thus, the relationship between audiences and holographic artworks suggests that the way of viewing could significantly affect the information received; in particular, the former would appear relatively more active when viewing a hologram than viewing a works of traditional time-based media. The audiences walking along the hologram, the viewing angle, even the pace of movement are interrelated in forming their understanding about this work; in other words, the holographic flow can be paused when the audiences stand still and remain at the same viewing angle. This unique aesthetic feature allows the audiences to define or create their own narrative progression, where to start, where to end, which can also be summarised as a result of interactivity between the audiences and holographic artworks. In his book, *Holopoetry: Essays, Manifestos, Critical and Theoretical Writing*, Kac (1995b) states, "Holograms become interactive events that can be perceived in any direction, forward or backward, fast or slow, depending on the relative position and speed of the viewer" (p. 83).

Lloyd Cross's well-known image in the 1970s, *The Kiss II* featuring his assistant Pam Brazier, was created by a conventional film sequence (Image 3). This integral hologram or multiplex hologram allows the audience to liberally view this work from many perspectives. The time and the pace of movement which occurs during the process of appreciating are dependant on the audience's interaction with the artwork.

This suggests that the expression of movement is not determined by Cross's original chronological composition.

Image 3 Lloyd Cross *The Kiss II*, c1976, Multiplex hologram on film, 12 x 23 cm

In addition, as the audience looks at this hologram, the sitter waves a hand; the audience may see her arm to appear distorted, as the edge of the image is overlapped by an image taken earlier or later than the one in the middle. This effect is usually described as "time smear" (Saxby, 2004, p. 285; Richardson and Wiltshire, 2017, p. 298). Although the image distortion seems an issue for scientists, from an artistic perspective, this effect could be seen as an expression to add the dimension of time to a holographic artwork, as it is result of all activities that may have been made during the recording.

To extend this discussion, if the abstract form caused by time smear could represent the progression of movement, it may also be used to interpret the motion of time. In other words, if the activity of light could be captured, the image of its act of transformation would be another effective visual expression to depict the motion of time. Light-in-flight (LIF) introduced by Abramson in 1978 is a technique that could capture light in its flight through the use of holography. As the propagation of light is normally observed statically, this high-speed recording could obtain a motion picture of light phenomena such as reflection, diffraction and focusing and allows a viewer to observe the behaviour of light dynamically through different media (Gariepy et al, 2015). To return to the earlier discussion, in artistic application, as light is a moving

object, the light in flight imaging could capture its activity which could also be used to interpret the motion of time; in other words, this visible expression is temporal. Although this technique is still mainly used for scientific experiments, it would advance time-based media art, as this medium become more accessible for artists.

As the sequential images are recognised as the most commonly accepted technique in the creation of moving image, holographers also embrace this cinematic form of expression to create motion-based holograms. For instance, Patrick Boyd's 2017 solo exhibition "Man with a Holo Camera" in London reflected his exploration of the temporal aspect in holography (Image 4). This UK-based artist employs the camera as an instrument to investigate his everyday life and uses photographic footage in a tracking motion to create a series of holograms and holographic stereograms; he describes the latter as "small movies with no cast, set or script". Moreover, when an audience views his work, one eye could see one image while the other eye could see another, which creates an illusory depth, as states on the exhibition website "The moments of time are then preserved with depth and time in a ghost like memory".

Image 4 Patrick Boyd *Morris Dancer #2*, 2016, Reflection hologram, 22 x 18 cm

In addition, with the use of computer graphics, the attention to the element of time in holographic images develops into more diverse directions than holograms created without these supports, for example, Jacques Desbiens' works of synthetic holography. Moreover, to consider the process of viewing a holographic artwork is determined by an audience's interaction, it suggests that the involvement of audience participation could be a key factor to activate the temporal expression within holograms.

Randazzo's work of 1991, *Remnant*, he comprises more than ninety different pictures with a combination of photographic prints and stereograms created from old home movies (Image 5). Most of his holograms are suggested to view from both sides, allowing audiences free to walk around the hologram. In his paper, "Beyond the spatial paradigm: time and cinematic form in holographic art", Kac (1995a) comments on Randazzo's work, "the space is outlined by motion and the relative position of images, but not by stability of forms".

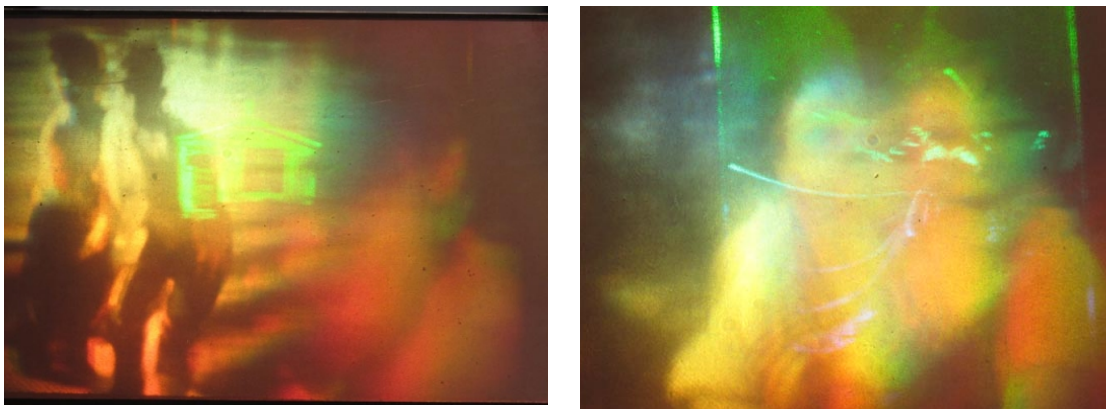

Image 5 Dean Randazzo *Remnant*, 1991, White light transmission hologram, 18.42 x 13.97 cm (left and right images represent each side of the hologram)

In addition, *Jumping Jellyfish* (2009) created by Martina Mrongovius reveals the role of an audience in animating holographic images. This installation consists of five jellyfish holograms hung around a trampoline, and the audience needs to jump on a trampoline and to reach certain height, in order to see the movement of jellyfish (Image 6 and Image 7).

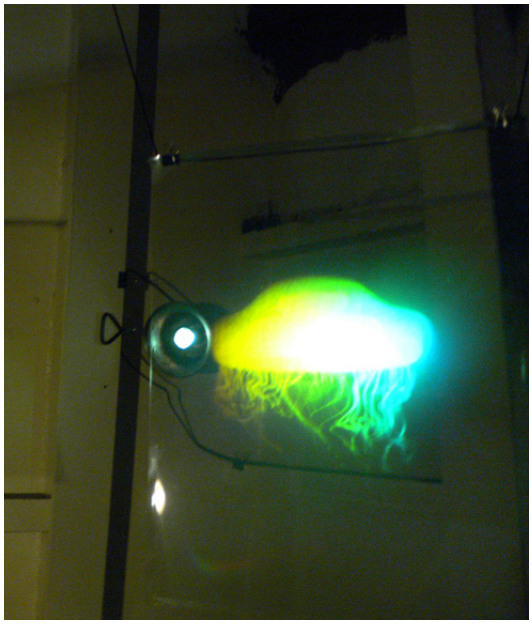

Image 6 Martina Mrongovius *Jumping Jellyfish*, 2009, Holographic image installation (left)
Image 7 An audience interacts with the hologram (right)

Her installation clearly breaks the cinematic convention of horizontal imagery replay; the appearance of vertical animated jellyfish is intrinsically interrelated with the movement from the audience (Image 8). It indicates that the audience and the hologram cannot be separated from this event. As Mrongovius (2011) states, "the jumping movement is an integral part of 'playing' the holographic animation" (p. 90).

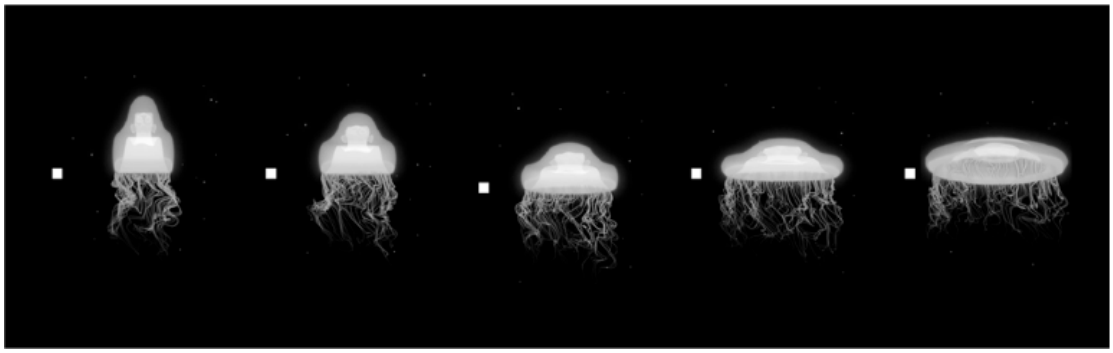

Image 8 Five frames of the digital image sequence used to make the master hologram of *Jumping Jellyfish* (Mrongovius, 2011, p. 90)

However, no matter to adopt electronic and digital synthesis images, or resourcing from other mediums, such as video and film, the majority of holograms carry the

cinematic features which are constituted by sequential images (at least more than one image), in order to create the illusion of movement. It leads the author to wonder, if any other approach can deliver a motion sensation without the use of the sequential images and still produce a similar visual outcome.

3. Summary

Based on discussed above, holography shows a great creative potential to provide a novel approach of delivering temporal aesthetic experience to the audience. As previously mentioned, an artistic expression can be a reflection of a period of time in history, its form and syntax are constituted by deeply blending with social and cultural elements. The art creations of linear perspective and Cubism clearly state very different views about the concept of reality. The former develops as a perspectival system for imitating the real space; the latter progresses as a style to depict the reality conceptually.

Those diverse manifestations indicate a subject explored through visual language that can be expressed from multiple aspects, even only when employing a single channel medium, such as painting. Therefore, by dealing with the themes of time and space, for instance, it is importance for holographic art to create its own interpretations on its own terms.

In the following chapters, the author will investigate further the two distinct properties of holography, spatial and temporal, in order to gain an in-depth insight that a new approach could possibly be expressed. Art projects will be introduced through her discussion, which would also reflect her view on the interpretation of the forth dimension, time.

Chapter 3 Methodology

1. Introduction

This study is aimed at establishing a new approach to adding a temporal dimension to artwork through the use of holography. The core of this study is to further the exploration of creative potential in holography, and the key methods adopted are closely associated with the creation of holographic artwork. This study could be described as practice-based, as the research process is mainly based around artwork creation. Its methodological approaches include a synergy of the process of making and the final artistic product, thus establishing creative practice as an integral part of the study.

In addition, this specific research aim can be approached more precisely and effectively through a direct visual explanation. The key findings and results of this study will be presented through artworks and further supported by literary discussion. The works created for this study, (which will be introduced in latter chapters), can be described as evidential products. In terms of practice-based research, "claims of originality and contribution to knowledge may be demonstrated through creative outcomes […]. Whilst the significance and context of the claims are described in words, a full understanding can only be obtained with direct reference to those outcomes" (Candy, 2006, p. 1)

2. Creative Practice in Holographic Art Research

In spite of the different study focuses, the author's experiences in learning fine art, design and holography, all emphasise the importance of repeating processes regularly as it is considered the way to become proficient in a skill. As more emerging technologies become art mediums, it seems a growing trend for contemporary art practitioners to engage multiple formats of techniques and processes in relation to employed mediums, in order to expand their creative horizon. In this case, practitioners may find it difficult to master all the skills required by individual mediums for their mixed-media art projects, which makes it even more important to recognise the interrelationship between the creative process and its

artwork outcomes. In this form of practice, technical working procedures are developed in close relation to the specific features of employed materials. To process each workflow could involve multiple iterations, especially as the progress of creation moves towards testing and refinement. Parallel to this stage, practitioners' knowledge and experience in creative practice could be augmented through frequent experimentations, which is key to further accelerate their existing practice.

In terms of holographic art practice, it requires a unity of practical experience and related background knowledge to formulate a feasible working process. The created holographic artwork can be seen as a result as well as a reflection of the effectiveness of the adopted working process, which means that the act of making and the outcomes of making are equally important. Furthermore, to advance creative practice, it is essential to integrate the act of self-observation and critical reflection into the creative workflow. This would lead to establishing a foundation for new knowledge transpiring from practice itself. In a similar sense, creative practice within practice-based research defines the produced artwork as an underlying support for exploring holographic aesthetics through its making. To facilitate the creation of novel art forms for depicting time, this study is primarily engaged with observation and reflection into the process of experimentation. This why the focus is not solely on creating something new, it is also the method of making that could materially affect the way of transforming ideas or experimental attempts into holograms or installations.

As mentioned previously, creative practice involves multiple iterations, occurring during the process of transforming creative intent into artwork, whatever form it takes. In particular, this study has progressed as a process of experimentation, where the core of its practice-based research form depends equally on the holographic artwork itself, and the combination of processes and techniques employed. Once the author creates a piece of artwork and scrutinise it, a new understanding could be formed, which is then fed back into further subsequent experiments. Therefore, this development of artwork creation could be described as a cyclical or spiral form rather than a linear process because of its repetitive nature.

This route of art activity seems very similar to what Schön (1992) refers to in his 'reflection in action' concept. In the paper "Designing as reflective conversation with the materials of a design situation", he describes the design process as "seeing –> drawing –> seeing" (p. 5). Although Schön's theories are more weighted towards design, Candy (2011) has recognised their value and interpreted them as a methodological foundation into the concept of practice-based research. According to her description concerning multiple iterations, creativity could be summarised as "creating –> reflecting –> creating again" (p. 46). Despite being formed by different disciplines, both paradigms closely involve the cyclic process of learning from actions, which is a key for the progression of this study.

3. Holography in Art Practice

3.1 A medium and its Artistic Application

As discussed earlier, the exploration of contemporary time-based media art would be more diversified through the inclusion of holography. It indicates the importance of understanding this medium's creative potential, especially in relation to the expression of temporal aesthetics. For progressing this study, the choice of holographic recording method is instrumental, particularly as it would directly affect feasibility when the final outcome is expected to be ready for recreation in a laboratory environment by other practitioners.

There are several distinct types of display holograms available for art practice, defined by the design of optical geometry and the recording materials. Denisyuk's single-beam scheme has been recognised as "the simplest" mode for hologram recording (Saxby, 2004, p. 49; Holography.ru, n.d.). Its relatively simple technical procedure is easy to follow, and allows inexperienced practitioners, who have never been formally trained in holography, to be able to access this medium with less problems and confusion, caused by the technical complexity of other methods. While the level of complexity in making holograms is generally determined by the adopted recording technique, the nature of holographic art creation is mainly driven by the combination of science and creative practice.

In the framework of this practice-based art study, the consistency of holographic image quality is an integral part of the discussion of aesthetic possibility. As mentioned previously, the simplicity within Denisyuk's system can be considered as a practical choice to secure the consistency of quality in the presentation of holograms. For these reasons, Denisyuk's design appears to be an ideal option for the progression of this study, which will be employed for the development of the series of experimental works, in order to allow a closer insight into the aesthetic value and the recreation potential of holography as a medium for art.

3.2 Denisyuk Hologram

A hologram is structured by the interference pattern generated by reflected light from an object (the object beam), which encounters a beam that purely emanates from the laser (the reference beam) (Unterseher et al., 1987). A relatively simple type of reflection hologram is produced with the use of the Denisyuk single-beam method. In optical geometry, the photosensitive emulsion (holographic plate) is placed between the laser and the object, and the reflection and object beams are incident on the emulsion from opposite directions. This results in the interference pattern storing the light behaviour (travelling and interacting), or otherwise known as wavefront reconstruction (Saxby, 2004).

Recording - in the recording process, a laser beam strikes on one side of the holographic plate, behaving as a reference beam. The light passes through the plate and illuminates the object and is then reflected back by the object, thus creating an object beam, which illuminates the opposite side of the plate (Image 9).

Display - after exposure, a processed hologram can be displayed with the use of a spotlight. The illumination source needs to be positioned at the same angle at which the plate was recorded, so that the same optical path can be recreated. The holographic image can be viewed when the reconstructed object beam is reflected from the hologram (Image 9).

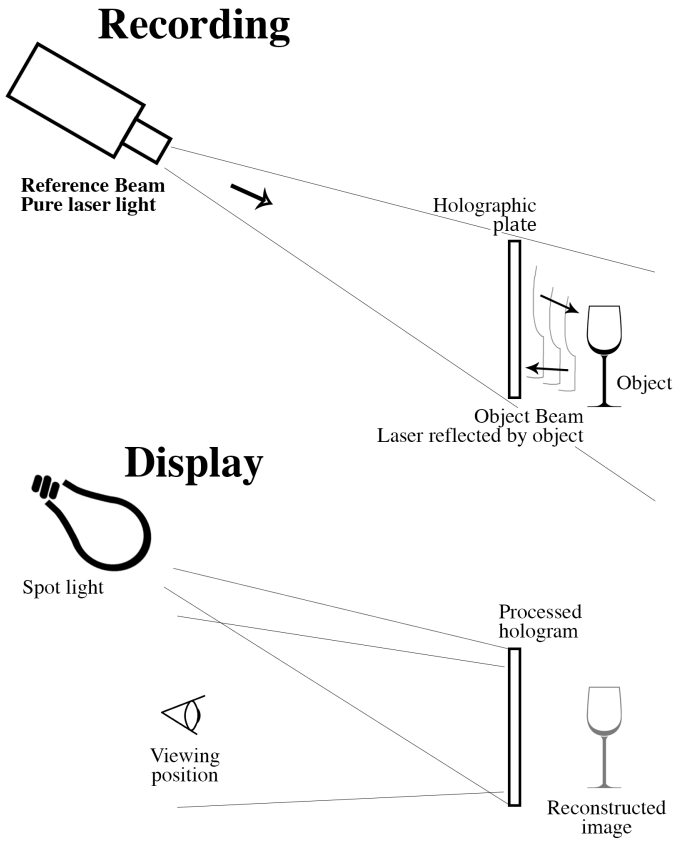

Image 9 Denisyuk single-beam reflection hologram (side view)

4. Reflection and Evaluation

It is important to recognise that the artworks created for this study are meant to meet the specific aforementioned research aims, which could also be seen as a form of outcomes. These holographic pieces should be viewed as role specific to the context of this study and should not be compared or confused with artworks created to satisfy other functions or artistic concerns.

Considering the author was not formally trained as a holographer prior to starting her PhD study, a cross-disciplinary cooperation was necessary for the progression of her research. Receiving practical support and guidance from peers with extensive expertise in relevant areas, enabled the author to bring her conceived concepts into existence. In this study, most pieces of artwork are created with the use of more than

one medium. The complexity of combing multiple techniques in a making process will require cooperative support in order to integrate the different material properties. With the support of peers from different disciplines, the author will be able to ensure that the suggested approach is feasible, which could be applied by other practitioners for their artwork creation; additionally, this study would benefit from evaluating the practicality of the experimental approaches.

