Classification of Holograms and Types of Hologram Used in Holographic Art

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ABSTRACT

Holography is a modern imaging technique which was created by the research and applications of numerous physicists, chemists, mathematicians and engineers, and which is still being continue to develop. With this technique, recording and storage of the light and sound and reconstruction of them at the desired time and space is intended. Mainly used in scientific and technological research and applications, holography, also began to be used increasingly in the field of art in many countries, by the time many artists had discovered the artistic potential of this technique in the 1960s. Holography is a technique that include many hologram types. Some of these types could be used in the holographic art, however each hologram type is not appropriate for artistic use. In order to understand which of them could be used in art, firstly classification of this technique as well as the types should be known. In this study, holograms are classified, and hologram types used in the holographic art,and holographic art terms are examined.

Keywords: Holography, hologram, holographic art, classification of holograms, types of hologram, terminology of holographic art,

INTRODUCTION

In 1947, Hungarian scientist Dennis Gabor who's an electrical engineer and physicist is the first who find the technique and gives it the name of Holography (Hecth, 2010). With this technique, all the features of the waves; wave intensity (wave height); wave color (wavelength) and wave direction (wave vibration angle) are recorded, stored and re-constructed (Onural, 2008). Previously, holography was a technique which is used only in laboratories, afterwards it increasinly has began to be used in more and more areas. Artistic potential of holography was discovered by a small group towards the end of the 1960s. Holography has a process which's similar to the history of photography in terms of technical improvements, market demand and artistic acceptance. The artistic

acceptance of the holography and the evaluation of it as a separate art form is based on the post-1980s (Johnston, 2006).

Holograms are produced by different techniques in holography, so that there are many different kinds of holograms. Knowledge of the classification of holography and the used varieties in understanding and evaluating the holographic art will contribute significantly to the preference of which type of hologram will be preferred. Therefore, in the study firstly the classification of holograms described and afterwards the hologram types which are frequently used in the holographic art is explicated (Işık, 2014).

CLASSIFICATION OF HOLOGRAMS

Holograms can be classified under the following headings (Işık, 2012):

Use and Study Area. There are many holograms which are used in many areas and for different purposes such as optics, electronics, medicine, IT, architecture, museology, art, culture, industry, military and security. These are classified according to the use and examination purposes under the headings like medical holograms, art holograms and security holograms etc.

Optic and Electronic Elements. Different kinds of holograms arise according to the *holographic optical elements* (HOE) such as lenses, mirrors, filters, prisms and etc. and *holographic electronic elements* (HEE) such as electrons, crystal displays, cameras, computers, etc. which are used in hologram recording and re-construction.

Holographic Object. Holographic object can refer to an object which is dead or alive, with or without motion as well as it can refer to the sound frequency, microscopic organisms, electrons which are so small to be seen visibly and subatomic particles. Also sometimes a hologram may be the object of another hologram (fig.1). Depending on the nature of the holographic object different hologram varieties are emerging.

Fig. 1. Copy and Multiplication Hologram's Hologram.

Photo. by Vildan Işık, Hangyo Int. Corp. R&D Center Holography Lab., Seoul-S.Korea.

Fig. 2. Developing/Bleaching.

Photo. by Vildan Işık, Hangyo Int. Corp. R&D Center Holography Lab., Seoul-S.Korea.

Fig. 3. Color / Illumination.

Photo. by Vildan Işık, Hangyo Int. Corp. R&D Center Holography Lab., Seoul-S.Korea.

Fig. 4. Illumination / Dimensions.

Photo. by Vildan Işık, Hangyo Int. Corp. R&D Center Holography Lab., Seoul-S.Korea.

***Referance and Object Beam*.** Different types of holograms have emerged depending on the positions, numbers and the angles of the reference and object beams used in holographic recording. There could be different hologram types such as reflection, transmission, single beam, off-axis, on-axis.

***Copy and Multiplication*.** Copying and reconstruction of holograms with various analog or digital methods is possible (fig.1). These methods are generally grouped under the following headings:

Broken Hologram. A holographic plate/film preserves all of the information belonging to the whole in all of its pieces even if it is broken. Each of the broken pieces may be used as a master hologram. This feature is not available in every type of hologram. Transmission-H1 holograms are that like holograms.

