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Characteristics of the Historical Transitions of Computer and Holographic Images

Sachiko KODAMA

Department of Human Communications, The University of Electro-Communications, Chofu-shi, Tokyo 182-8585, Japan
E-mail: kodama@hc.uec.ac.jp

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Abstract. Visualization techniques based on computer and holography were developed simultaneously, but their evolutions followed opposite directions, figurative and abstract. Referring to art works of computer graphics and holography, the author discusses histories of these techniques along with their technological fundamentals and other factors.

1. Introduction

Many artistic images have been created both by computer and holography. Those media were invented almost at the same time in the middle of the 20th century, and various visualization techniques have been developed therewith. Some of these techniques were applied to art and resulted in a lot of artistic images. We can see several differences between computer and holography, both in visualization technique and type of art. It seems that there are some definitive rules that determine direction of development of artistic expressions. These rules are considered to be derived from technological processes.

2. Why Computer and Holography?

We compare images that are created by computer or holography mostly in terms of the form of images. Technological differences must affect those of image expressions. The most important as media to communicate information is that the computer treats digital data, while the holography is concerned to continuous and coherent light.

A computer is a machine that calculates and processes digital information sequentially. Holography is a technique that reconstructs a wavefront using interference patterns and processes analogue information. Note that the photography is another technique that deals with analogue information, but records the light amplitude recorded on a film, while hologram includes the phase information.

Thus, computer and holography show a strong contrast in the way of processing visual information, which is why we compare their histories.

3. Characteristics of the Historical Transition of Computer Images

The first step in computer visualization techniques was to draw points or lines on the display, namely in the early 1950s digital computers were utilized to show images on CRT displays. Later, some elementary visualization techniques such as drawing perspective were developed in the late 1950s. Around 1960, two important achievements were made, one by Fetter's group in Boeing Company (FETTER, 1965) and the other by Sutherland of MIT (SUTHERLAND, 1963).

In Fetter's graphics, he put data of three-dimensional coordinates of an airport and airplane into a computer, and made wire-frame models that were animated to simulate airplane flight under variable conditions of weather by the use of FORTRAN programs. In this kind of technique, a model consists of sets of data and programs, and the computer performs calculations to show graphics without human intervention. It is considered to be computer graphics in the original sense.

In Sutherland's graphics, he held a light pen in his hand and drew wire-frame figures communicating with the computer interactively. His Sketchpad system was able to interpret information drawn on a computer display and to change drawings. It was the first system that enabled interactive image processing.

These two examples show that there were already two directions in the early stages i.e. computer graphics and image processing.

In the 1960s, a small number of art works based on image processing were produced, because there were few computers and input/output machines with sufficient image processing capacity. While computer graphics works were created under the name of "computer art", those were generated purely by sets of programs and numerical data, and output by printer or plotter. At first, it was computer engineers and mathematicians who made art works, with an aim to express solutions of equations. But, subsequent drawings were created in a more artistic approach. Noll, who was working in Bell Laboratory (NOLL, 1966), and Nake and Nees, who were affected by Benze's information aesthetics, created distinctive line drawings to construct geometrical figures using random number generating programs (BERKELEY, 1966). Kawano made several drawings by the Monte Carlo method (KAWANO, 1972). Franke, who had already produced art works using an analogue system in the 1950s, also made plotter drawings by some mathematical processes (FRANKE, 1985). Csuri and Shaffer made pioneering works of image processing by using computers to transform images that had been originally created by photography or hand drawing (BERKELEY, 1967).

Experimental computer animations of both kinds of computer graphics or image processing were also created in this period. Whitney made 'Permutations'(1967), which consisted of various types of dot patterns in rhythmical motion (WHITNEY, 1969).

After that, the development of techniques split into two directions. One was three-dimensional computer graphics (3D-CG), which generated images based on programs and data, and the other was image processing, which could manipulate images that had been acquired through optical instruments.

In the field of 3D-CG, objects of image expression changed from geometric abstract to figurative bodies. Sutherland, who had moved to the University of Utah, played a central role in the development of this field. From 1968 to 1974, he and his colleagues developed hidden-surface algorithms, shading, and image mapping algorithms, which became the basis of 3D-CG. Based on these prior studies, many important researches were made in the 1970s. Innovative achievements in 3D-CG since 1974 are shown in Table 1.

Research of methods to create realistic images made a progress, and in the 1980s researchers looked for objects that had not been expressed in computer graphics and tried its realistic expressions. In the late 1980s, various expressions of materials were investigated, such as cloth modeling (WOLFE, 1998). Realistic 3D-CG was rapidly introduced into commercial purpose, especially by film industries. 'Luxo Jr.'(1986) was a famous animation that demonstrated the amazing capability of computer graphics in this field. 3D-CG was introduced in the design field, too. On the other hand, artists produced art works making use of 3D-CG. Kawaguchi simulated growth patterns of seashells or plants in his animations and produced a fantastic world of artificial creatures (KAWAGUCHI, 1994). Latham also used non-linear mathematical models to make highly complex forms (LATHAM, 1989).

The other direction of computer visualization techniques, image processing, also developed from the 1960s. Early digital image processing techniques were used to analyze pictures taken in planet research. In 1969, the first book that dealt with digital image processing was published (ROZENFELD, 1969).

It is clear that video technology influenced the art works of digital image processing. Paik's video art was pioneering in this field. In the late 1970s, full digital image processors appeared and were used by artists. (Around the same time, video games became popular.) Representative digital image processing machines are shown in Table 2.