The main focus of this study is to investigate the temporal aesthetics of holography in order to create a new approach to time-based media art practice. The artworks created for this study would provide an explicit visual context for the suggested expressive form, which will be discussed in later chapters. In addition, this study is significantly dependent on the process of artistic creation and its created works. This suggests that the role of the resultant holographic artworks can be defined in several ways, based on a given situation, such as a result of an art experiment, a finding of this study or an evidential document of the investigation. The multiple definitions or roles of the artworks created for this study emphasise that the core of this study is practice-based.

Based on the discussion above, this study can be clearly understood by experiencing the artworks directly and referring to the written description as a secondary supporting context, because of its practice-based nature. In other words, evaluating those experimental approaches could be assessed by observation, since the results are primarily revealed through the artworks as a visual narrative, which is purposely developed for responding the conceptual and practical questions of this study. Moreover, in the context of this practice-based holographic art study, it is important to recognise that the resultant work with its aforementioned multiple roles could be seen as a summary of factual information from the process of inquiry, which can be described as “what you see is what you get”. This would reinforce the validity of the suggested new approach and establish it as visually self-evident.

5. Summary

This study views the creative process and the resulting artwork as the act of making and the product of making, where both are equally essential to practice related research in contemporary art. Within this context, reflecting objectively on the above two elements is fundamental for the further development and enhancement of the quality of this research practice. Through a critical evaluation, the author could review the previous progressions and reconsider how this process could be possibly worked differently, and how the end result could be approached more effectively or precisely.

Over the course of this study, a number of projects have been planned and carried out. Each experimental approach to a particular project will be reviewed in depth and justified through the creation of artworks, which will provide more substantial grounds for proving the feasibility of new expressive forms. Even though these projects are not to be perceived as an artistic sequence, the insights, experience and knowledge gained from every project is used as a basis for the next one. This cyclic paradigm is not solely intended to serve as a ground for stability in the repeat procedure, but rather to find a different approach to the adaptation of the various situations, which can be described as a spiral form.

The information and experience gained from this practice could be used to add to the author's current knowledge, as well as elevate the level of understanding of holography as an art medium, its creative potential and optical aesthetics. In Kolb's words, "learning is the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping experience and transforming it" (2014, p. 67). Along similar lines, Ostermand and Kottkamp (1993) characterise experience as "the basis for learning", while "learning cannot take place without reflection" (p. 3). They further detail that reflection is the essential part of the learning process, which intrinsically involves action.

6. An Overview of Artwork Development

The following chapters intend to propose a new approach to depicting time through the use of holographic art practice, in order to expand and diversify the aesthetic culture of time-based media. The new suggested approach is primarily based on the application of the characteristic qualities of holography, meaning that it would be difficult to recreate the same visual effect without the use of the same medium. The artworks created through this study demonstrate the uniqueness of this imaging technology and its irreplaceable position in time-based media. In other words, it reveals that the discussion of time-based media art would not be comprehensive if not taking holography into consideration.

In the foundation artwork, the author uses 3D printed walking figures to study the three-dimensional image representation of holography and the interrelationship between light, shadow and the object recorded within a hologram, in order to gain an understanding of the temporal properties of holographic images. Based on the findings of this project, two extended projects, Anamorphic Time and Holographic Script, are created for the further investigation of both aspects of the creative potential. The final formulated approach will be demonstrated through the project of Holographic Slips.

As the experience of viewing the 3D printed walking figures hologram is similar to viewing this object in real space, it indicates that this piece of artwork can be seen from many perspectives, suggesting that the multitude of viewpoints could correspond to multiple points in time, meaning that an object-orientated holographic image could also carry temporal properties. To further investigate the temporal properties of a 3D image, the author creates an anamorphic skull and juxtaposes it with a plane mirror and a cylindrical mirror, in order to emphasise the different appearances in relation to the different perspectives. Moreover, the shifting viewpoints denote the moving of time.

To return to the discussion of walking figures holograms, the author identifies that moving a light source could create a sense of movement, which is considered as a different approach to creating an impression of motion, instead of sequential images. This leads the author to create the project of Holographic Script, in order to gain a further understanding of the interaction between a light source and a holographic image. In this series of artworks, Chinese calligraphy is written on a piece of glass and recorded into a hologram; the image of handwriting and its corresponded shadow would move as the lighting angle changes. Moreover, the application of a portable lighting device may add an opportunity, which could stress the rhyme and rhythm that inhabit in classical Chinese poetry.

In terms of artistic expression, the artworks discussed above lead the author to shift her focus into the text-orientated hologram creation, as the nature of written language could benefit more from the movement of the lighting than the earlier mentioned 3D printed object holograms. The impression of motion created by the manipulation of the display lighting could be seen as an abstract form to assert the temporal qualities in holographic images. Moreover, the author explores the possibility of integrating the form of Chinese bamboo slips into the presentation of a hologram, in order to gain an insight if this early medium of writing could benefit the holographic artwork to articulate its text-orientated temporal expression.

Chapter 4 Foundation Artwork – Walking Figures

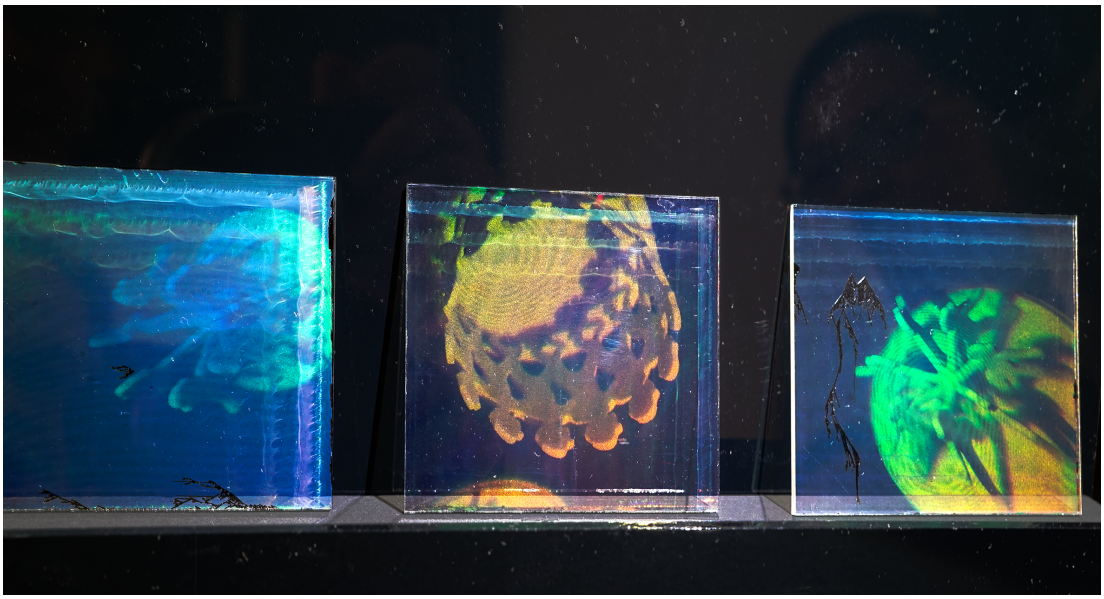

Image 10 *Walking Figures*, 2014, a series of 3D printed objects reflection holograms, 6 x 5.5 cm

During the process of appreciating, the viewer can hold an illumination source to interact with the holographic image; the position of light and shadow recorded within the hologram could be changed as the lighting angle moves. Moreover, the colour presentation of these images could alter as the viewing angle shifts (Image 10).

1. Holographic Expression

1.1 Three - Dimensional Visual Language

Three-dimensional display technology is a current popular topic in contemporary art; however, a review of its historical development provides evidence that audience's demand has had a number of peaks and troughs in the past few decades. A benefit of being able to use these emerging technologies in art practice may offer a better opportunity to convey artist's concepts more completely, especially as it provides an extra dimension to allow the artist to express their view compared to 2D art medium. It should be noted that 3D techniques did not discover the property of depth, but a representation, giving an illusion of space, which enhances the volume of dimensional depiction. As the acclaimed cinematographer and co-inventor of Fusion 3D, Vince Pace (2012) states, "it's important to realise that we did not invent depth and dimension overnight; it has always been a part of the cinematographer's toolset.

It's just that now we are emphasizing it more in the way we present it to the viewer (p. 178).

The artist and engineer Bernard Mendiburu (2012) states in his essay "The 3D Creativity Challenges", "Story is the key, and storytelling is the art" (p. 183). With the flourish of emerging technologies' involvement in art practice, the high-tech creation tools become more and more accessible for practitioners. This tendency is introducing an opportunity for a complete reformation of the grammar of visual communication language, as well as for the dismissal of the traditional paradigms with respect to the processing, distribution and representation of visual data. 3D techniques do indeed carry different functionality, which features their unique distinction and contributes to the diversity of artistic representations. While 3D technologies could bridge the audience to enter artist's creative world, the accessibility and applications of these mediums would be able to enhance the viewer's experience of a more in-depth exploration of the artwork, and open the way for their interaction with it at a more advanced level.

From the author's point of view, there is a major concern with respect to the information being contained in this art cosmos and not delivered into the physical world, in other words, a medium does not create art, artists do. When an art genre contains an indication of the medium's name in its title, for instance, electronic art, new media art or digital art, it suggests that the medium has been employed by the artist in order to a better construction and delivery of their creative message. Although, art is not created by the medium, still it is relying on its features, which serve to the purpose of enriching the artists' individual expressive language and allow them to make their personal choice for the delivery of their artwork, either in a 2D form, or a 3D mode.

A compelling example of the power of visual representation and the aesthetic impact of 3D is the movie "Gravity", which gained instant popularity with its cinema release. In his movie review for the BBC Radio 5 in live November 2013, the film critic Mark Kermode states, "the construction of images is an extraordinary ballet between

the real and the digital, the physical and the virtual". The member of the British Academy of Film and Television Arts discusses the effect of the combination between human creativity and the strong expressive capability of 3D medium in order to emphasise that standard fiction should be delivered in 3D visual language: "This is what happens when technology and humanity meet in the middle. And it is visually breathtaking!" (Kermode, 2013a).

Most people could never experience zero gravity in their life, therefore the sensory description, created by the movie is taken to a completely new perceptual experience by telling the story with the means of an immersive technology, such as 3D. "Gravity" would otherwise be a standard Sci-Fi movie, with a storyline, which could even create the impression that it is lacking a little bit of a depth of character narrative, but its 3D presentation enriches the visual language, and becomes a key factor to the successfully delivery of the story. The spatial effect evokes audience's sensibility and enriches the storytelling by generating a 3D perceptual experience through a masterful use of cinematography techniques, "The film does a terrific visual job of trying to demonstrate to you what anti-gravity might feel like by creating a visual experience that gives you the sense that you are actually in this world, in which there is no longer any up or down or sideways, there is just everything around you" (Kermode, 2013a). In this case, it can be honestly said, that it is the 3D visual effect that engages the audience in the unfolding of the story, and that "Gravity" could serve as an example of how technology can make art. Moreover, in his written review for the Guardian, Mark Kermode (2013b) also states, "I fear that Gravity may lose some of its experiential raison d'etre if stripped of its meticulously orchestrated stereoscopy, exposing a lack of narrative depth, looking a little (how shall I put this?) flat. Like the Imax space documentaries to which it also owes a debt, Gravity needs to overwhelm you; to engulf you; to surround you; to discombobulate you".

Based on above discussion, it leads the author to consider that 3D imaging representation can be an effective option to deliver an artwork. However, in terms of holographic art, it seems more important to create an artwork by realising through the medium itself. In other words, if holography represents a kind of 3D visual

language, which differentiates from a 3D film, the content needs to be developed based on the holographic syntax.

In her paper "Light and Shadows in Holography: A possible dialogue between Art and Science by using Artistic Holography", published in 2011, the artist Rosa Maria Oliveira discusses how visualisations and materials, originally recorded in 2D, could be developed further in order to allow a perception of three-dimensionality with the use of techniques, originating from the binocular principles of parallax. She refers to Unterseher's work to explain the mechanism behind stereoscopy, which is based on the use of two separate images, taken from alternative perspectives, correlating with an approximation of the separate views of the left and the right eye. The 3D sensation is achieved when the human brain combines the two images, however, the perception is physically restricted, as the viewing angles are determined – any change of the static position of the observer would result in losing the depth of the image.

Of all the known 3D representation systems, only holography provides a parallax identical to the original object, with no need to use any other auxiliary interpretation instrument, as in stereoscopy. In addition, stereoscopy and 3D film both create an illusion of 3D effect, but potentially may cause eyestrain; only holography can offer a perceptual experience, which is similar in function to the visual sensory mechanism of human sight. In a holographic image, the human eye naturally focuses on light in a real 3D space; a stereo pair representation of the same image would have the eyes focusing on flat artwork in order to perceive the notion of a 3D space.

Moreover, in terms of the characteristic qualities of holography, Popper (1993) states that it is free "of colour pigment and the referential relation to material reality." He uses the word "sensation" to describe holography as an art medium, which broadens the spectrum for aesthetic experience and human interaction with it (p. 38). Oliveira (2011) adds that the holographic image can be referred to as a "light sculpture", because of its immaterial nature, while the hologram as a medium is tactile and interacts with human perception of the dynamic.

Like other emerging technologies involved in art practice, holography is still evolving. What one cannot ignore is the fact that holography can propose a variety of solutions and artistic possibilities for practitioners, which traditional art media cannot present. For building this media its own identity and aesthetics, Popper (1993) suggests that holography needs to detach itself from "dependence upon the photographic paradigm" and reassess the artistic quality of its optical elements. He endorses the feature of "self-creating power of light" as the creative foundation of the holographic medium, which bears the same significance as three-dimensional visualization (p. 37).

1.2 Holographic Syntax

The debate as to whether the hologram as an object can be viewed and distributed in quite the same way as other new media remains quite a paradigm. In his book "*Art of the Electronic Age*", Popper (1997) states: "The holograph is not only a product or a tool, but a statement of specific effects based on an autonomous structure of its medium, light" (p. 38). An art holography display can be viewed as an "active optical element", containing an ethereal imagery. Moreover, the holographic plate can be referred to as a piece of hardware, which holds the whole information of the light wavefront in the moment of recording. With the strong representation capability of three-dimensionality and the "self-creating power of light", holographic space offers a dynamic interpretation to the volume and shape of recorded objects. Hologram also can be considered as a complete individual artwork. The interrelation between action of light, chemical process and object blends into an exclusive holographic phenomenon, and consolidates as a piece of aesthetic expression.

Based on the above discussion and exploration, it leads the author to consider a possibility of a cross-mediums approach for the creative implementation of her own artistic ideas. It aims at broadening the generally established vision of mediums' originated functionalities, and jumping out of the stereotype by re-investigating, re-experimenting, and re-defining the mechanisms behind the creation of artwork as they used to be.

In visual art practice, artists have been experimenting with various painting techniques and pictorial elements in order to depict the illusions of perceptual volume and space on a flat surface, such as linear and aerial perspective techniques in Western art, or parallel perspective in traditional Chinese painting. Those perspectival systems provide different methods for representing three-dimensional objects and spatial relationship on a two-dimensional plane. To respond to the emergence of new technologies, in the first quarter of the twentieth century, artists created different approaches to representing and interpreting the modern world of industry and technology. For example, Marcel Duchamp's *Nude Descending a Staircase* series (1911-1918), and Giacomo Balla's *Dynamism of a dog on a leash* (1912), both tend to use painting techniques, such as blurring, multiplication, and superimposition of body, to depict motion or successive points in time. This suggests that the interpretation of modern life is considered more from the temporal point of view, rather than spatial oriented perspective, as those new approaches aim to express the idea of the dynamism, the energy and movement (Tate, n.d. b). This reflects that the artists' view of "reality" or "space" seems to be modified by industrial civilization.

In addition, Duchamp states that his *Nude* series are not painting, but "an organization of kinetic elements – an expression of time and space through the abstract presentation of movement" (Popper, 1993, p. 12). It means that employing painting as an investigation method to explore the phenomenon of movement indicates that painting could be used in a way which is not associated from its conventional aesthetic purpose. To extend this discussion, Duchamp's opinion leads the author to consider that holography can be viewed as a simple 3D imaging technique, but also can be used as a medium to explore light art, or temporal art, and its aesthetic culture and potentially could be possibly expanded by using it in unconventional ways. This suggests that the new identified role and artistic quality of holography can be used as a basis to develop a new mode of expression.

As holographers make links with conventional art practice, their main concern focuses on the exploration of the uniqueness of holographic expression from an

artistic point of view. They strive to outline the essence of the medium's identity through a connection map, reviewing different art genres within a historical context. In her paper "Holography in the history of contemporary art", García-Robles (2006) considers holography as an art medium, which is similar to painting, sculpture, printmaking, photography or cinema. Meanwhile, she recognises that the characteristic qualities of holography provide some features which are unique to current artistic visual expressions, leading her to contextualise holography in relation to contemporary art tendencies, such as Op-Art, Kinetic Art and Conceptual Art. In the author's opinion, holography's uniqueness can be referred to as a signature, emphasising its distinctiveness as an art medium, just as practitioners should be striving to raise their own voice in support of their creative concepts, projecting their own artistic identity.

For instance, in the depiction of time, holography shares several similarities of visual expression with lens-based creative mediums, such as photography, video and film. An aesthetic quality, time suspension in holographic image preserves the whole light information (i.e. a laser light wave patterns reflected from the surface of an object or scene) at the moment of recording. In a way, it can be compared to photography, which retains the scene at the second of pressing the shutter button. In the paper "Mixed Media: Holography Within Art", Martin Richardson (1987) states, "A hologram preserves the three-dimensional information that is lost in a photographic image". He details the comment on holography as a creative medium, "at a crude level, as relating to a photographic image much as a sculpture relates to a painting" (p. 251). In other words, holography could add an extra dimension to artwork, as it contains more information.

Additionally, from the author's point of view, a movie is considered to be good when it comes with strong cinematic language, and if the film is paused, it should be able to present an excellent photograph with each frame. In this case, it would be worth comparing a holographic image with a paused 3D film in order to establish more clearly the differences between both of these time-based media. Unlike an ordinary frame of a 3D film, which holds a static scene with fixed lighting, a holographic

image relies on the "self-reference of light", which represents "an essential form for the articulation of the holographic message" (Popper, 1993, p. 37). The dynamic holographic optical performance breaks down the traditional understanding of Renaissance perspective, and also makes its own contribution to spatial interpretation by recreating a unfixed vanishing point in an indefinite environment. As the audience moves around in front of a holographic image, even though the object is recorded in a static condition, the interaction between viewpoints and the positions of lighting could still create kinetic effect.