Hologram's Hologram. Making a hologram to be the object of another hologram and producing a new hologram is possible. These could be defined as copy hologram or H2, H3 etc. White light transmission, rainbow and multi-channel holograms are of this type.

***Developing Phase*.** Some holograms has been going through a bathroom process in the dark room after the record. In this process which the recorded image is stabilized, to increase the transparency and gloss of the hologram also a *bleaching* operation is applied with chemicals (fig.2). This type hologram which become transparent by bleaching is called *phase hologram*. Artists often uses bleached phase holograms to show the 'back' of the hologram to the viewer.

***Color*.** Different kinds of hologram arises according to the usage of red, blue, green laser beams individually or by a combination (fig.3,4). These are different hologram types such as achromatic, true color, pseudo colorand, multi color.

***Illumination*.** Depending on the method they're recorded, holograms are displayed in different ways and are sorted accordingly (fig.3,4). Some holograms are visible with laser, some in a special light reference, and some in an ordinary light reference or daylight. For example, transmission-H1 holograms are visible with laser, whereas holograms such as rainbow, solar embossed hologram can be seen in ordinary light.

***Construction Stages*.** To define the holograms according to their construction stages H1 and H2 symbols are used. In some types, for example in sandwich holograms H3, H4 symbols are also used (Tornare, 2007). H1; is a single step hologram which can be used as a master hologram. This is the direct recording of the laser beam as a one step

operation from the object. The symbol of H2 is used to define a copy hologram which is the hologram of a hologram or a two step hologram (MIT, 2001).

Dimensions. Dimensions is pointing to the hologram size as well as to x, y, z planes (fig.4). It is possible to classify the holograms according to their size in three different ways:

Thick and Thin Holograms.

Thick hologram points to the *volume* and thinhologram points to the *plane*.

Small and Large-Scale Holograms. Size definition, an edge with new techniques, it usually ranges from 60 cm to large is called large-scale hologram. Produced many hologram size is quite small, but nowadays can produce 3 m^2 white light transmission hologram.

Dimensional Holograms.

1D hologram is the linear record of one of the x, y or z-axis data. One-dimensional sound frequencies' holographic record is done in acoustical hologram.

2D hologram is used to define the holographic recording material such as glass or film, the holographic printings without parallax effects however which various colors could be seen and the holographic projection without parallax effects.

2D/3D hologram is used to define holographic recorded surface and the dimensions of this surface. The 3D identification here refers to the paralaxe property of holograms, and to the real and virtual area or the distance between the images which're recorded over and over on a single surface. 2D/3D identification is used for many kinds of holograms that are used frequently by the artists (fig.4) and for some holographic printings used in security systems.

3D hologram is used to mean to display a shiny, transparent, three-dimensional hologram which is visible from every point and which you can go around them.

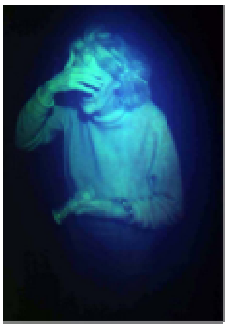

Fig. 5. Reflection Hologram

Anaït Arutunoff Stephens, *Scearching*, 1997, pulse laser reflection hologram (art-in-holography.org. 1996).

Fig. 6. Transmission Hologram

Al Razutis, *Pose*, 2007, master transmission hologram and model (alchemists.com)

Fig. 7. Denisyuk Reflection Hologram

Yuri Denisyuk with his reflection hologram (vanrenesseconsulting.com).

TYPES OF HOLOGRAM USED IN HOLOGRAPHIC ART

***Reflection Hologram*.** These holograms can be H1 and H2 as well as they can be single color and multicolored. During recording, reference and object light is in the opposite direction of recording material in its reproduction, it has to be illumunated from the front with 45^0 white light. Field depth of reflection holograms is smaller than transmission holograms. Virtual and real image are limited by approximately 25-30 cm. Despite this, reflection hologram preserves its parallax perspective as horizontal and vertical. In this holograms bleaching are very important because these holograms have a very small amount of natural brightness (Leonardo, 2001). Examples: Margaret Benyon's*Tiger Girl*1985, Patrick Boyd's*Lucy in a Tin Hat* 1988, Harriet Casdin-Silver's*Coda* 1990s and *To*

*Van Eyck and Bosh*2004, Alexander's*Surprise* 1992, Ana Maria Nicholson's*April* 1990s (fig.9), Rudie Berkhout's *Lift-Off* 2001, Anaït Arutunoff Stephens's *Scearching* 1997 (fig.5).