2. Exploration

In practice, because of the similarity of exhibiting requirements and methods, holograms are commonly included in the category of 2D art media, such as painting or photography, and simply described with height and width. However, each individual art form represents very different technical methods for constituting and delivering an artwork, and those various approaches evoke diversified perceptual experiences in spectators. In the author's personal practice exploration, as part of her study, she drafted a human figure, appearing to be in between two states, it could be perceived both as standing, or walking, depending on the perspective. The body posture attempts to imply the blurred borderline between the definitions of the different holographic aesthetic descriptions – static/dynamic.

In the creation of this series, the author intends to keep this model very flat; the volume of the body figure is designed to be created by light and shadow, when the light source moves, the visual presentation of this model will be altered. Popper (1993) refers holography as light art, because light "is not only a generative principle but a subject and the basic substance of the holographic image" (p. 38). It suggests that light appears as a key element to turn the holographic image visible and also control the form of result that can be seen. This artwork creation process involves several stages of development, paper and pencil are used to outline the concept, the produced image is digitised via scanner, and the digital copy of the silhouette is utilised in the form of a thin, flat body figure within the 3D software application Cinema 4D (Image 11 and 12).

Image 11 Digitised body figure

Image 12 Digitised body figure

As there are considerations with respect to whether the construction is robust enough to resist the 3D printing, the author decides to make multiple copies of the digitised body figure and experiments with them by grouping these figures in basic geometrical shapes – a circle and an intersection (Image 13.a to d). These identical figures are built by the process of copy and paste, which is relatively unusual to the hand made culture of sculpture.

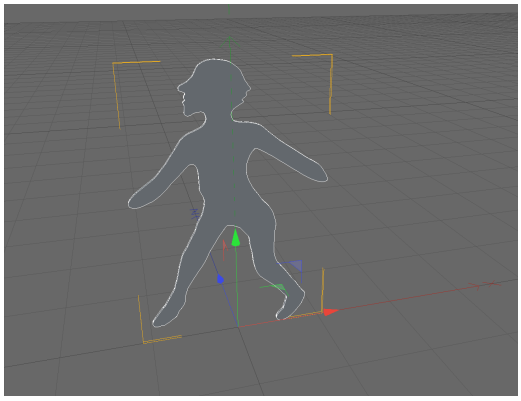

Image 13.a Screen shot

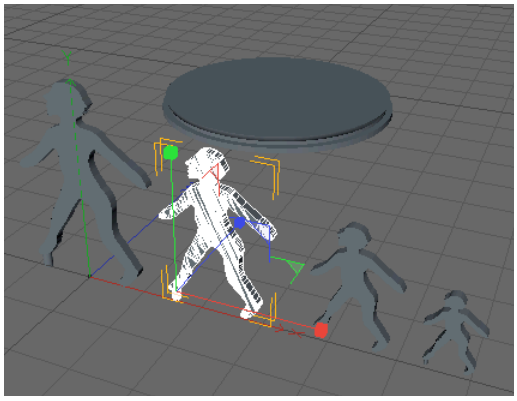

Image 13.b Screen shot

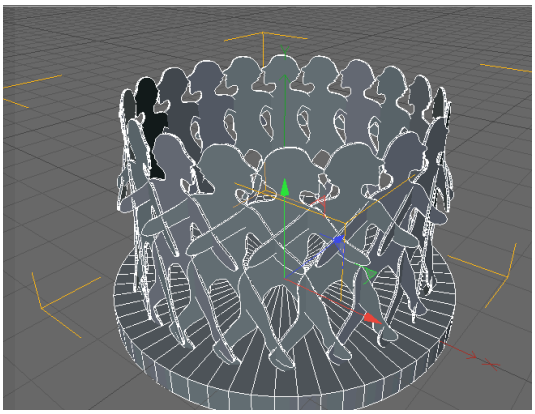

Image 13.c Screen shot

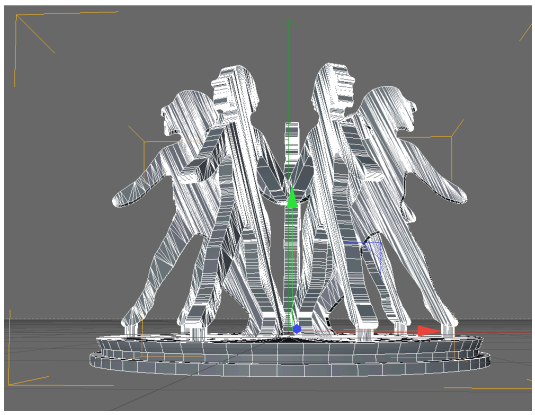

Image 13.d Screen shot

The resultant 3D printings are carried out by a SLS (Selective Laser Sintering) machine (Image 14 and 15). Both models are formed and act similar to the art of paper design, paper cutting, which is highly influenced by the interaction of light and shadow. The author intends to explore the relationship between light and the holographic image through the use of minimalism design.

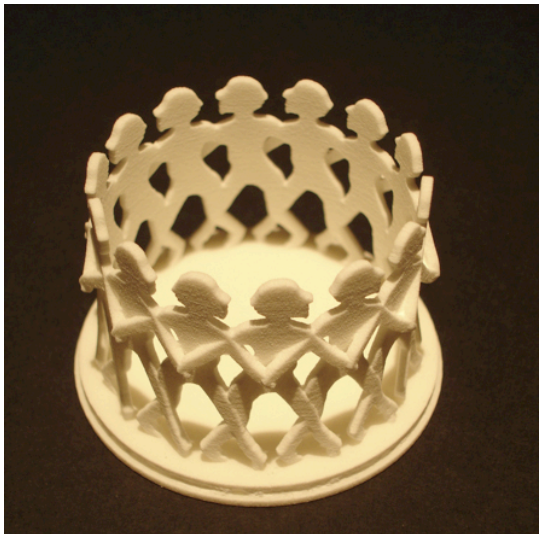

Image 14 *Walking Figures No.1* print

Image 15 *Walking Figures No.2* print

The produced powdered nylon models of the circular and intersected objects are then recorded as holograms (Image 16.a-b and 17.a-b). The holograms are photographed from different angles in order to show changing colours. This indicates differences in appearance of viewing angles due to the self-reference light as part of holographic aesthetics. Meanwhile, the shadow recorded in the holographic image will also move as the position of lighting changes, or the plate is observed from the different points of view.

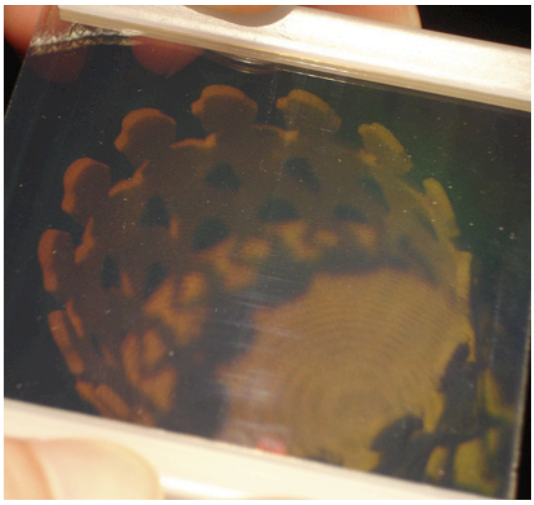

Image 16.a *Walking Figures No.1*

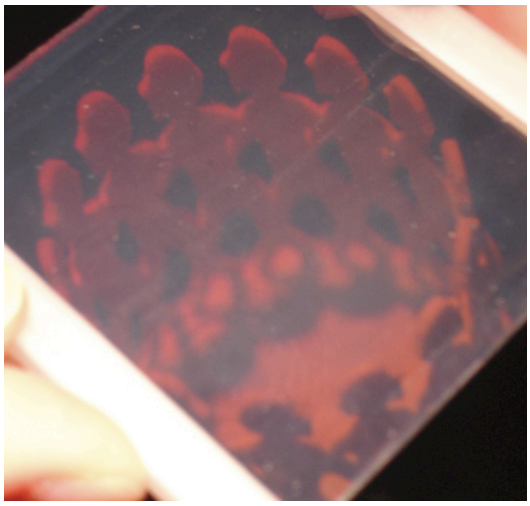

Image 16.b *Walking Figures No.1*

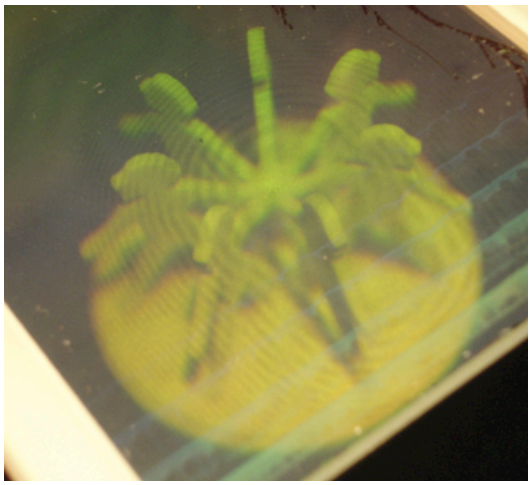

Image 17.a *Walking Figures No.2*

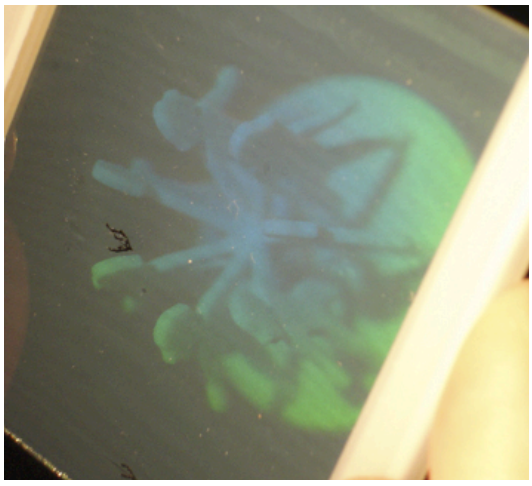

Image 17.b *Walking Figures No.2*

"It is the process of conception and realisation with which the artist is concerned" (Lewitt, 1999, p. 13). The creative concept for this project is formed around the deliberate use of traditional art material for the initial stages of the artwork

development, and the integration of several other different mediums plays a critical part for the final completion of the idea. The artist's work can be referred to as a bi-direction exchangeable artistic format, which bridges the virtual realm with the material world, by transforming between mediums, computational data can move between solid material, physical objects and cyber space. Cross-disciplinary practice offers enormous potential for both the development and the perception of artwork – a notion, challenging the conventionally established understanding of art, and also suggests a complete transformation of the interrelationship between practitioner, artwork and audience.

The goal of this project is not to simply demonstrate the transformation of the idea throughout the process of the practical work, but to visualise the concept, to allow a clear observation of the metamorphosis, caused by the transfer from one medium to another. Both the graphics version and the 3D modelled sculptures are characterised by their aesthetic uniqueness and can themselves be considered as distinctive artwork. The practical work has led to the conclusion that every stage of development of the author's creative work can be reflected as a separate piece of art – a discovery, which would serve as a basis for a further research into the interrelation between tool and product at different stages of the progression of artwork.

3. Summary

Technology is evolving, the current notion of the visual art world is changing, and so is the creative process of art practice. New technologies continually and increasingly involve the projection of another artistic dimension, and the term "visual" embarks on challenging the generally accepted notion of understanding art and interacting with it. In term of 3D modelling, the digital data shapes objects in cyber space; the file information could then be exported to a 3D printer, in order for a sculpture to be created. Moreover, the 3D printed work created for this project could be viewed as a subject matter (tool) for hologram recording, and also a finished artwork of the creation (product). The same view can be applied to art holography practice, as laser encodes wavefront information onto holographic plate, the light could be considered

to be a tool; but light also releases the image from a piece of dark holographic space, thus becoming a product by itself.

As regards holography, the image is an evidence of a moment, being taken out of the material world. However, this is not the end of the potential output. A hologram can be used in various ways to present a practitioner's concept, for instance, an individual kinetic work or a part of installation. The multifarious exhibiting requirements restrict audience's access to holographic artwork through other media, but, on the other hand, its comprehensive information display engages audiences in the perception of an incomparable sensory experience.

4. Reflection

This section presents a brief reflective view of wider aspects of this project, which is considered as not directly connect to the further stage of this study. However, the part of discussion provides an observation for holographic art practice in a wider sense.

4.1 3D Printed Sculpture

The last decade has seen the emerging of a technological development towards digital modelling and fabrication. Various 3D modelling software, as well as additive and subtractive manufacturing processes has been applied in this realm. Recently, the rise of a new medium has not only enabled practitioners to rapidly implement their ideas into the material world, but also to transform the creative media landscape in three-dimensional printing (Zoran, 2013).

From a self-fund practitioner point of view, the 3D printing technology broadens the capability of artistic practice in many aspects. The virtual environment offers artists an opportunity to shift their traditional studio, which is restricted by a fixed-size space into an unlimited cyber space. The various 3D software applications can achieve a realistic representation, based on the combination of diverse textures and material properties. As both light and shadow are essential components of a creative piece and its presentation, the possibility to simulate lighting within a 3D program is

an invaluable advantage, allowing the formation of a comprehensive pre-visualisation of the final display of the artwork. The series of processes involved in the development of a model only demand a small workstation – a desktop, a laptop, a tablet, or even a smart phone, or any other mobile devices. In the new digital era practitioners are presented with an opportunity to create their art anywhere – at home, in a park, or a coffee shop, just by tapping the keyboard or touching the screen. Furthermore, through its online interactivity the Internet allows a completely new level of creative collaboration – one and the same piece of art can be developed by different specialists at different stages of its creation.

As artists work with digital mediums, the advanced parametric tools available to them do not only bring the benefit of the creation of a mobility-shifting working place in cyber space, thus liberating it from the restrictions of the physical studio, but also change the process of artwork development itself. In traditional fine art training, sculpture studies normally require 3-4 years, full-time, in order to gain a basic understanding of equipment functionality and material operating, and to achieve a skilled practicing experience. However, unlike conventional sculpture creating process, 3D printing is considerably less sophisticated.

3D printing, in the technical sense is "additive manufacturing" – a term, which is more descriptive of the actual printing process. In traditional crafting process, artists usually need to cut material for the construction of a physical object or the formation of a new shape, based on pre-made models. 3D printer fabricates three-dimensional objects from virtually designed files by stacking requited raw material into layers.

In the book "*Fabricated: The New World of 3D Printing*", Lipson and Kurman (2013) indicate this "climate change" – the digitalisation of sculpting process: "Design software and 3D printing technologies are together leaping forward and changing the way people design and make things" (p. 91). Using a computer for the modelling process makes the virtual sculpture easy to texture and render, it can produce a simulation of the physical environment and realistic lighting, as required by the artist. Moreover, the functionality of the preview feature of the software enables

practitioners to change and improve their design, to edit, and even revise completely the virtual model at any stage of its development. In this case, cyber space plays an instrumental role, due to the several different layers of advanced functionality, it adds to the process of art creation. It acts simultaneously as a working environment, which accommodates the design, transformation and creation of a model, as a space, allowing the existence of artwork in its immaterial form, as a distribute channel, and even as a virtual gallery with adaptable lighting and background.

In addition, sculpture is one of the visual arts that operate in three dimensions; the interactions with light and shadow can be considered as essential elements to both expressing and articulating the artistic message. In contemporary sculptural process, the involvement of new materials and techniques liberates today's sculpture by detaching it from its traditional manifestation, known as plastic art, from its dependency on material and process. Making sculpture is a time and space consuming process; however, digital technology enables practitioners to shift their studio into cyber space. In this virtual environment, 3D graphics suites allow artists to keep back-ups of their work at different stages, thus making it possible for them to re-visit and revise their concept transformation, following a "click-back" pattern, which allows a formation of a new concept at any stage of the development of the original piece. The benefit from cyber environment, apart from not requiring physical working space, is that it turns the creative process into a light and efficient workflow.

4.2 Space within Space, White Cube, Black Box

It is interesting to witness the transformation from intangible digital data to concrete solid artwork. Through the synergy between a computer and a 3D printer, sets of millions of x, y and z data coordinates have been decoded, so that a virtual object could be detached from its simulation space and immateriality and converted to a material object. In this process, 3D printed sculpture becomes an interface, which connects the cyber space and real space and bridges the virtual object transition into the material world. After the finalisation of the 3D printed creative work, a consideration of its presentation becomes a critical stage of the delivery of the artistic

message – what should be the best format for display? How should the artwork be exhibited?

Following an expanding context of the implementation of interdisciplinary, the artistic exploration of cross-media launches multiple layers of dimension and diverse combinations of creative presentation. This tendency blurs the boundary between artwork and exhibition space, and strengthens their interrelationship. The richness of visual narrative brings the message of art to bridge the gap between virtual and reality. For instance, during the 1960s and early 1970s, the emerging projection technique opened new methods of imagery representation. The role of physical display space, such as museums and galleries, has been transformed and redefined – from a passive exhibition space it has been diversified to an active environment, providing opportunities for dimensional presentation. The lighting, the shadows and flashing beams, the sound design, and supporting technologies become vital components of artwork display.

The advance of the so called "perceptual field" from a well-lit professional gallery to an immersive dark theatre can be compared to a two-box spatial model, containing disparate characteristics, as Iles (c2001) states, "Artists working with the projected image shifted the coordinates of this perceptual field from the brightly lit architecture of the gallery to the dark, reverie-laden space of the cinema. In this hybrid of white cube and black box, each model of space informed and modified the characteristics of the other" (p. 33). Additionally, in his review from 1968, included the book "*Six Years: The Dematerialization of the Art Object*", edited and annotated by Lucy Lippard, the conceptual sculptor Hans Haacke wrote, "A "sculpture" that physically reacts to its environment is no longer to regarded as an object. The range of outside factors affecting it, as well as its own radius of action, reaches beyond the space it materially occupies" (Lippard, 1973, p. 37).

4.3 Creativity in an Information Age

As art practice moves into an information age, the link between art and technology is forming a new coalescence to enter the digital world. Following this tendency,

practitioners increasingly expand their interest and devote their energy towards a more intensive artistic experimentation with technology. By estimating and evaluating its advantages, practitioners are building their own, distinctly expressive language. The 3D graphics software applications are vivid parametric tools, introducing new dimensions to creativity; the computational and algorithms-based media features its determinability to give shape to new forms of art. The intersection between art and technology constantly challenges the ways of perceiving art; it provides opportunities for the evolution of the convention of art itself, as well as a possibility for creative exchange, collaboration and visual representation, “New media art seems to call for a distributed, "living" information space that is open to artistic interference -- a space for exchange, collaborative creation, and presentation that is transparent and flexible” (Paul, 2007, p. 251).