Transmission Hologram. "A master or copy hologram in which the image can be viewed when a light reference passes through the recording medium, somewhat like a slide. When a transmission hologram is a master hologram, it is reconstructed using laser light. Copy transmission holograms, however, are illuminated with white light, and in some cases, can be viewed with a mercury or a sodium lamp" (Leonardo, 2001: 379). This type"is viewed with laser light, usually of the same type used to make the recording. The virtual image can be very sharp and deep. Captures an image of a subject much bigger than the holographic plate or film sheet that records the hologram. Reflection holograms cannot do this easily.Have an image can be projected onto a screen or other surface with a laser. Can be broken into small pieces whereby each piece still contains the entire image" (Jeong and Jeong, 2005). Examples: Paula Dawson's *To Absent Friend* (1989), Al Razutis's *Pose* 2007 (fig.6).

Denisyuk Hologram. This hologram found by Juri N. Denisyuk in Russia, 1961 is a hologram of reflection in which a single laser beam for object and reference beam (fig.7). These holograms are the first visible H1 holograms seen in white light. Despite having generally quite a small depth, an extremely realistic image of an object can be viewed. For the brightness and clarity of the hologram, as in all reflection holograms, in Denisyuk hologram as well, recorded image should be stabilized by developing and cleared afterwards. Denisyuk hologram has been a kind mostly used in arts to record invaluable objects in museums for the documentation of objects (Leonardo, 2001; obel.ee.uwa.edu, 2011). Examples: Al Razutis's*Newtonian Galactic Assembly Line* 1974-76, Wenyon & Gamble's *Biblyography* 1992.

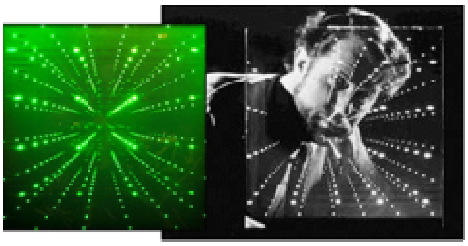

Fig. 8. White Light Transmission Hologram - WLT

(a) Stephen A. Benton, *Crystal Beginning,* 1977, white light transmission hologram, 30,48 x 30,48 cm, Eve Ritscher Collection **(b)** Stephen A. Benton with his work (www.holophile.com. 2009).

White Light Transmission Hologram – WLT. It is also known as Benton hologram because it was developed by Stephen Benton in the USA in 1969 (fig.8 a,b). It is a H2 hologram which was produced from master hologram. Benton's works brought important development not only scientific but also artistic as well as commercial areas (mit.edu, 2003). Especially WLT holograms can be seen in daylight and can be hung on the wall and these reasons played very important role increasing of artistic potential of hologram (Johnston, 2005). Thus, as an artistic device, artists started to use holograms which can be seen in daylight or halogen, led or ordinary light bulb instead of making holograms that can be seen only with a laser. Examples: Rudie Berkhout's *12mW Boogie*1978,Setsuo Ishii's *Frozen Time*1983, Sam Moree's *Phoenix 46*1996, Harriet Casdin-Silver's *Ian* 1994, Richard Kostelanetz's *On Holography* 1978 (fig.11).

Fig. 9. Pulse Laser Hologram

Ana Maria Nicholson, *April*, 1990s, approx. 50 x 60 cm, silver halide holographic film. Model: Korean dancer April Yao (anamarianicholson.com).

Fig. 10. Multi Channel Hologram

Vildan Işık, *HoloSuret-V*, 2012, two channel reflection hologram, 19 x 23,5 cm, silver halide holographic film, center wiev. Produced place: Hangyo Int. Corp. R&D Center Holography Lab., Seoul-S.Korea. (Işık, 2012).

Fig. 11. Holographic Stereogram.

Lloyd G. Cross (b. 1934) with oil lens in 1977. Credit: Courtesy of the Massachusetts Institute of Technology Museum, Cambridge, Massachusetts (Johnston, 2006: 179).