In the paper “When The Cables Leave, The Interfaces Arrive - immaterial networks and material interfaces” published in 2006, Laura Beloff discusses the apparent tendency of digitalisation in the contemporary art: “The last decade has seen the dawn of a technological development towards a wireless networked world”. The Finnish artist and curator addresses the advent of mobile technology, resulting in the development of diverse interfaces, which have an increasing impact on daily life, and merge in all of its aspects: “Everything will become an interface, from a cup to a shirt”. Furthermore, she considers the importance of the various opportunities, provided by this new digital infrastructure and their significant influence for the formation of “new conditions for artistic practice” (p. 211). Employing these new technologies and the mobility opportunities they offer, would facilitate the origin of a completely new set of artistic forms and mediums, as it would liberate artists from the restrictions of physical working space and provide them with more advanced ways of processing and distribution of their artwork.

Chapter 5 Anamorphic Time – Anamorphic Skull

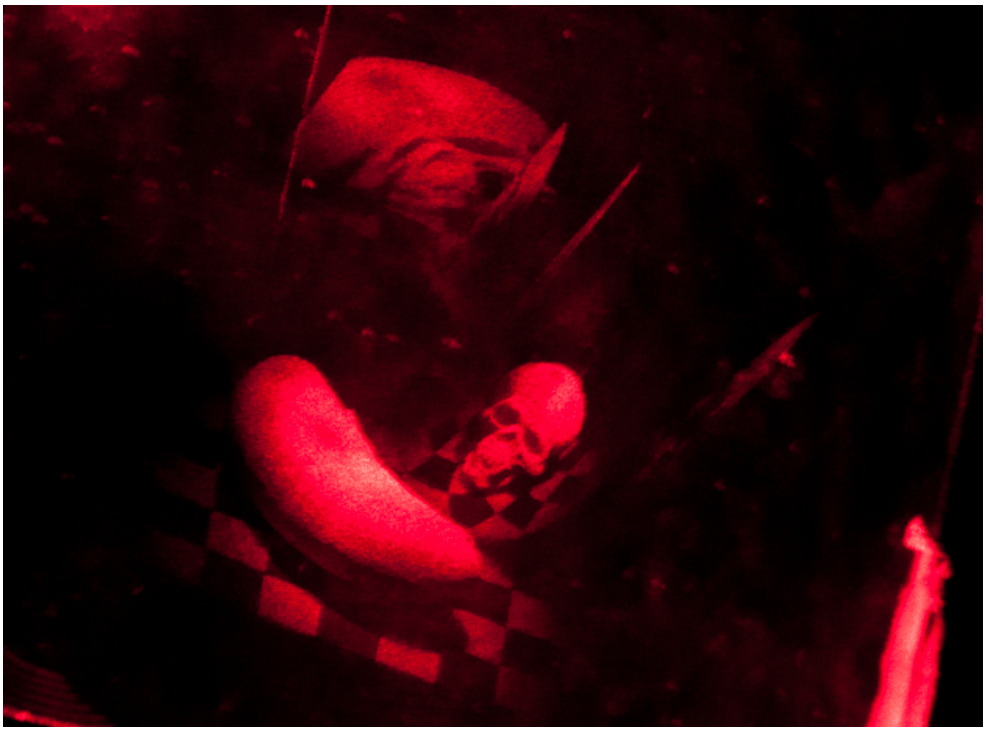

Image 18 *Anamorphic Skull*, 2015, a 3D printed object transmission holograms, 25.4 x 23.32 cm

This image could be seen by shining the light (red laser or red monochromatic light source) from the back of the hologram, which is the opposite side of the viewer. The skull has been placed in a position surrounded by two types of mirror with the object back toward the audience. The left side shows an image reflected from a plane mirror; the centre shows an image which is reflected from a cylindrical mirror (Image 18).

1. Introduction

Holography as a time-based art medium has its own unique aesthetics and techniques to interpret and represent colours and light. This exclusive descriptive visual language does not simply represent a particular scenario in the moment of recording, but also documents the performance of light during the recording process. In terms of holography art practice, the majority of the subject matters are selected from readymade objects, although this style has been proved in its popularity and great commercial value, it would often lead the role of holography to be underestimated as an imaging technique, rather than considering it as an individual art medium.

In Benyon's creative practice, she uses holography as "a medium in the way a film-

maker uses film or a painter paint. Rather than producing holograms of art work, there seems more point in using holography as an art medium itself and developing its unique properties" (1973, p. 5). She also points out that the importance of a new visual idea is realised through this form of art practice. In this case, 3D printing makes it possible to create an object which is purposely designed for a hologram recording. Moreover, this additive manufacturing technique could bridge the gap between cyber space and the holographic world; that is to say, this emerging technique would be denoted as a link, which connects computational data and light information.

In the depiction of perceptual volume and space, various pictorial perspective methods provide artists alternatives with respect to the representation of three-dimensional space with the use of two-dimensional mediums without restriction, for example, canvas, wall, or other mediums with picture plane surface. Anamorphosis lifts this classical perspective practice of spatial interpretation to a completely new level, which makes it possible to hide, or conceal an image, message, or dimension from the canvas by distorting its projection of the subject matter. Those artworks created by the pictorial technique of anamorphosis, either require the audience to view a particular piece of art from a specific vantage point, or to employ optical devices in order to reconstitute the image with its correct proportions, or decrypt the visual message.

Two well-known examples of anamorphosis are *King Edward VI* (attributed to William Scrots, 1546, National Portrait Gallery, London) and the skull in Holbein's *The Ambassadors* (1533, National Gallery, London). Both paintings use distorted perspective to illustrate the subject matters, and the correct proportions can only be perceived when the masterpieces are viewed from a particular vantage angle. A comparison between these two artworks establishes that while this piece of the Portrait of King Edward VI relies on a single viewpoint for its display, Holbein's work demonstrates a complex combination of viewing angles and the impact they produce, due to its incoherent perspective design. The main figurative composition of *The Ambassadors* is organised in a traditional manner, following the conventional understanding of perspective representation of a three-dimensional space with the use of two-dimensional medium. And then, unexpectedly, the audience is presented with a mysterious image of an object, deliberately placed on the foreground by the artist. It is an anamorphic skull, whose distorted perspective makes it nearly impossible for the

audience to perceive, or even estimate the actual shape, unless standing at a very specific viewpoint. This restriction results in the common opinion that it is impractical to consider that this pictorial technique could be observed in its entirety only from a single angle, in particular, as it is combined with another perspective systems (Baltrušaitis and Strachan, 1977).

As the author suggested in the chapter of Holographic Aesthetics, if one viewpoint represents one point in time, a traditional one-point perspective painting has a single vanishing point, which suggests the timeline is fixed. However, a 3D object-oriented hologram is opened to let the audience move around, this viewing experience is especially similar when viewing the object in real space. Different viewing positions represent multiple points of time; in order words, the different perspectives of this holographic image is revealed by the audience's movement, which responds to the essential description of time-based media, (they have duration as a dimension and unfold to the viewer over time). Furthermore, in terms of the technical premises of these two art forms, anamorphosis and holography seems irrelevant but both have potential to create a scene with multiple perspectives, which make possible to represent the multiples point of time.

2. Context

As mentioned earlier, Holography and anamorhosis both feature temporal quality within their creative potential and the fact that their expressive language is not strictly defined relates to the essence of their visual display, which is never determined by a single viewpoint. For instance, the "fluidity" of the holographic visual presentation creates an un-fixed form, the perception of which changes, according to the viewing position and thus, opens new possibilities for varied interpretation of their content by the audience, while the concept behind them remains practically unaltered (Kac, 1996). In anamorphic art, viewers find that standard perspective and its hidden dimension have been located in different viewpoints – a fact, which makes it very difficult for both of them to be observed simultaneously. Moreover, viewers often presume that a deformed image could be a representation of a personal character – an assumption, which facilitates the formation of the viewers' own standard of satisfaction about "correct" or "true" proportion and shape, relating better to their individual

understanding.

In addition, anamorphosis itself could be used to conceal images – a fact that could have a number of applications for personal safety and privacy, even in the sense of "artistic privacy" – hiding the original artistic concept behind a metaphor, thus challenging the audience to play with different notions in their attempt to decode and interpret the artist's idea. In this stream of thought, it is worth emphasising that it would be important to consider the possibilities of applying the anamorphosis technique in holography, as it would enrich the medium with new opportunities for artistic expression.

New technology involvement within art mediums never limits the possibility of developing new forms of expression. The emerging 3D printing technique, for instance, could be considered as a novel component, which would enrich the holo-textual narrative. Due to the increased interest in three-dimensional fabrication techniques, their development is constantly evolving, they became not only easily accessible, but also affordable, and as a result, their artistic application has extended its expressive language. 3D printing has a unique combination of mathematical accuracy and physical output, could inject the conventional visual manifestation with active and tactile features, especially when utilised as part of the development process of anamorphic artwork. If 3D imaging recording and displaying techniques can be considered as a key improvement for transforming artistic visual language into a three-dimensional form or practice, then 3D printing will be entitled to gaining the credit for bridging the gap between digital imaging and material shape. Similarly to the way photography disputed the values of classical painting and digital imaging technique confronted analogue photography, holography and 3D print challenge the conventional notion of art and also introduce new creative potential to influence the already established aesthetic culture. Moreover, the involvement of new creative mediums could bring new forms and meanings to contemporary art practice and take them to undiscovered realms of experience, by breaking the conventional boundary with other innovative techniques and processes.

Based on above discussion, a combination of holography and anamorphosis could potentially give a 3D printed object an extra dimension, and an advanced spatial-

temporal artistic interpretation. When referring time and space as essential features of a holographic display, one needs to acknowledge the fact that so far analogue holography is relying mainly on the recorded representation of existing physical objects. However, the digital software packages and the 3D printing technique could provide artists with an opportunity to create an imaginary form and shape, to give “flesh” to innovative concepts, and then to reproduce them in the material world, augmenting immensely the holographic subject variety.

3. Exploration

3.1 Technical Premises

Anamorphosis is a pictorial technique, which finds its greatest application in art and perspective studies’ practice, and is based on the use of distorted image, which can only be interpreted in its proper proportions either by being viewed from a specific vantage point, or through its transformation, due to the employment of optical devices, for instance, peepshow box or cylindrical mirror. A key principle of this system is based on “negative perspective, since the positions of painted image and perceived image are reversed with respect to conventional perspective panting” (Brown, et al., 1987, p. 67).

With time and evolution of artistic practice, anamorphosis has become a constantly developing and increasingly complex exercise. Even though there are various technological methods for the creation of anamorphosis, two major styles have been established as most commonly used by artists: perspective (oblique) and mirror (catoptric). The unconventionality of the form of anamorphosis, usually referred to as "oblique", arises from the fact that the image must be viewed from a position, very distant from the usual frontal and straight-ahead position, from which audience would normally expect images to be observed. In the other common form, termed "catoptric", the image reflection must be perceived in a distorting mirror, where the most common shapes, produced as a result would be cylindrical, conical and pyramidal (Kent, 2013). In the interpretation process, the linear anamorphic image appears to be easier to recognise, as it mainly relies on one-point perspective, namely created by stretching the normal picture in one dimension. Unlike the linear anamorphosis, the circular one, referred to also as curvilinear image, is designed to be viewed as a reflection in a

cylindrical or a conical mirror and appears nearly impossible to read without their use.

An artist would not simply add an extra dimension on the canvas; they also manipulate it in a manner that would prohibit the viewer from perceiving and decoding the image from the standard perspective, as it could only be seen from a particular angle, or in a mirror image. This results in the fact that ordinary perspective is still present in the medium used, such as a canvas, but it exists simultaneously and in combination with the hidden presence of a secret, a visually distorted image, while the anamorphic design only allows spectators to perceive one scene at a time. Artistic interpretation of a hidden dimension of a painting is instrumental in terms of revealing the concealed meaning and space. The process of anamorphic design makes it possible to diffuse a concept by embodying and concealing meanings of a political, religious or erotic nature, thus giving them an element of confidentiality in order to target particular circles of audience, while excluding others (Kamp, 2013).

As the 3D printed anamorphic sculpture is recorded within holographic space, it could be possible to introduce a different approach of holographic aesthetics. In other words, this adductive manufacturing technique could take holography from a basic stage of time-space interpretation, like an object-oriented analogue hyper-realistic hologram, to an advanced elevation of imagery representation, while the application of the anamorphic principle to the expressive form of 3D printed sculpture would facilitate the quality of the end product, which could then be reproduced.

3.2 Creative Development

In the planning stage of the practical development, this project takes into account a variety of different possible designs in order to refine them and make a final decision with respect to the use of a particular anamorphic object. The author needs to examine further existing artwork, based on two simulated scenes. *Skull No.1* is an anamorphosis, presenting an elongated shape, which could be reconstituted to the original proportions of the object by observing it from a vantage viewpoint, while *Skull No.2* displays a different arrangement and can be decrypted via cylindrical mirror. After a careful consideration, and based on the comparison between these two simulations, the conclusion establishes that the second model produces is preferred, as this design present more depth in its structure (Image 19).

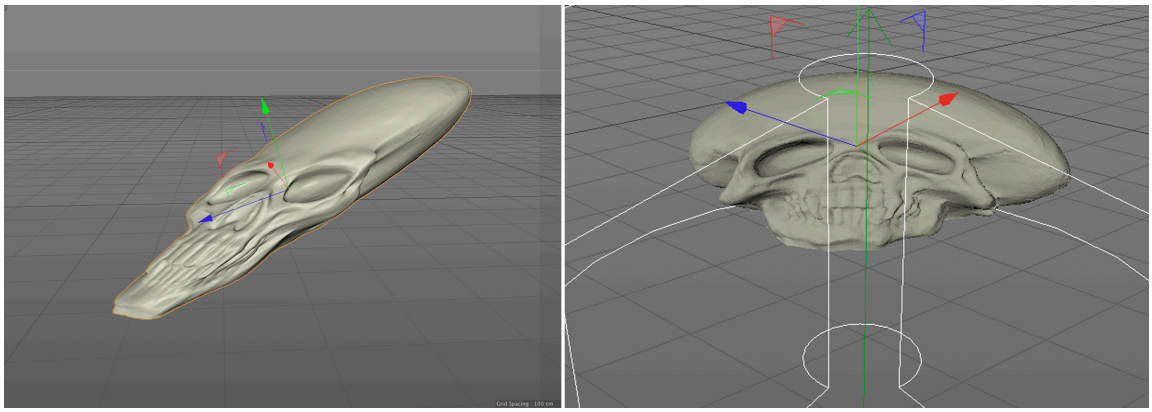

Image 19 *Skull No.1* (left) and *Skull No.2* (right) formed in computer simulation

Cinema4D suite has many ways of distorting the mesh of a 3D model beyond simple resizing and rotating. These might include such deformations as explode, melt, wrap, shatter, but this exploration requires much simpler techniques, such as shear and bend. Shear can manipulate a control box that the model fits in, and corners of that cube can be moved independently distorting the model inside. The bend function achieves much the same thing, but with algorithms that calculate the distortion around a cylinder. Both 3D printings are carried out by a Selective Laser Sintering (SLS) machine and processed with polyamide material, *Skull No.1*, and high performance composite powder, *Skull No.2*.

3.2.1 Skull No.1

The design is inspired by linear anamorphosis, which is created by simply stretching the normal 3D model in one dimension (Image 20). As there are considerations with respect to whether the construction is robust enough for the 3D printing process, after several discussions with the Leuven-based online 3D print lab, the author decided to change the anatomically correct bone structure to a simplified printable skull model.

Image 20 *Skull No.1* print, shot in three different perspectives

The original unedited model is sourced by an online library of 3D models, specifically for printing, named “Thingiverse.com”. The author has to overcome several limitations posed by the actual process. Not every model can actually be printed, for instance, wall thickness, overhangs and the level of detail must all be taken into consideration when designing the model in a digital environment. For illustration purpose, the author simulates two types of mirror images of the anamorphic skull. Image 21 demonstrates the possible undistorted images, which are reconstituted from a plane and a curved reflective surface. In a close up photographic shot, the image demonstrates a clear juxtaposition, between encoded and decoded visual representation (Image 22).

Image 21 *Skull No.1* in computer simulated version

Image 22 *Skull No.1* print in a photographic scene of cylindrical mirror image

3.2.2 Skull No.2

This design is based on the principle of mirror anamorphosis, which is shaped by bending the normal 3D model around a circular form thus deforming it (Image 23). In this process, there are minimum and maximum limits to the level of deformation. The author finds that amount of deformation would be critical to produce a reflection that actually resolved itself into the original skull.

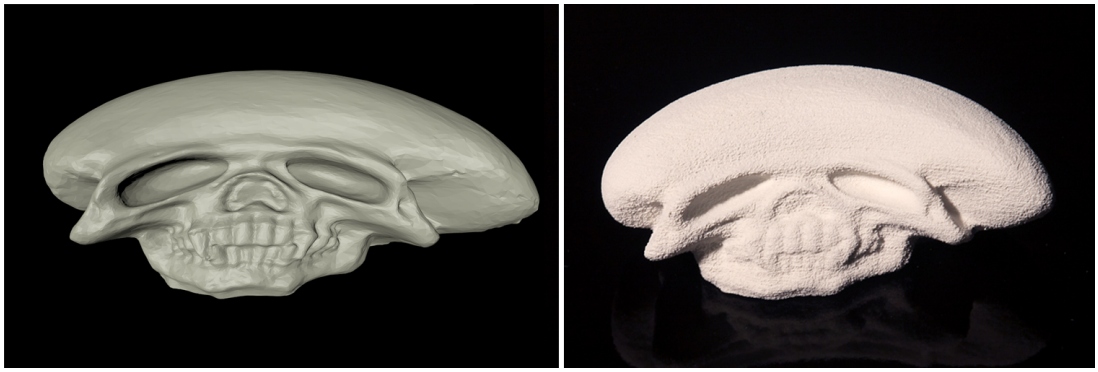

Image 23 *Skull No.2* presented in rendering version (left), and in a layered printed structure (right)

The author creates two types of background with black and white chess board style bases, 12×12×12 cm. To investigate the different effects of the mirror images, one scene has been arranged with a single cylindrical mirror, and another design has added two extra plane mirrors (Image 24).

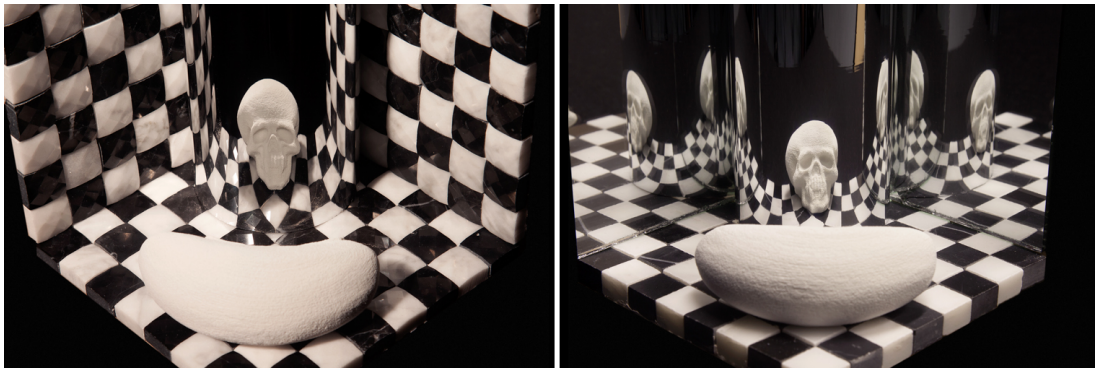

Image 24 *Skull No.2* displayed in a scene of a single cylindrical mirror (left) and exhibited in a scene of two plane mirrors and a cylindrical mirror (right)

The final work is recorded as a single beam transmission hologram (Image 25). In the resultant hologram, without giving any information in advance, an object has been placed in a position surrounded by two types of mirror with the object's back toward the audience. Although holography is known for its highly realistic three-dimensional image representation; however, the object recorded in the hologram can only offer very limited information, as it cannot be seen by the audience directly. Only through the reflective background, the audience could learn more details about this object; two plane mirrors reflect the distorted skull, and the cylindrical mirror transforms it into an undistorted form. The juxtaposed mirror images within the hologram reflect different appearances of the anamorphic skull, which provide an explicit example of viewing the object from different angles and time.

Image 25 *Skull No.2* hologram recorded in a scene of two plane mirrors with a cylindrical mirror (left); a close up shot of this hologram (right)

4. Summary

"To seek the essence of perception is to declare that perception is, not presumed true, but defined as access to truth" (Merleau-Ponty, 2003, p. xviii).

In his article "The 'Unusual Character' of Holbein's Ambassadors", Hagi Kenaan (2002) describes that anamorphosis is more than a simple optical trick of "the hidden presence of a secret" and also "a visual cryptogram" (p. 68). In terms of the perspective system, anamorphic technique transforms ordinary visual expression in a manner that objects appear distorted, or illegible when viewed conventionally. This not only extends spatial depiction in art practice, but also broadens the ways of perceiving. He considers that "the presence of anamorphosis is in itself suggestive of the need to replace one's conventional view of painting". Kenaan provides a further insight, the inability to access the hidden dimension of the painting is because the viewers habitually place themselves with a frontal view when observing a painting, and commonly take "the painting's form of appearance for granted" (p. 69). For instance, if an anamorphic application makes the concealed mystery in *The Ambassadors* elude the viewer because it is always in plain view, the scholar of Philosophy suggests: "we need to allow that which is before our eyes to lose its obviousness" (p. 69).

Unlike traditional one-point perspective systems, which limit and pre-define the spectator's interaction as a more passive mental event (the viewers are told what they should see when everything is displayed on the canvas in a 2D plane), anamorphic projection allows them to navigate between multiple viewing positions within various ways, thus facilitating interactivity and reaching far beyond a normal viewing experience.

This series of experimental works creates actual visual statements of the holo-aesthetic message. A 3D printed anamorphic sculpture, when used as an object, positioned within holographic space, brings its own interpretation and intrinsic expression to interact with the holographic aesthetic culture. This "cyber sculpture" could be described as a product of the complete transformation of a virtual entity to a material object, which engages both a digital environment and the physical world. Within the holographic space, the object retains its presence of the actual characteristics and

features, while inhabiting this ephemeral dimension, but also reveals its absence from materiality. The holo-imagery texture is both solid and emptying, a dichotomy and unique combination, which opens layers of expressive potentialities in holographic art. Holographic space is defined by a non-linear immateriality, which could not be interpreted by conventional mathematical principles. Its exclusive artistic features – light-based colour system and realistic three-dimensional image representation – in Popper's words, presents the "tactile" and "motor" senses of "the referential relation to material reality" (1993, p. 38).

This project emphasises the notion of perspective, different viewpoints represent multiple points in time, which is applied in the juxtaposition of the distorted and undistorted mirror images. Through the use of the principles of anamorphosis, computer aided design (CAD), 3D printing technology and holography, this project integrates pictorial, sculptural and holographic artistic elements to establish an approach, which could be able to add a temporal dimension to holographic aesthetic expression. Moreover, the anamorphic skull is placed with the back toward the audience, which means that this object can only be seen by looking at the mirror images. It could make the audience to wonder which reflective image would be true.

Today's 3D graphic software and the Internet offer artists greater mobility in both the development and the delivery of their artwork. In addition, the diverse web-based social media presents unlimited and various spaces to facilitate artists in the exchange of creative knowledge; it enables them to collaborate on their projects with external connections, such as participants and specialists. Using technology in artistic application, it could take considerable time to build a complete understanding of this medium, which would be able to take a full advantage of the benefits its use offers. The development of this experimental series seems originated from the holographic 3D representative culture, and move forward into the temporal-based discussion. In other words, the 3D printed skull is considered from a point of view of how this piece can benefit from more than just a three-dimensional presentation with the use of holography. Furthermore, this study aims at looking for a new artistic possibility of temporal expression, deriving from the interrelation between analogue holography and 3D printing. It will also attempt an articulate assessment of 3D printing within the dynamic holographic aesthetics.

Another important outcome of the project, which should be emphasised, is that it explores completely new contextual possibilities and relationships, and clearly defines new connections between technology and creative arts. The application of 3D printing in contemporary art promises to reshape the process of artistic creation, as well as the form of visual narrative itself.

Chapter 6 Holographic Script – Li-Bai's Night

Image 26 *Li-Bai's Night No.3*, 2016, a Chinese calligraphy reflection hologram, 23.32 x 25.4 cm

This work can be seen by using a light source to point at the right edge of the hologram, the image will be reconstructed in the same direction with the traditional Chinese writing layout. An audience can also hold a torch to interact with the image, as the torch moves the shadow of calligraphy moves. The above images are taken while the light source is placed in different positions. The left side shows the image of Chinese calligraphy and its corresponding shadow; the right side shows the image of calligraphy nearly invisible, only the shadow can be seen (Image 26).

1. Introduction

Following a rapid development of emerging technologies, the interdisciplinary approach to contemporary art is constantly restructuring the conventional manner of the creative process, as well as the form of visual expression and presentation. If the aesthetic culture of an art medium could be seen as the visual summary of the medium's characteristic qualities, the engagement with different media could possibly provide a new perspective to employ this medium in its artistic application. The creative potential of traditional art, such as painting and sculpture, could be extended, as the aesthetic elements of a new medium are added into the traditional mode of expression. In other words, to consider the engagement with other mediums, old or new art form, it may advance the exploration of holographic artistic qualities.

In Brill's opinion, holography as an art medium "has opened a new realm where imagery is composed and conveyed within a three-dimensional space" (1989, p. 289). Holography transforms the nature of its optical property into an art agent, which offers artists new ways of liberation from the conventional principles and extends their visual communication beyond the three-dimensional realm, thus enabling viewers to visit a space they could not access previously. Art holography study allows practitioners to explore and manipulate various optical instruments and spatial representations. The aesthetic nature of holography provides practitioners with opportunities to expand their creative minds and concepts in new directions, as well as to place their experimental visual narrative in a three-dimensional holographic context. Holography has developed from a technological science tool to an art form that engages the public to apprehend many principles and aesthetic attributes. This constitutes an optical art medium where innovation in visual and multi-sensorial perception, interactivity influences the development of aesthetic communication techniques. "As holography continues to evolve as an art medium, it continues to define itself, both as a technological process and as an expressive art form" (Brill, 1989, p. 289).

2. Context

On 20 March 2015, the United Nations Postal Administration (UNPA) issued a set of 6 stamps to commemorate World Poetry Day. In celebrating this event, The United Nations Educational, Scientific and Cultural Organization (UNESCO) acknowledged the unique ability of poetry "to capture the creative spirit of the human mind". They focused on six different languages - English, Spanish, Chinese, French, Arabic and Russian as the key message of the day was to support "linguistic diversity through poetic expression" (Hynes, 2015, p. 12). The Chinese poem, presented on the World Poetry Day - "Thought in the Silent Night", is Li Bai's (701 – 762 A.D.) famous poem from the Tang Dynasty. It had been chosen not only because it was representative of the Chinese language, but also as it embodied the deepest human emotions of nostalgia and longing for home and family reunion:

"Beside my bed a pool of night – Is it hoarfrost on the ground? I lift my eyes and see

the moon, I bend my head and think of home." (translated by Yang Xianyi & Dai Naidie) (cited in Hynes, 2015, p. 13).

The Tang dynasty is often considered as the Golden Age of Chinese poetry, which imposes structural rules of form. Referring to the original Chinese text (which does not directly translate to English), Li's work demonstrates a common composition of the poetic form in the era, which limits the length to four lines each consisting of five characters. The popular themes of this common poetic form mainly adopt from the surrounding social and nature scene. Generally, rhyme and rhythm are integral parts of classical Chinese poetry composition, as well as the application of aesthetics and rhythmic properties of language to aid memorisation and oral transmission, which is a common tradition in ancient societies. This intimate literature form is not as static as it would appear from printed editions, and the use of Chinese calligraphy in the writing process would enhance its deep aesthetic value of linear temporal quality.

In its conventional script style, calligraphy often refers to a visual art connection within the written language system. Chinese traditional calligraphy and painting are closely related; they involve and share similar tools and techniques, mainly a brush dipped in black ink as oils are not used. Both art forms are commonly applied on paper, or silk materials, and the finished work can be mounted on scrolls, for instance hanging scrolls, or hand scrolls displayed either vertically or horizontally, depending on the content.

Traditionally, Chinese characters are written in vertical columns from top to bottom, and ordered from right to left; the first line being on the right side of a page, and the end line on the left. Text is read in the same way. Although, a text can also be written in horizontal rows, either in the classic style - from right to left, or the modern format from left to right, these pages are both read from top to bottom. However, the standard vertical writing system still remains the dominant direction in places such as Hong Kong, Macau and Taiwan where the traditional Chinese orthography is used. While classical Chinese poetry could be typified by certain formal structures; the uniform layout of composed text shows that its originality came from the general

writing tradition.

Language is not simply a collection of words, and using a creative medium for the presentation of written content could strengthen the effect of the message, as well as saturate it with further aesthetic qualities. In terms of Chinese calligraphy, it contains both linguistic and graphic aesthetic qualities, which does not merely convey a literary message, through the use of a brush; it could also add a pictorial element into the original text. This suggests that the meaning of a poem presented with the use of Chinese calligraphy could go beyond a stationary level. Moreover, through a skilful manner and precise execution this unique expressive form is capable of breaking the writing format's restrictions and introducing a sense of dynamics into the poetic narrative. As a comment made by Stanley-Baker (2010), "Calligraphy is sheer life experienced through energy in motion that is registered as traces on silk or paper, with time and rhythm in shifting space its main ingredients" (p. 9).

Considering that Chinese characters assume different meanings according to certain organisations in varied linguistic structures and contexts, the reproductions of printed pages may limit the creative potential of this form of narrative due to the two-dimensional representation. Compared to handwritten poems, the printed version seems to produce a less mobile impression. It leads the author to consider that the use of Chinese calligraphy in combination with holography may possible create a bond between literary and visual expression and also add a vibrant voice into the writing process. This integration of these two art forms would include the dynamic quality of calligraphy and the fluidity of holographic image, which could expand the depth of poetic syntax.

The evolution of advanced techniques pushes the boundary of the application of creative mediums and display formats, bringing enormous potential into new media arts. A collaborative combination of holography, Chinese calligraphy and classic poetry could augment the development of poetic expression due to the utilisation of both technical and aesthetic qualities and advances.

3. Exploration

Based on the above discussion, it leads the author to wonder if the artistic potential of Chinese calligraphy could be expanded by engaging holography. In particular, the former mainly employs a brush as the tool, and operates in a similar way with Chinese painting, which indicates its pictorial quality, and explains that its presentation is considered more dynamic than a printed copy. Holography as an imaging medium is possible to add its unique optical properties into calligraphy the ink and brush based art form, in order to create a light-based Chinese script. This combination may be able to provide a different view to explore the creative potential of text-oriented visual narrative, especially the recording object is a flat surface.

3.1 Technical Premises

Holography is a practical means of storing and reconstructing wavefronts of light; the recorded, and consequently processed, photosensitive film or plate is called a hologram (Collier et al., 1971). A hologram is a physical structure, which can diffract light to form an image. "The term 'hologram' can refer to both the encoded material and the resulting image" (Mrongovius, 2011, p. 122). Although holography is often referred to as a three-dimensional photography, the only common aspect these two mediums share is the use of photosensitive emulsion. The image production process is then carried out in a very different manner. A hologram is a photographic recording of a light field, which is a wave phenomenon, a record of its unfocused diffraction pattern, while a photograph is taken with the use of a camera lens by directing focused light onto the film (Collier et al., 1971 and Saxby, 2004).

There are a number of different types of holograms, for exhibition purpose, this discussion focuses on display holography, which could generally be divided into two forms: transmission and reflection, both relying on laser exposure to create the diffraction of light. In addition, the different manners of recording exert a significant influence on the consequential image-reconstructing, (also referred to as wavefront reconstruction) (Saxby, 2004). The transmission hologram is developed with the use of object and reference light beams, incident on the same side of the holographic plate; therefore, the observer has to stand on the side of the plate opposite an

illumination. The light is directed straight from the back of the hologram, and the image is transmitted with the light to the observer's side (Unterseher et al., 1987).

The reflection hologram is made with the object and reference beams incident on the opposite side of the holographic plate - the resulting image is reconstructed with the use of a point source of light, located on the observer' s side of the hologram, where the light is reflecting from hologram to the viewer (Saxby, 2004). Both kinds of display holograms can be exhibited in a conventional darkened space. The transmission hologram is more restricted by the lighting, because a laser is a desirable illumination source. While reflection holograms can also be shown with the use of a laser, they are viewable in ordinary light, which makes them popular to present in museums and galleries, as well as an ideal medium for art holography.

The focus of this project is to combine a written language with the use of holography in order to create an artwork, allowing the author to explore the creative potential of text-orientated holographic images and its temporal aesthetic elements. Considering the nature of reading text, the created artwork would be expected to provide a viewing experience which is similar to reading a book. This suggests that the artwork would be recorded as a reflection hologram.

3.2 Creative Development

3.2.1 Holographic image replaying process

This section attempts to manipulate the principle of Denisyuk single-beam reflection hologram and turns the display convention into an interactive lighting method. A standard gallery lighting system normally lights its artworks from above; for displaying ordinary two-dimensional images, both exhibiting styles - portrait and landscape could be well presented under this illumination specification. However, the traditional Chinese characters are written in a vertical layout from top to bottom; right to left. For that reason, this series of experimental artworks intends to suggest a different arrangement of the scene design of Denisyuk display hologram recording.

This alternate setting attempts to build an optical path that has to be reconstructed by

lighting from the right edge of a plate, which results in the final holographic image only being seen from the right-hand side. The way of image presenting would reflect the linear temporal quality of traditional Chinese language. Moreover, this series tries to differentiate the display hologram from a fixed gallery lighting exhibiting style into an interactive mode. This method of image replaying would encourage beholders to experiment with illumination tools, ranging from a high intensity source of light such as a small spotlight to even a candle; testing with different lighting to explore the effects they like best.

Recording - In order to display and perceive the hologram of Chinese calligraphy in its traditional writing and reading orientation, the optical setup of the Denisyuk hologram needs to be re-arranged in accordance to the object's positioning. Changing from the conventional position, the object needs to be rotated 90 degrees anti-clockwise to the alternate position (Image 27).

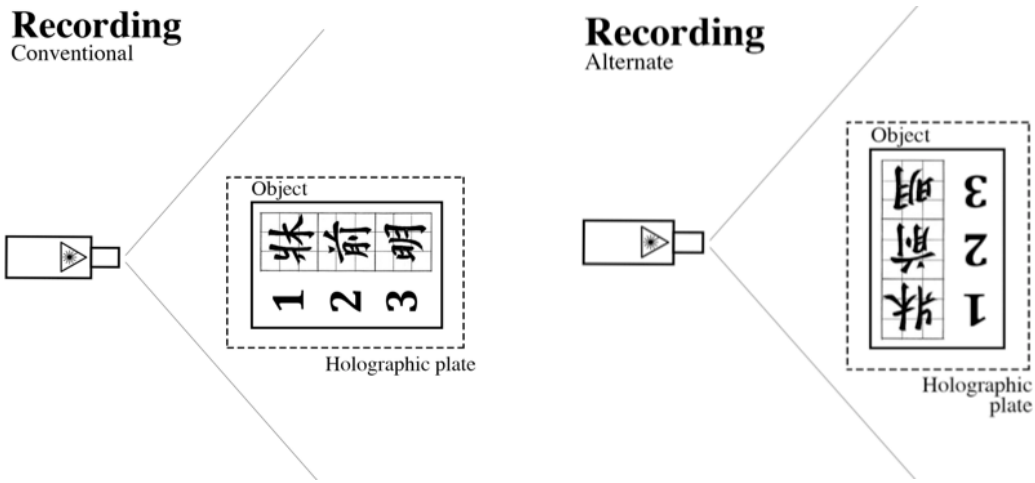

Image 27 Recording comparison (top view)

Display - in practice, if the hologram is illuminated according to the conventional set up, used by most galleries and museums, the viewers' perception of the Chinese writing would not correspond to the traditional orientation of the text. In order to resolve this issue, lighting from the right side of the plate is used instead to create the correct impression of the text orientation (Image 28).

Displaying a hologram is as important as producing it. This process is completely dependent on the optical arrangement of the recording, which has a significant influence on the final presentation. To comply with the objectives for hologram display, it is vital to meticulously follow the process of the holographic image reconstruction as a sequence of “rebuild” or “replay” actions, resulting from the light activities during the exposure. In this result, the interaction between light, shadow and the image can be controlled by the viewer moving the illumination source, following the right side of the plate in a set path and angle.