Pulse Laser Hologram. Pulse laser is a firm solid state laser spreading complying lights in short and non-permanent form. This laser is used to record animate objects and vivid scenes. Once only being able to record inanimate and static objects, with the advent of this laser now it is possible to record animate objects such as humans, animals, flowers as well as active inanimate objects such as falling water, soap bubbles, scattered feathers and popcorn with the help of pulsating laser. The development of pulsating ruby laser in the early 1980s allowed much easiness for hologram artists (Leonardo, 2001; holograms.co.uk: 2012; Nicholson, 2009).Examples:Ana Maria Nicholson's *April*(fig.9) and *Keith Haring's Portrait* 1990s, Sally Weber's interferograms, Al Razutis's*Pose* 2007 (fig.6), Anaït Arutunoff Stephens's *Scearching* 1997 (fig.5).

Multi Channel Hologram. This type of hologramis produced by the masking and multi exposure methods of hologram patterns. More than one holographic plate can be used in layers and also can be multi exposed by using one or more than one patterns. This technique provided much flexibility for artists in terms of manipulating the form and colour. Multi-channel holograms can be produced with these holograms exposed many times with laser light(Leonardo, 2001). Examples: Margeret Benyon's *Tiger Girl* 1985, Vildan Işık's *HoloSuret-V* 2012 (fig.10).

Holographic Stereogram. This technique consisting of taking and combining the images from different angles through camera and computer, combines photography, cinematography and holography. Lloyd G. Cross, who is an American physicist, first took pictures turning around a person or an object with traditional photographic diapositive and then made these series of diapositive holograms (fig.11). Later, he mounted these holograms in a roller which is 120˚ or 360˚ so revealed the first holographic stereogram (Cross, 1992). Holographic stereogram which was developed by Cross influenced considerably the use of holography artistically. Generally stereograms are displayed by turning on an axis but the movement and depth of partial cylindrical holograms show up

with viewer's movement which is in front of hologram (Leonardo, 2001).Example: Paula Dawson's *Luminous Presence* 2007 (Dawson, 2008: 303).

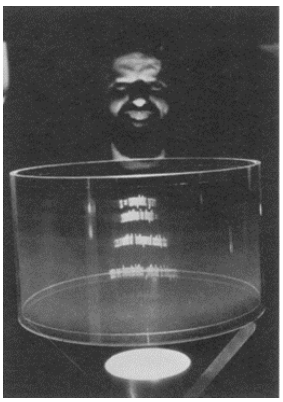

Fig. 12. 360˚ Hologram.

Richard Kostelanetz, *On Holography*, 1978, 360^0 cylindrical white-light transmission hologram, R .41.5 cm, h. 24 cm, photo: Robert Haller, Pittsburgh, Penn. "The cylinder was rotated by an electric motor at 1 rev/min" (Kostelanetz, 1980: 40).

360˚ Hologram. There are many ways to make holograms which have effect of 360˚ parallax. 360˚ holografik stereogram, 360˚ cylindrical hologram and volumetric hologram are some of this kind of hologram (Saxby, 1994). Volumetric holograms are images which are 'floating' in the air, can see from all angles by turning around of people but almost not possible to make it without controlled laboratory tests (komar.cs.stthomas.edu). 360° holografik stereograms and 360˚ cylindrical holograms are the most common used by artist. Vildan Işık's work which is called *Holo-Suret IV* is an example of this hologram. It is formed by combining two 180˚ holograms which are recorded separately. This is also called integral hologram. Image formed in the middle of the cylinder in the air and only can be displayed by laser. Examples: Aaron Kurzen's*Primal Manifestation* 1977 (Kurzen, 1983: 10), Ray Park's *Coexistence* 2011, Richard Kostelanetz's *On Holography* 1978 (fig.12).

CONCLUSION

Using different diversity of different holograms in art enriched visual expression and figuration also it enlarged the limitation of many branches of art. It is also necessary to emphasize holographic art is not limited just is explained in this study. There are also many diversity of holograms which are used for artistic purpose such as computer generated, embossed, rainbow, holographic interferogram and digital hologram etc. which do not take place in this study. If we regard that holography is a technique which still continue to develop, it is possible to say that it will be changes in the diversities of

holograms which are used in art. Because of complexity of holograph technique and high of its cost, even if these pose an obstacle it will be used more common in art in time. Thus, it will emerge a new philosophic trend between reality, virtuality and multi-sensory areas.

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