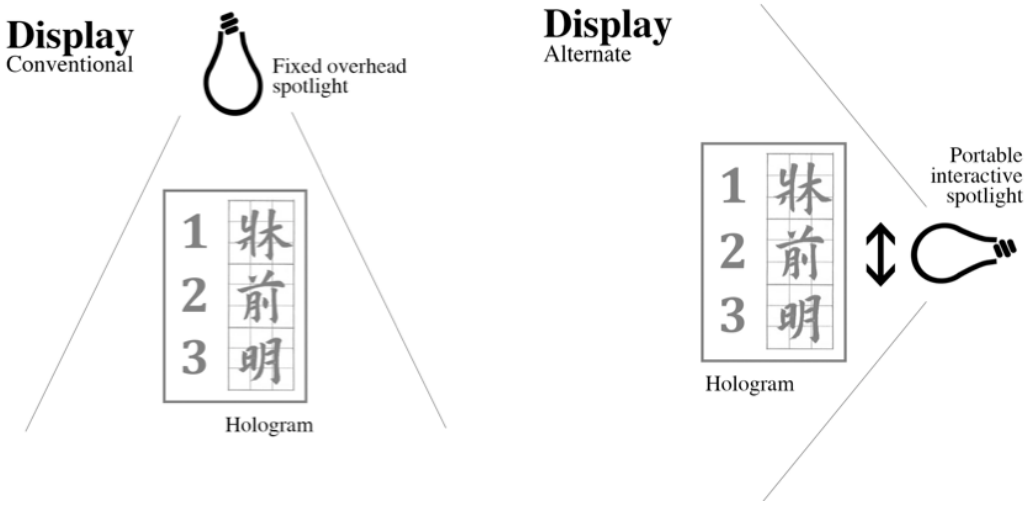

Image 28 Displaying comparison

3.2.2 Holographic Script

As a light source does not hit at the accurate angle, or is overpowered by ambient light, a hologram would not be able to diffract light and reconstruct the image efficiently, and cause the image to appear dim and lack contrast and sharpness. Although hologram display might seem quite demanding and posing challenges and problematic illumination requirements, it could be evolved to a directional expressive form in art holography. This photograph depicts a scene of the original arrangement, materials include: semi-spherical lens, stones and a piece of white tile. Moreover, there is a plate of clear glass suspended above all other objects, which incorporates traditional Chinese poetry written in metallic ink. In relation to the scene, the holographic plate is placed above all of the described objects (Image 29).

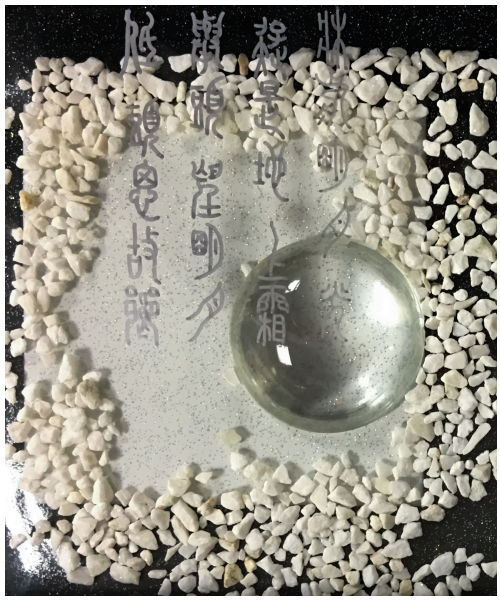

Image 29 A depiction of the scene

Li Bai's Night No. 1 is a reflection hologram recorded from the scene described above. This holographic image is reconstructed by incandescent white light positioned to the right hand-side of the plate. As the viewer moves the portable light source, the interaction between the Chinese characters incorporated on the glass and the shadows that are cast can be seen. As the light source is moved, the shadows move, replaying the scene as an actual arrangement of objects (Image 30).

Image 30 *Li Bai's Night No. 1*

Li Bai's Night No. 2, a reflection hologram depicts the traditional calligraphy arranged above a seashell. This plate documents and represents the well-preserved texture and detail of the shell. The shadows cast onto the shell are distorted by the uneven surface (Image 31).

Image 31 *Li Bai's Night No. 2*

4. Summary

This project integrates linguistic, pictorial and optical elements to create the light-based kinetic holographic script. The combination of Chinese calligraphy and holography in developing visual expressive techniques establishes an ephemeral dimension, which would allow the ancient literature to inhabit the holographic space. This research employs an investigation into the use of optical properties and the light-based representation of Chinese scripts, aided by analogue holography technique and its artistic elements, such as the optical, spatial and temporal visual qualities, to produce a series of creative works. This experimental process may lead an opportunity to develop a novel expressive form through the creation of a cross over between holography and Chinese calligraphy.

4.1 Language as a Culture Heritage

Language is a fundamental part of everyday life - it follows a path, paved by prominent speakers, writers and creators conceptualising their world. Human evolution suggests that language development usually follows behavioural change. The different styles of language application and practice could reflect the users' individualities, based on their preferable expressive structure, leading and influencing their perspectives of connecting and interacting with the world they inhabit. Hence, one can argue that calligraphy as a part of the Chinese writing system, is an ancient communicating practice and an art form which both shared the expressive nature of scripts. The variable style is predominately created by calligraphers, depending on their different levels of skill and technique or individual aesthetic attempts, so the same content could be interpreted in various ways.

Holographic script retains the graphic qualities of Chinese characters and converts the nature of two-dimensional written presentation into an optical mode, which activates the static text and also adds a vibrant tone to Li Bai's work. To disclose the interrelationship between viewing holographic images and reading holographic scripts, this project moves the poem, transposing from a physical surface to the holographic space. The final creative works reveals an advanced expressive possibility of the Chinese writing system as an art form.

For establishing a new expressive form to depict time, this project investigates the practical part of the light in this creation process, and found that light is intrinsic to the holographic art practice. Through the interactivity of light and shadow, the image of the holographic script can be faded in and out and distorted via constantly shifting the positions of the illumination. This image replying technique creates a kinetic visual effect, which could modify the rhyme and rhythm in the original text as well as stretch and reinterpret the meaning of "Thought in the Silent Night".

Holography is a studio, quasi laboratory-based art medium, which can only be processed and displayed in certain ways as in the early stages of photography. This project enhances the understanding of the nature of the mechanism within this

technique through a series of creative practices. It enables the exploration of artistic features within this material that are unique and representative of this medium itself. In terms of the processes of recording and displaying a hologram, the light is the essential tool to capture and playback the holographic image itself. Having formed the interference pattern, the light constitutes a hologram; moreover, the key of decrypting the invisible wavefront information into a visible content is the light as well. This project adopts the materiality of the light and takes it a step forward, using light as an intangible and directional guide to stress the linear layout for reading, but also, in the same way, the viewing orientation.

The project of holographic script demonstrates a great potential to present Chinese calligraphy holographically, which adds a temporal dimension to the traditional art form. Through this manipulation of reconstructing the optical path, the relationship between holographic image and written language could be redefined.

4.2 Temporal Aesthetics within Holographic Script

In terms of viewing holograms, constantly shifting the viewing point shares similar results by physically altering the position of the light source or artworks, which creates dynamic visual effects. In other words, either the audience or the hologram remains still, the holographic image can only be seen statically. This project applies the principle of holographic imaging replaying to create an illusion of movement (by moving the illumination), which can be considered as a different approach, since the majority of time-based media use sequential images to generate moving image in order to produce a similar experience. This also indicates that the temporal aesthetics created by holography is light-based.

In her article “Holography in the history of contemporary art”, Garcia-Robles (2006) coins the term of “real temporal movement” to express the main characteristic of the Kinetic and Light tendencies. She suggests that holograms are not just spatial representations; the aforementioned perceiving process could also produce similar syntactic features by using holography (p. 138). Moreover, the Canadian historian and artist, Desbiens (2012) uses “content metamorphosis” to illustrate the

modification of the holographic visual state. It could be created and further explored by the angle and distance variations between the illumination source, the hologram and the audience. Thus, indicating observational movements are the integral part of appreciating holograms. These variable imaging presentations highlight the temporal quality of holographic aesthetics; this time-related imaging performance, and its unique interrelationship with audiences reflects the nature of holography as a time-based media. As Boissonnet (2012) states, “the time of the image is the time of the observer. There is complete temporal identity between the image seen and the act of seeing”.

This project applies the holographic visual texture to classical Chinese poetry in order to revitalise its linear temporal quality, while liberating the internal movement and fluidity from traditional static perspectives. Furthermore, the setting of the optical path suggests a possibility to display a hologram, which shifts from image-orientated to text-orientated. Through the directional optic path reconstruction, non-Chinese speakers can further explore and experience the value of the classic layout in Chinese language.

Additionally, Chinese speakers could adapt the movement of the lighting source as a holographic representation method, in order to rediscover the interplay of symbolic and iconic visual language. In other words, viewers perceive Chinese calligraphy both as words and images, or even light and shadows, floating in the indefinite holographic space, where the structure of text could be constantly modified and create new meanings via a holographically defined linguistic experience. It signifies appreciating the holographic script as a spatial-temporal event, “it evokes thought processes, and not their result (Kac, 1996, p. 186).

Chapter 7 Holographic Slips – Thought in the Silent Night

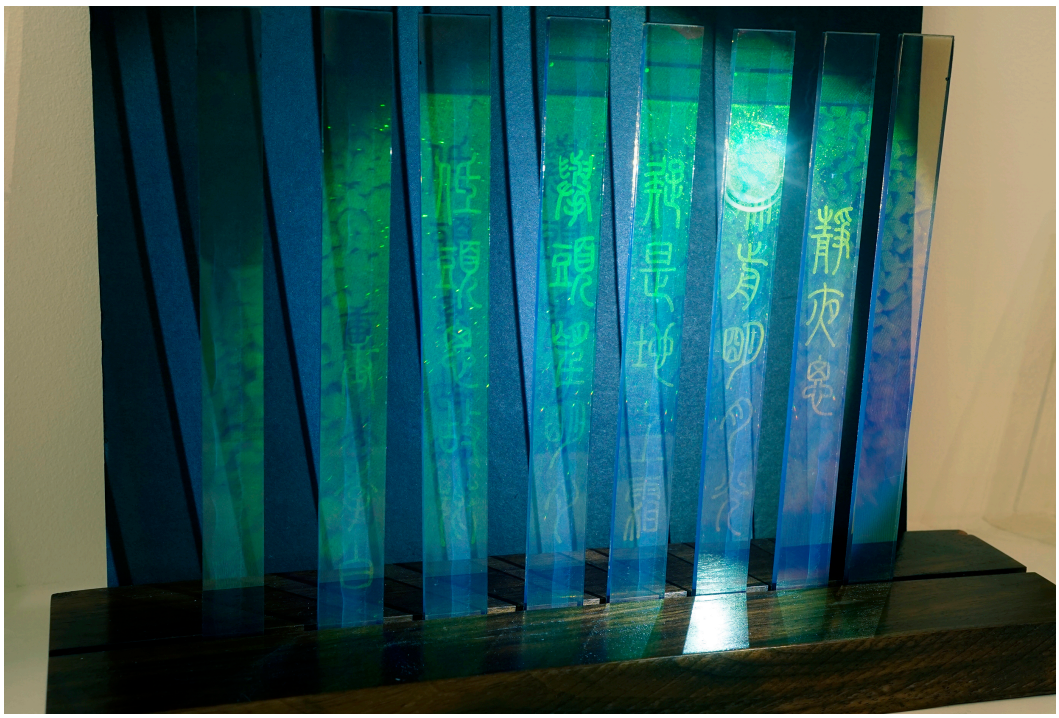

Image 32 *Thought in the Slight Night*, 2017, reflection hologram, 23.32 x 25.4 cm

This hologram is a complete piece of glass divided into a slips form, and the work is viewed section by section. The long and narrow shape emphasises the linear layout of classical Chinese poetry and reveals the whole message over time, adding a temporal dimension to this work. The image can only be better replayed when the illumination source hits the right side of the hologram, which leads the image to be viewed in the same direction with the Chinese writing convention (Image 32).

1. Introduction

In terms of contemporary art, time-based media generally refers to artworks that have duration as a dimension and unfold to the viewer over time. This could be a video, slide, film, computer-based technologies or audio. As part of this category, holography pushes this visual-oriented narrative a step further, which brings a real 3D image to invite audiences to revisit a scene of the past, at the moment of recording in space and time. They could also experience the kinetic holographic aesthetics through constantly changing either the positions of the viewpoint or the

illumination source, in order to create dynamic visual effects. In other words, when the audience remains still, the holographic image can only be perceived statically. In particular, this unique mode of aesthetic experience is not created by computer simulation; the principle of wavefront reconstruction process makes holographic art an exception from other time-based media.

The relationship between artists and audiences is intertwined; a novel artistic application of modern technology may come with a new sensory experience, or suggest a different way to perceive and understand the world we are living in. Although it is known for its three-dimensional imaging representation, the discussion of aesthetics of holography would be incomplete if the scope overly focuses on the depiction of the "third" dimension. Thus, this project intends to take a different viewpoint on the exploration of this medium's characteristic qualities through a series of art creations in order to take a more analytical view of the creative potential of holography.

2. Context

For displaying a holographic image most effectively, the way of positioning an illuminating source is critical. In practice, a standard gallery lighting system tends to be placed statically, in order to deliver a consistent quality of illumination for an exhibiting space. However, the project of Holographic Script demonstrates a artistic potential, which proposes that the use of a portable lighting can create a kinetic effect of a holographic image. This suggests that the manipulation of light source activates the image replaying process; the reconstructed optical path could lead the audience to view, read and interact with the image in a certain direction. Additional, the process of viewing this artwork encourages the audience to hold a torch to illuminate the image, instead of fixing the light on a wall, which indicates the importance of the audience participation in this project as well as shows the interrelationship between light and the holographic image. Furthermore, the kinetic effect could diversify the visual expression of the Chinese calligraphy; it could also expand the literal and figurative meaning of the selected classical Chinese poem.

Therefore, it seems important to recognise that the light can be viewed as an active element in the holographic image replaying process, and the impression of movement could not be created without the audience's participation. This suggests that the holographic optical property constitutes the piece of art and also constructs its own aesthetic convention. In other words, the materiality of this medium has a great impact on the process of artwork development; the nature of the material is intrinsically interrelated with the form of the resultant artwork. To extend this discussion, if the characteristic qualities of a medium dominate the structure of an art creation, in terms of Chinese characters, the traditional vertical linear layout might be influenced by early mediums that conveyed the written information, which includes bamboo slips. This leads the author to wonder if the linear quality and temporal aesthetics of the holographic script could be further reinforced by transforming this work into the form of bamboo slips.

2.1 Written Chinese and its Layout

Chinese is one of the oldest languages still in continual use. Jerry Norman (1988), in the preface to his book *Chinese*, suggests that "Chinese is only one of a very few contemporary languages whose history is documented in an unbroken tradition extending back to the second millennium BC". Although the development of Chinese writing is about two millennia later than the first appearance of writing in Mesopotamia; however, the latter is no longer used to write any living language in the modern world (Boltz, c2000). The earliest generally accepted evidence of Chinese writing, "oracle bone inscriptions", dates from the time of the late Shang Dynasty, (c. 1200-1050 B.C.). These scripts, engraved on turtle plastrons and ox scapulae, are used in a form of divination. It is estimated that at the end of the Shang dynasty there were between 4,000 and 5,000 graphs or characters already developed in common use, which suggests that the Chinese writing system was already well established (Norman, 1988). In addition, the characters that are in use in modern Chinese are structurally identical to the Shang script of 3200 years ago, which are created on the same principle, requiring that each word has its own separate graphic representation (Boltz, c2000).

For the purpose of general communication, Norman (1988) suggests that an ordinary college-educated person would know between 3,500 and 4,000 characters. A written sentence can be oriented in either a vertical or horizontal direction, since the Chinese characters consist primarily of monosyllabic units (or ideographic units), conforming to a roughly square frame, thus allowing for flexibility concerning which direction texts can be written. In the Chinese handwriting tradition, right-to-left vertical layout is the dominant structure, and Chinese calligraphy is the main medium to accompany this literacy culture.

Since the nineteenth century, cross-cultural written communications have become gradually more common; the editing techniques underlying that communication need to manage the intersection of their layout conventions. In terms of modern publication, there are a great number of different writing systems in use, operating on separate linguistic principles and individual graphic elements, which reflects various challenges and demands to a multi-script typesetting system (Etemad, 2005). Responding to this tendency, it has become increasingly common for Chinese characters to be written or printed horizontally, starting from left to right, with successive rows going from top to bottom. Adopting Chinese writing in horizontal alignment makes it easier to incorporate with other writing systems, for example, the insertion of mathematical equations, physical and chemical formulas and Arabic numerals. Moreover, this horizontal arrangement is easier to read, in particular, as two languages are bound together, for instance, listing English and Chinese side by side on utilitarian signs such as at a shop, street, train station or airport.

Additionally, there is no strong evidence to show which publication first printed Chinese text in horizontal alignment. However, Robert Morrison's "*A Dictionary of the Chinese language*", is a well-known early example of a break from the established vertical convention. This multi-script (Chinese-English) publication was published in Macau between 1815-1823. More recently, the emerging use of contemporary computerised typesetting, word processing software for Chinese

publication and the Internet, has led to a further growth of the horizontal writing layout.

2.2 Literacy and Chinese Calligraphy

"Literacy in China involved not only a profound knowledge of the written classics but also the ability to wield a brush, either to paint a landscape, usually with a poem inscribed at its side, or to write Chinese characters so as to convey not just their meaning but also their aesthetic vitality and the taste of their composer" (Keightley, 1996, p. 68). Chinese calligraphy is a genre of the writing of characters, which has been extensively used over many centuries in traditional Chinese society. In terms of execution techniques, Chinese calligraphy and painting are closely related; in particular, both are accomplished using similar implements, namely, brush and ink. Early evidence of using a brush as a writing tool can be traced back to a few oracle bone inscriptions that have been found. Here writing was done in red or black ink (Keightley, 1996). While modern publishing has increasingly encouraged the use of horizontal text layout, the vertical tradition still dominates the culture of Chinese calligraphy.

Furthermore, in the practice of written communication, Chinese calligraphy is generally associated with good penmanship. However, it is also frequently viewed as an art and is appreciated and exhibited in the same way as classical paintings. Due to these two art traditions, writing and drawing are mainly executed on Xuan (or Shuan) paper or silk. These are soft, thin and fragile materials. The ancient mounting technique and scroll-making process are also essential for the preservation and appreciation of both forms. This reveals that the Chinese calligraphy represents the dual role of written communication and visual art. Chinese calligraphy and brush painting are both deeply revered in Chinese art culture. The former still has a distinct identity, especially in its emphasis on solid lettering information rather abstractive visual expression.

3. Exploration

In terms of the holographic image replaying process, a reflection hologram can be displayed in a similar way to other traditional two-dimensional art forms such as photography, painting or print. The gallery lighting for holograms and audiences both are positioned on the same side in a conventional exhibiting space, creating an experience which is close to the process of viewing aforementioned 2D artworks. In this sense, it suggests that the reflection hologram is a preferred recording method for the text-oriented theme; in particular, the resultant artwork is designed to be viewed in a similar way as reading the text.

Moreover, Chinese calligraphy and painting operate on separate visual expressive systems, despite sharing similarities. In other words, while the traditional Chinese landscape painting is composed using perspective rules, the written language layout is constituted by it own linguistic culture. Thus, it is important not to confuse Chinese calligraphy with brush painting; especially, when an artist intends to record one of them into a hologram. It could lack the individuality, if the artist views these two aforementioned art forms in an undistinguished way.

3.1 Technical Premises

Optical settings play a significant role in the hologram recording and displaying. It means that the design of holographic image replaying directions could differentiate Chinese calligraphy from traditional painting. In this project, the author proposes a method to playback the image in the same direction as traditional Chinese writing layout. This concept integrates the structure of written Chinese and the principle of Denisyuk single-beam reflection hologram, in order to investigate the possibility of using the light as a guide to create a directional visual expression.

This setting intends to create an optical path which has to be reconstructed by illuminating from the right edge of a plate, resulting in the holographic image only being seen from the right-hand side (Image 32). Thus, in the design of optical geometry, the photosensitive emulsion (holographic plate) is positioned between the

laser and the object; the reference and object beams are incident on the emulsion from opposite directions. A processed hologram can be displayed with the use of spotlight, and the holographic image can be viewed when the reconstructed object beam is reflected from the hologram. The way of image replaying would correspond to the linear tradition of the written Chinese, right-to-left vertical layout (Image 33).

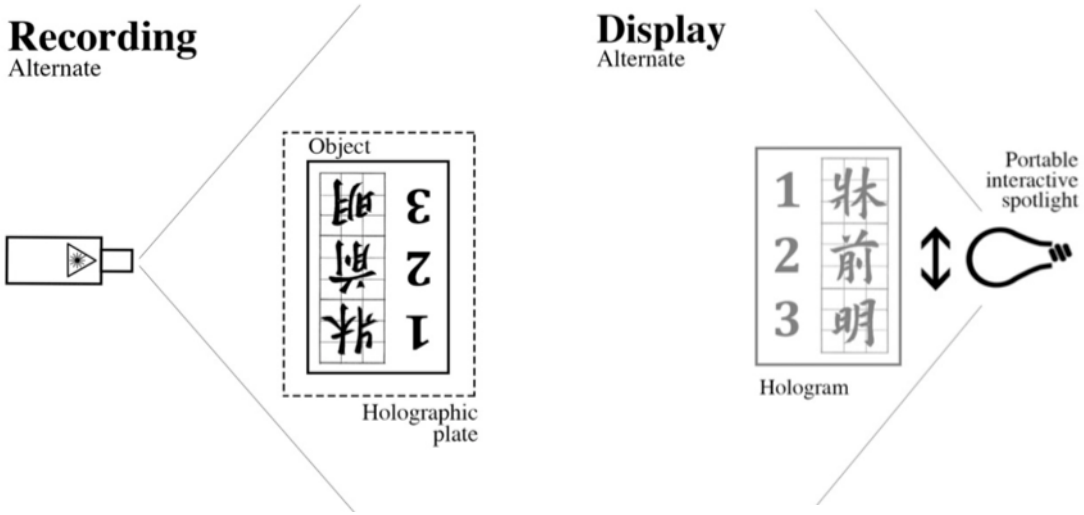

Image 33 An illustration of recording setting and displaying setting (top view)

3.2 Creative Development

This project continually uses Li Bai's "Thought in the silent night" as the content for the hologram recording. Image 34 illustrates the position of the light source during the process of image replaying. Using a spotlight to aim at the right edge of the plate, the holographic image could be revealed in the same direction as the conventional right-to-left Chinese writing layout. Image 35 shows the Thought in the silent night reflection hologram, which is composed with four lines each consisting of five characters. In addition, this work can create an impression of movement as the light source moves. This kinetic effect emphasises the characteristic qualities of the art of handwriting as well as the poetic text. Holography makes it possible to unfold the image to the viewer over time.

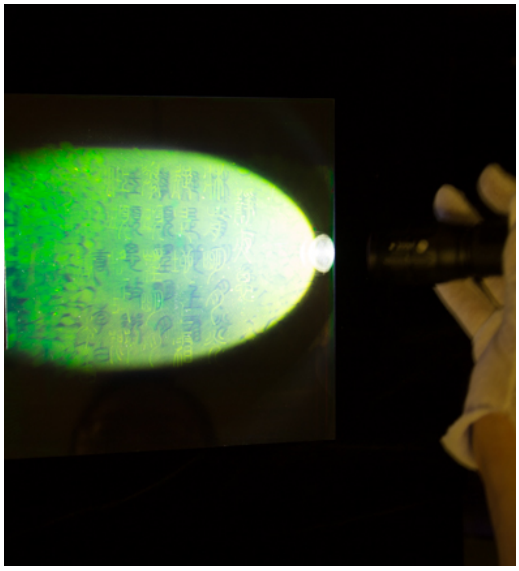

Image 34 A lighting position

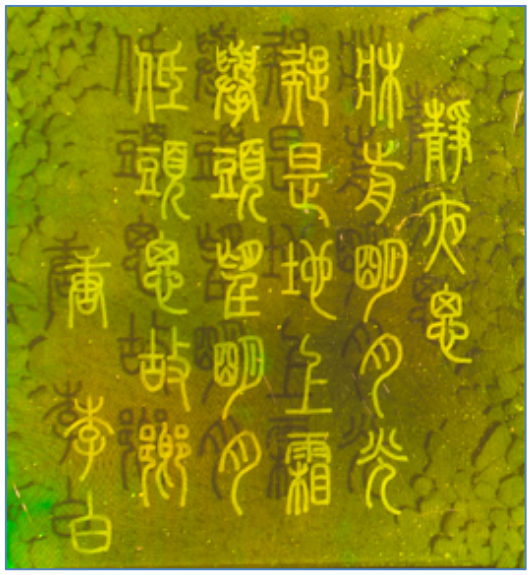

Image 35 *Thought in the Silent night* (uncut)

Bamboo slips are commonly used as a substrate to write on in ancient China and also an early adaptation of Chinese books. In the pre-paper times, a book was formed when all slips bearing all lines of an article were joined together with cord. The form of this material has been designed in a long and narrow shape, and the creation of vertical linear writing style corresponds with the structure of bamboo slips. Characters are generally written with a brush and ink, with one line on each slip.

By observing the relationship between bamboo slips and written Chinese, it reveals a paradigm which presents how a storage device interrelates to information it conveys, suggesting that when information has been stored or carried by a medium, the original information would need to be converted into a certain format which can be accepted by this medium. In other words, as Chinese calligraphy is recorded into a hologram, the way to appreciate it is no longer the same as the original calligraphy; despite both forms of artwork being exhibited in a similar exhibition space.

Therefore, based on the above discussion, it leads this section of the project to move the focus into exploring the relationship between the medium and the formation of information it conveys. Thus, the further development would transit the design of bamboo slips to the hologram, in order to investigate if the linear aesthetics of the

holographic script could be reinforced by transforming a standard glass plate into a scroll form. In addition, as discussed earlier, it has been proved that the movement of light can create a kinetic impression, suggesting that it can be viewed as an effective approach to strengthen the temporal aesthetics of the new formed holographic slips (holographic scroll). Furthermore, the intention of turning the holographic script into a scroll form would provide an opportunity to encourage the audience to hold this piece of work and to interact with the illumination source, leading the audience to further explore the linear temporal aesthetics which is created by a text-based visual expression.

In terms of Chinese language, it is important to recognise that the writing system and the materials it used were invented long before the emergence of paper. It suggests that the forms of Chinese characters could be influenced by the materiality of the various writing mediums, such as oracle bone script and bronze inscriptions. As paper and print were considered to be a relatively new media in ancient China, these two materials contributed not only an improvement in the technique and presentation of writing, but also had a positive influence on the spread of literacy. This novel creation brought an opportunity to access the written word in a less expensive and more convenient way. Now, in this increasingly post-paper age, people have multiple choices in both the way they write and the materials they use, shifting from old to new media, from solid materials to digital devices. Thus, at the centre of this holographic slips project is the desire to make connections between holographic properties and ancient Chinese philosophies. The bamboo slips are read by un-rolling the object, section by section. During the unrolling, the slips are placed flat on a table, thus revealing the whole message over time.

Moreover, the work of holographic slips is designed to be viewed or read in the same way as the bamboo slips. When the audience is un-rolling the piece of work, the whole message is revealed over time. This phenomenon is not only in the nature of perceiving a hand scroll, but also features a critical temporal quality in holography, which suggests that this medium could be argued to be time-based. In addition,

during the un-rolling process, what the audience perceived is not just the message, but also a physical weight of information in the hands, which has a strange and paradoxical contradiction to a hologram made out of light that has no weight.

Image 36 depicts the author's another artistic attempt, a prototype of holographic script uses 3D printed hinges to connect the slips, which could make the connection more durable. Image 37 shows computer simulated illustration of the completed holographic scripts. Due to the difficulties of photographing the unusual object, this simulated image depicts the final expected outcome.

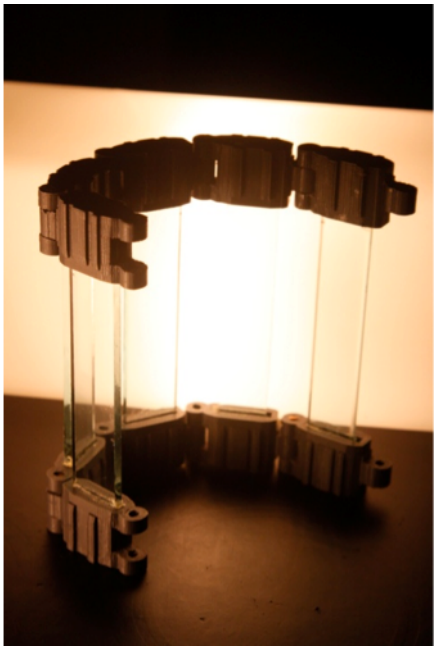

Image 36 3D printed hinges

Image 37 An illustration of the result

4. Summary

The invention of writing is one of the most important technologies in human history. A broad definition of writing is one form of human communication where verbal communication is represented visually. Olson (2016) defines writing as "the form of human communication by means of a set of visible marks that are related, by convention, to some particular structural level of language". There is a fundamental difference between writing and language. In the article titled, "The study of writing systems", Daniels (1996) states that "language is a natural product of the human

mind […] while writing is a deliberate product of human intellect: no infant illiterate absorbs its script along with its language; writing must be studied" (p. 2). Although writing had been created after language, it makes written historical records possible. Daniels (1996) describes writing as "a system of more or less permanent marks used to represent an utterance in such a way that it can be recovered more or less exactly without the intervention of the utterer" (p. 3). As the information is conveyed in the written form, it does not easily change from person to person. Therefore, the remaining accuracy and originality of the information can be easily delivered to people, thus passing on knowledge onto future generations, moreover, speeding the spread of modernisation.

A new optical kinetic expression is suggested via the experimental combination of holography, classical Chinese poetry and calligraphy. It is important to clarify that the creation of holographic slips is not intended to be a reproduction of bamboo slips. In the creative process, Li-Bai's poem is recorded into a hologram, and the resultant image is displayed in the scroll form. The linear literal visual expression of this work is structured by the original composition of the poem. It shows that each single sentence is arranged in a certain order, and presented through the use of narrow and long slips of hologram, which reinforces its linear quality.

In addition, as the image of the poem can only be seen holographically, it means that the portable lighting technique activates the optical properties of holography in order to create the impression of movement; in other words, the viewing experience of the holographic artwork could be considered as temporal. Holographic slips show a distinctive visual quality, which is clearly different from the poem when reproduced in other mediums. A common place shared between those mediums is that the linear narrative of the poem would lead the audience to view or read this piece, word by word, and line by line. This experience seems similar to playing music.

The development of holographic slips reveals the relationship between the medium and the formation of information it conveys. In particular, this work demonstrates

how a visual expression could possibly be modified by simply altering the physical shape of the hologram. It responds to the previous discussion, the creative potential could be expanded if the art medium can be broken down into a smaller substance or material.

This probably can be used to explain that time-based media artworks are mainly finalised in installation forms. The concept of turning holographic script into the scroll form would encourage the audience to further explore literal-based holograms. By holding this piece of work and moving the illumination source, this interactivity will not only adapt the linguistic quality in poetry, such as rhyme and rhythm, to visual form, but also open a space to discuss the altered meaning, when the same text has been conveyed by different mediums. As the author of “The medium is the message”, McLuhan (1964) proposes in the first page of the article, “content of any medium is always another medium”.

Chapter 8 Conclusion

1. A Reflection of this Research Process

Based on the earlier discussion, the works created for this study demonstrate that the visual quality of holography is clearly different from other time-based media, especially its technical and aesthetic factors are closely interrelated with light. As the dimension of time in visual art is commonly interpreted through the use of the impression of movement, and the conventional time-based media mainly employs sequential images as a technique to create kinetic visual effect. This study proposes holography as an art medium to establish a new approach to adding a temporal dimension to artwork. The resultant artworks state that the suggested approach could redefine the conventional notion of artistic temporal expression, as it creates a visual impression of motion with different means. Moreover, this indicates that the optical properties of holography and its art application need to be further investigated, as it could lead the aesthetic culture of time-based media to be expanded and diversified.

This study employs holography to explore the creative potential of time-based media, since its characteristic qualities are primarily light-based, which could depict the temporal aesthetics and not merely reproduce a similar effect or experience in a conventional way. By observing the development of time-based art, it shows that the works created in this category are mainly presented in installation forms, as the visual temporal expression could be effectively explored by a mixed-media creation. Therefore, to integrate the characteristic qualities of individual raw materials involved in the study need to be taken into consideration when formulating the new approach. It is also important to recognise that the choice of media combination and the arrangement of artwork presentation are deeply interrelated to the distinct materialities within mediums.

Following the above discussion, it suggests that aesthetic culture of an art medium can be viewed as a summary of its creative potential. For instance, a variety of holographic artworks created by predecessor artists demonstrate how this medium could have been treated, and what manifestations thus created. It is also important to consider whether holography should be handled in the conventional fashion, or depart from this approach. Since the goal of this study is to establish a new approach to the

interpretation of temporal aesthetics in visual art; the findings are supposed to present a different consideration on the artistic application of holography.

In the early stages of this research, the author focused on the development of skill and experience of holographic recording, as practical knowledge is essentially required to further this art practice research. After completing the project of 3D printed walking figures, the author gained more understanding about holography as an imaging technology and realised that the characteristic features of this medium are fundamental for the exploration of the new approach. The author recognised that a hologram commonly consists of multiple perspectives, allowing the audience to observe it from different viewpoints, which is similar to the experience of observing the object in real space. Meanwhile, the colour presentation of a holographic image could be changed as the viewing angle moves. Instead of shifting the viewing position, a similar visual effect could also be created by the movement of a light source; in other words, a manipulation of the image replaying process.

Inspired by Holbein's 1533 painting The Ambassadors, this study continually employed 3D printing technique to create an anamorphic skull for the recording of a hologram. In the holographic image, the audience cannot directly see the frontal view of the object and only can observe it from its mirror image. This leads the audience to study the skull which is based on the mirror images within the hologram, rather than directly refer to the object within the hologram. Unlike perspectival anamorphosis, the audience needs to observe from a vantage point in order to see the undistorted image; the mirror-based anamorphosis is reconstructed by the curved surface of a cylindrical mirror, suggesting that the specific viewpoint is not required. In terms of this anamorphic skull, it is created from a temporal point of view, as its (original) frontal view can only be seen in the plane mirrors. To reconstitute it into an undistorted form, a cylindrical mirror needs to be placed behind the distorted object, then the undistorted form can be viewed in the mirror image. These two types of mirror images are meant to be different, the altered appearances shown in the mirrors emphasise the changing perspectives and its interrelated points in time. The nature of 3D image representation leads the audience to walk along this holographic artwork, creating an experience which is similar to observing the skull in real space, relating the sense of time to multiple viewpoints. This project shows that the combination of

the principle of mirror anamorphosis and art holography practice could be an effective approach to unbinding the spatial and temporal restrictions of a conventional picture plane surface. The formation of this artistic expression is structured by closely engaging with holographic optical qualities, and its creative potential is clearly stated by the resultant work, which could be seen as a challenge to the conventional view of representative systems.

In a reflection on the project of Holographic Script, the author identifies that its image replaying process would be critical for displaying the holographic artwork, as light could be seen as an intangible guide, leading the audience to illuminate the hologram from right to left, in order to "view" or "read" the image from a direction, which is the same as the traditional Chinese writing layout. Moreover, the addition of the portable illumination could activate the text-orientated holographic image, and also reinforces the poetic meaning of the written form of classical Chinese poetry. The manipulation of lighting reveals the inherent temporal quality of holography, and the creation of the kinetic visual expression is fundamentally differentiated from the use of sequential images.

After completing several projects, the author gained more understanding about holography as an imaging technology and found that creative potential could be expanded if the concept of medium could be allowed a relatively broader explanation. By consulting the *Oxford Living Dictionaries* (OLD), the term "medium" is defined as "the material or form used by an artist, composer, or writer" (in its meaning 4). It leads the author to consider whether a hologram is a simple entity or if it can be viewed as a combination of simpler substances or materials. For instance, a hologram can be described as a holographic image encoded on a light sensitive plate, or a layer of gelatine coated on a piece of glass or film. To push one step further, if a hologram is described as a combination of a plate and the image it conveys, the discussion of materiality of this medium could be divided into two subjects, such as an image and a plate, or a layer of gelatine and a piece of glass. In this sense, the view of the further development of art holography would be different when considering it more than an imaging technology.

In response to the discussion above, the author created the project of Holographic Slips from the perspective of considering a hologram as a medium of image and a substrate of glass, in order to develop a different view in the discussion of holography art potential. This project illustrates a crossover application of the optical properties of holography with the form of the Chinese bamboo slips; the suggested illumination technique reveals this work's inherent light-based quality, which could be used to explore the creative potential of a text-orientated holographic art creation. The holograms created for this project are from a completed piece of glass divided into slips; each individual narrow and long piece clearly states the linear quality of the written classical Chinese poetry and also indicates that the temporal dimensional structure within this artwork is linear. The project of holographic slips reveals the relationship between bamboo slips and written Chinese, indicating how the writing convention could connect to the medium it uses, and also how a storage device interrelates to information it conveys. In other words, this suggests that when information has been stored or carried by a medium, the original information would need to be converted into a format which can be accepted by this medium.

2. A Conclusion of this Study

The intention of this study is to investigate the aesthetic qualities of holography in order to develop a new approach which could add a dimension of time to holographic artistic visual expression. This approach could also expand and diversify the creative potential of time-based media art, as other time-based media and also imaging technologies predominately use sequential images to constitute artworks. In the reflection on the artworks created throughout this study, the author identifies that the combination of both the slips form of a hologram and the portable lighting device is the fundamental structures of the suggested new approach.

Through the creation of Holographic Script project, it shows that the image replaying process could be manipulated as an intangible guide to lead the viewer to see an artwork which requires a viewing direction. The author also recognises that the use of the portable light could create a kinetic impression, which allows the audience to experience the appearance change of the holographic image over time, instead of shifting viewpoints. In addition, the project of Holographic Slips demonstrates that

the slips form of a hologram could unfold the image to the viewer as they unroll the artwork, which reveals the temporal quality within this form. Moreover, the author finds that this design could emphasise the poetic linearity, as the narrow and long pieces are used as an infrastructure to compose the layout of text-oriented holographic artworks. Therefore, based on the discussion above, the new approach formulated in this study would consist of the use of a portable lighting device and the slips form of a hologram, in order to create a visual narrative in a linear temporal format and present it from a specific direction.

The motor and tactile senses created by this approach are primarily constituted by the manipulation of light, along with the scroll form of text-orientated artworks that unroll during the viewing, both add the dimension of time to the holographic manifestation. This indicates that the principles of this approach are fundamentally different from the use of sequential images, leading the author to consider that the approach will develop new advances for time-based media art practice. In addition, it is also important to recognise that the proposal of combining the two key elements as the foundation for this approach is based on the concept of viewing a hologram as an imaging medium and also a glass substrate, which clearly draws a difference from simply employing holography as an imaging technology.

Furthermore, in terms of the characteristic qualities of holography, the visual expressive techniques and aesthetic features created for this study indicate that such works cannot be recreated without the use of holography. This study demonstrates that the irreplaceable aesthetic qualities of holography, suggesting that it could expand and diversify the creative potential of time-based media art, and the discussion of this category would not be comprehensive unless we take this medium into consideration.

A thought of the suggested approach to the future artistic application, the holographic image replaying process should be considered as an active role in the creation and presentation of holographic artworks. For instance, a literature-based subject matter could be presented in a dynamic form through the use of a portable lighting, which could possible reinforce or recreate the meaning of this written context. Moreover, with the application of the slips form, the holographic image is divided into long

pieces which reveals that this context could be restructured through this transformation.

After this process of investigation and exploration, the author is led to ponder the future of holographic art practice and her place within it. During the creation of the latter artworks, more opportunities for art pieces started to present themselves. Having deeply investigated topics such as temporal aesthetics, material characteristics and challenging mainstream notions of time-based media, the author feels one of the most exciting avenues for further practice is by using the virtual optical properties embedded within the material specificity of a hologram, with real objects created from the virtual, such as three-dimensional additive fabrication. This combination of the real and virtual created from the virtual and real, could have boundless possibilities that might go on to challenge notions of the installation.

Appendix A

Publications

CHANG, Y. N. and RICHARDSON, M. (2017) Holographic space: presence and absence in time. In: *Proceedings of SPIE 10127, Practical Holography XXXI: Materials and Applications*, San Francisco, CA., 28 January - 2 February 2017.

CHANG, Y. N. and RICHARDSON, M. (2016) Writing with Light: Interweaving Holographic Aesthetics with Classical Chinese Poetry. In: *Proceedings of the AVANCA | CINEMA 2016 – International Conference Cinema – Art, Technology*, *Communication*. Avanca, Portugal, 27-31 July 2016.

CHANG, Y. N. and RICHARDSON, M. (2015) Time within time: 3D printed sculptures within holographic art practice. In: *Proceedings of SPIE 10127, Practical Holography XXXI: Materials and Applications*, San Francisco, CA., 7 - 12 February 2015.

CHANG, Y. N. and RICHARDSON, M. (2014) Are you ready speak in 3D?. In: *Proceedings of the AVANCA | CINEMA 2014 – International Conference Cinema – Art, Technology, Communication*. Avanca, Portugal, 23-27 July 2014.

CHANG, Y. N. and RICHARDSON, M. (2012) Drawing Lines with Light in Holographic Space. In: *Proceedings of the 9th International Symposium on Display Holography (ISDH)*. Cambridge, Mass., 25-29 June 2012.

Award

2017 Leicester Society of Artists Student Award shortlist.

Exhibitions

2014 Practice- Based Research Showcase. Phoenix, Leicester (15th - 17th August).

Appendix B

The following document is a reflection of the early stages of the author's study, and this previously published paper focuses on the artistic quality of anaglyph and lenticular, which does not directly connect to the topic explored in this thesis in a coherent chronological manner. However, as some of the artworks included have been short listed for awards and others contributed to collaborative exhibitions; it is the authors opinion that this work can add some background exploration to some of the themes discussed in the main thesis. Therefore, it could be considered as a supportive written discussion as it is excluded from the main body of the thesis and also to give the reader an overview of another aspect of this research.

Drawing Lines with Light in Holographic Space

Drawing Lines with Light in Holographic Space

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Abstract. This paper explores the dynamic and expressive possibilities of holographic art through a comparison of art history and technical media such as photography, film and holographic technologies. Examples of modern art and creative expression of time and motions are examined using the early 20th century art movement, Cubism, where subjects are portrayed to be seen simultaneously from different angles. Folding space is represented as subject matter as it can depict space from multiple points of time. The paper also investigates the way holographic art has explored time and space. The lenticular lens-based media reveal a more subjective poetic art in the form of the lyrical images and messages as spectators pass through time, or walk along with the piece of work through an interactive process. It is argued that photographic practice is another example of artistic representation in the form of aesthetic medium of time movement and as such shares a common ground with other dynamic expression that require time based interaction.

Keywords: Holographic Art, Cubism, Motions.

1. Introduction

The theme of time has dominated aesthetic consideration in fine art. This is of course invisible but it sets boundaries and the ultimate challenge for artists is in developing, depicting and exploring methods to visualise quantifying rates of its change, not only as a visual abstract concept, but to also as the narrative of human condition.

The invention of photography made visual statements became more accessible for ordinary people; tourists can take pictures to illustrate vivid experiences from their point of view. Light is a compulsory element to create an image exposure on a frame of film, the developing process could be regarded as a novel technique that reveals very personal artistic perspectives, reproducing flakes of reality as the image creator experiences the world and time.

Stereographic based practices such as anaglyph, lenticular and holography offer a new dimension of visual art. That expedition into new forms of expression and aesthetic effects in time and space constitutes one of the most fascinating adventures in the history of art. This paper will trace the links between cubism and photographic artwork and then connect these to the theme of time and movement. This will involve an examination of depicting methodologies and representations.

This Research aims to explore the interaction between space, time, movement and visual perception by using three-dimensional representation tools such as anaglyph, lenticular and holographic technologies. It identifies potential associations between spatial imaging, perception, artistic interpretation and interaction. These practices will be a key for gaining an in-depth understanding to develop knowledge within the context of art.

2. Depicting Time

Following the advent of new technologies since the Industrial Revolution, people found that they could reach and connect the world quicker and broader than before. The invention of photography offered opportunities to make visual recordings more available and accessible for ordinary people. The concept of emerging techniques has had a tendency to lead artists into looking for new ways of communication in visual languages, similar to other new technologies that were crossing the geographical restrictions and bring people to explore diversity through world.

In the early of 20th-century, cubism launched its distinguished abstract style of modern art and introduced new ways of seeing. Cubists questioned the belief that art should be reproduced from natural and also challenged the traditional techniques such as perspective, light shadow, proportion, modelling and foreshortening.

This new way of seeing required a fresh concept of artistic representation. Cubist painters reduced the detailed description of objects and fractured the natural forms into semi-geometric shapes. They depict the simplified object from a multiple or contrasting viewpoints or fold space in this way they can portray the object at different angles and motions at the same time, according to the Heilbrunn Timeline of Art History [1]. The satisfactory results showed on their 2-D canvas, a single object can be seen from multiple perspectives in time.

Cubist painting responded to the innovative technology development; also captured this era's unique characteristics and transform it into a novel visual language. The artistic expression in painting and photography showed unexpected similarities between the manual visual statement and the mechanical visual statement. In near-monochromatic colour tone (e.g. browns, greys or blacks), objects be transformed to a series of overlapping plans, and the iconic artistic expression not only to represent cubist's aesthetic concept, but also could be found the analogous features of photographic works such as Muybridge's photographic works.

Eadweard Muybridge (1830-1904), made pioneering experiments, photographing motion which used multiple cameras and improved the development of the shutter to capture motion in stop-action photographs. Previous failed work was attributed to the lack of a fast shutter. "Woman walking downstairs", one of his remarkable works, viewers could distinguish the whole activity as separate movements through each frame. After this cooperated research programme with University of Pennsylvania, a portfolio "Animal Locomotion" has been published in 1887.

Muybridge's experimental photographic studies are recognised as an influential development on artistic creative practices and captured body movements by representing consecutive still images. These black and white photographs influenced Cubist's, who tried to simplify the colour description, in order to emphasise the fracturing geometrical objects in motions or seen from multitude viewpoints [2].

Figure 1-"Woman walking downstairs" (part), 1887, Eadweard Muybridge.

Let's compare it to 1912, Marcel Duchamp presented his distinguished oil painting of perpetual motion, "Nude Descending a Staircase (No. 2)". He responded Muybridge's photographic works, depicted fracturing body forms through successive images of movement in near-monochromatic gold and beige tones to represent a nude female in motions. This mechanistic style has successful signified the idea of visualised time movement, also showing the inspirational links with Muybridge's photographs and films on the analogy of visual narration, according to the website of Metropolitan Museum of Art [3].

Figure 2-"Nude Descending a Staircase (No. 2)" (left), 1912, Marcel Duchamp.
Figure 3-"A nude descends a staircase" (right), 1942, Gjon Mili.

A communication has been created between oil painting and photography, each medium has its unique artistic representation, but also expanding the potential possibility after blending their visual languages. Through Duchamp and Muybridge's work, Gjon Mili has developed a series of investigational works to successfully capture a sequence of action in one photograph by using stroboscopic instruments [4].

Following this emerging unique technology, holography made a strong dynamic visual statement to illustrate the movement. Jacques Desbiens's computer-generated hologram, "The Broken Window" (2006), the motion of a scroll painting from unrolling to expanding; a branch breaks through the window from behind, which brings allows the viewer to experience a new visual effect when they move from left to right, depicting a new narrative possibility connecting time and space [5].

Figure 4 -"The Broken Window", 2006, Jacques Desbiens.

3. Holographic artistic expression

Dieter Jung (2006) has described holographic art as being based on a technical medium, but its diversity and attractive vitality catch the attention of artists, leading them to transform vivid experimental imaginations into the "real virtual space", "shimmering with reflections of truth, fiction and fantasy" [6].

"A new sense of the notion of information has been constructed around the photographic image. The photograph is a thin slice of space as well as time", stated by Susan Sontag (1977) [7]. Compared with painting and photography the natural characteristics of medium, holographic technologies, these three-dimensional image recording mediums could offer multiple dimensions in 2-D materials for artistic representation as well as bring profound experience to audiences through its interactive display.

Setsuko Ishii (2006) has suggested that holographic art demands new forms of artistic expression and also has classified the characteristics of visual effects into three categories: "realistic three-dimensional image reconstruction", "viewing area constraints" and "colour of light". Based on these potential competences and relating the findings of artistic interpretation in cubism and photography, a series of creative artworks, which explore the dynamic, expressive, possibility of holographic art, as well as demonstrating the potential of spatial imaging as applied to the pictorial image [8].

3.1 Lenticular in art practice with still life

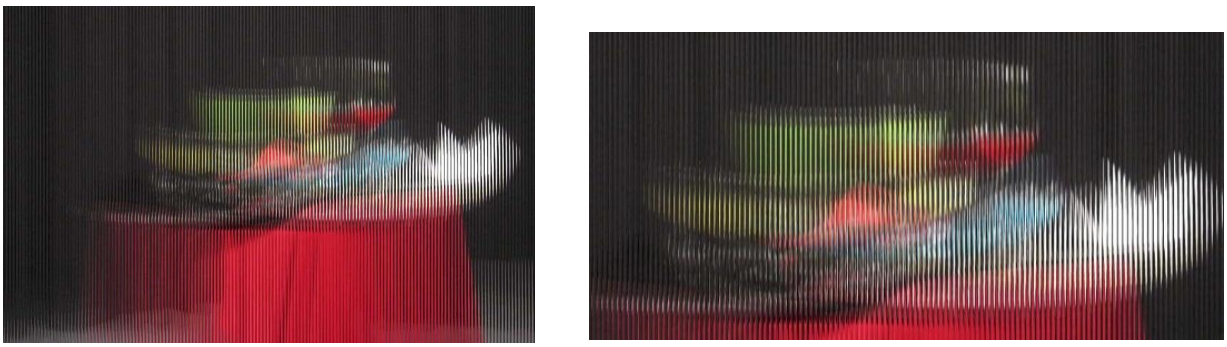

Figure 6- a) "Fly away". b) Enlarged details view.

Figure 6-"Fly away", 2011. a) Main part, which gives an idea about the working environment in which it was created; b) Enlarged details from the original source, a very strong sense of the semi-fracturing movement continues with the construct.

One of the outstanding characters of lenticulars is the representation of the three-dimensional image. This studio shoot was set-up with a digital camera, artificial lighting, tripod and rail. A sequence of digital photographic shots of the sill life has been made utilizing the movement of the rail system, capturing a multitude of viewpoints. Twenty-five frames have been collected, after the process of interlacing and lamination a view through the lens represents the image of three-dimensional reconstruction.

It is interesting to observe that the interlaced image has delivered a strong graphic statement as it displays without lens. A numbers of semi-fracturing objects form from different perspective when seen through consecutive recordings, these familiar narrative methods could relate to cubism artworks. Moreover, this visual effect has not come from artists' fantasy, that visual effect is the resultant form of computer graphic processing.

3.2 Lenticular in art practice with human motions

Original recorded (Fig. 7) by digital camera filming and editing before processing in Photoshop to create multiple layers. These consecutive frames show a man in motion. This process before interlacing is a vital creative step to check motion and flow. An excited finding shows the connection between photographic techniques and computer software, delivering movement within the still image.

Figure 7-"Passing" displayed in sequential format.

Passing (Fig. 8) was generated from 25 frames; a man just walking past the camera. However, his figure has vanished after the interlacing process because of fast movement. This unexpected result strongly points out that "time" is still is a key factor of image recording. The relation of motion speed and camera shutter could be defined as a key factor as the interplay between light and shadow.

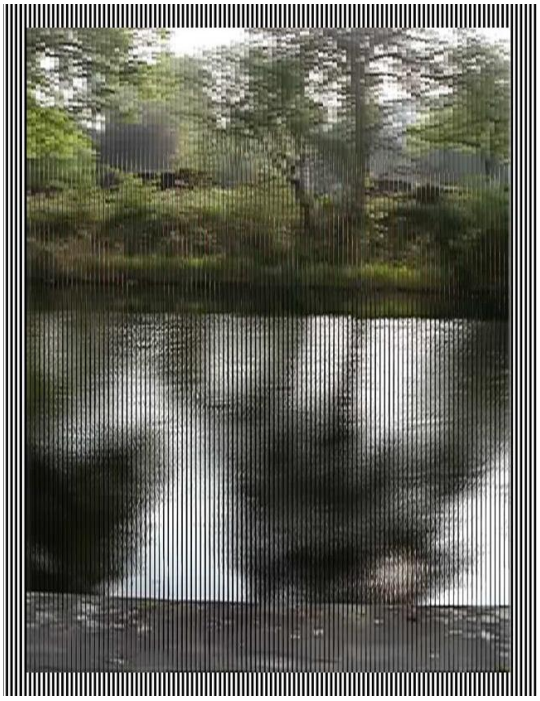

Figure 8-"Passing" displayed in interlaced format.

3.3 Anaglyph in art practice

Anaglyph offers stereoscopic (three-dimensional) effect by focusing each eye's image through applying filters of different colours, usually chromatically opposite (such as red and cyan.) It is explained that Red-Cyan glasses became very popular as 3-D movies became more and more accessible. However, what could be seen in the image as the viewer wears the glasses in a wrong way (right eye in red; left eye in cyan)? Can people visit an exhibition, but perceive two versions at the same time? To imagine it, people wear a pair of red glasses to visit an exhibition, and turning back re-visit the same images but only wearing cyan glasses that is fascinating! In "Good evening" (Fig. 9) there are two versions, viewers need to try on the glasses in both ways, the background may confuse viewers by its three-dimensional array paradox (pseudoscopic view).

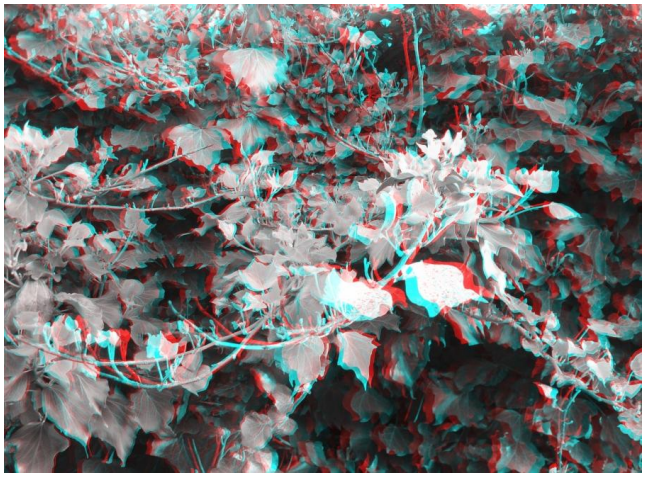

Figure 9-"Good evening".

Flip canvas (Fig. 10) refers to the concept of a multitude of viewpoints and traditional perspective law, using a mirror effect to recreate a composition; vanishing points locate the lower centre of this picture. The first glance with naked eyes, a convincing space was rebuilt. However, the reality only existed under the red-cyan world; people can see truth behind the sense through the specialised glasses when closing each eye alternatively.

Figure 10-"Flip canvas".

4. Summary

Moholy-Nagy identified photography is a form of artistic expression, which shared a similar tendency with other creative forms. The main influential factors are dependent on "present technical, scientific sociological trends and their relationships. As these relationships are not obvious to everyone it will be necessary to make an analysis of this statement and show by examples what its meaning is" [9]. It shows the importance of understanding the potentialities of materials, in order to distinguish their unique characteristics of being and how artists reflect their perspective of contemporary tendency by using such medium of artistic expression.

"A space inside other space, a shape inside other shape" says Isabel Azevedo (2012) [10]. In holographic arts practitioner possess an extraordinary instrument for reproduction/recreation. Art can be perceived by exploring multiple layers of meanings. Experiencing and interacting dynamic three-dimensional artwork will help the audience to experience the full concept of an artwork.

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Image

Figure 1 MUYBRIDGE, E. (1887) *Woman walking down stairs*. [Photography]. In: MUYBRIDGE, E. (1955). *The human figure in motion*. New York: Dover Publications Inc.
Figure 2 THE METROPOLITAN MUSEUM OF ART (2004) *Nude Descending a Staircase (No. 2)* [Online image]. Available from: http://www.metmuseum.org/toah/hd/duch/hd_duch.htm
Figure 3 LIFE (1942) *A nude descends a staircase* [Online image]. Available from: http://life.time.com/photographers/its-about-time-gjon-milis-stroboscopic-portraits/#7
Figure 4 I.JACQUES (2006) *The Broken Window* [Online image]. Available from: http://www.i-jacques.com/Text/Perspectives%20of%20synthetic%20holography-JacquesDesbiens-ISDH09.pdf

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