Emshwiller's 'Sunstone' (1979) used the PAINT system developed by Smith, and took advantage of digital frame memory that had been just developed. In this animation, faces appear on the surfaces of round stones, changing expressions and repeating self-reproduction. Vazlka's 'Artifacts' (1980) used Shire's image articulator and tested various processes enabled by it. This animation starts with an experiment of noise, and various techniques were used for images of hands and spheres. He explored the potential of digital image processing in this work.

Table 1. Progress in three-dimensional computer graphics.

1974	Sutherland	Computer graphics: ten unsolved problems
1975	Blinn, Newell	Utah teapot
1976	Crow	Aliasing
	Blinn	Image mapping, texture mapping, bump mapping
1979	Whitted	Ray tracing
1980	Carpenter	<Vol libre> (fractal mountains)
1981	Potmesil, Chakravarty	Field rendering
1982	Max	<Carla's island>
1983	Potmesil	Motion blur
1984	Goral, Torrance, *et al.*	Radiosity

Table 2. Transition of digital image processing machines.

1970	Kitching	ANTICS
1975	Smith	PAINT
1976	McArthur	SAID
	McArthur, Shire	Digital image processor
1979	Scitex	Scitex color system
1980	3M	Scanamural
1982	Quantel	Quantel paintbox

From a historical viewpoint, we can see a direction of 3D-CG from geometrical abstract to pictorial expression, while in image processing figurative images were edited into newly integrated ones.

4. Characteristics of the Historical Transition of Holographic Images

Holography was invented by Gabor when he was trying to improve resolution of electron microscope, i.e. holography was born in relation to "seeing" from the beginning. In 1962, Denisyuk invented white light reflection holography (DENISYUK, 1962). In 1964, Leath and Upatonieks created the first laser transmission hologram that enabled the reconstruction of clear images of deep objects in three-dimensional space (LEATH and UPATONIEKS, 1964). Projected by a helium-neon gas laser, it represented a model train engine behind a glass plate. In the 1960s, the basic techniques of holographic display were developed, for example, cylindrical holograms related to holographic stereograms, and techniques of HOE (holographic optical elements). The first human portrait was made in 1967 by the use of a pulsed ruby laser (SIEBERT, 1968).

The early holograms made by artists were mostly expressions of real objects. They regarded holography as three-dimensional photography, which could record things in 3-D space. In the late 1960s, Benyon began to use holography and made a variety of 'Still Life' to investigate the potential of this new medium (BENYON, 1973). Nauman recorded a man's face in 'Making Face'. Some years later, Casdin-Silver made a holographic installation, in which observers could see a bundle of 3-D forks (CASDIN-SILVER, 1989).

In 1968, Benton invented the white light transmission hologram (rainbow hologram), which was important because it enabled multi-color brighter images (BENTON, 1969).

Around 1970, several techniques combining computer graphics (or ordinary photographs) with holographic stereograms were examined (KING *et al*, 1970).

Full-color holography techniques were investigated, but faced with various difficulties, such as cross talk and recording material problems. Also, the difficulty of recording outside scenery was thought to be a drawback of holography. So, fields of application of these new inventions were soon changed to creative works.

Pictorial expressions like Benyon's works continued to be produced and varieties of expression expanded gradually from the late 1970s through the 1980s. A good example is a technique to divide a hologram and to reconstruct an image from small fragment holograms, or a technique to treate a hologram as a lens. These new methods allowed editing of holographic images more freely as the artist desired.

Berkhout produced one remarkable example. He improved the HOE techniques to make geometrical light float in front of or behind a hologram plate (BERKHOUT, 1989). Holographic stereograms were used in Cross's multiplex type, that represented mainly short animations of moving people. This was intended mainly for commercial activities, but some artists tried to use holographic stereograms for more serious artistic works. Jung produced 'Motion in space—Space in Motion' (1988), in which several primary-color light squares moved slowly in space. His works were mostly expressions of beauty in a pure arrangement of light (JUNG, 1986). Some converted ordinary photos into holographic stereograms. Boyd used this method to animate impressive everyday life scenes, which looked sometimes ironical or humorous.

The number of holographic installations increased in 1980s (Table 3). In the early 1980s, embossed holograms began to be used to print rainbow images on credit cards, premium goods, and publications. Embossed holograms became widely used mainly for copy protection and security, but not frequently in art.

5. Discussion

As described above, it is obvious that the images of computer graphics and holographic display have followed opposite directions, i.e. from abstract to figurative expressions or vs. (Fig. 1).

Why did these opposite tendencies appear? We must consider the social aspects of art works and the features of both technologies. We find that the tendencies are related with

Table 3. Holographic installations introduced in the creative holography index.

Year	Artist	Title of work
1979	Benyon	Solar Maker
	Ishii	Encounters II
1982	Razutis	Window
1984	Mitamura	Heliostat in Aqua
1987–89	Fornari	Planning for Human Nature
1988	Dyens	Cosmogony
1989	Dawson	To Absent Friends
	Tyler	Transponder
	Weber	Threshold of A Singularity
		A Memorial
1990	Pepper	Positive Attempt Redrawn (floor piece)
1991	Burgmer	Terrene Holosphere
	Wenyon & Gamble	Bibliography
	Gauchet	Les Couleurs du Temps
1992	Boissonnet	Awareness of Limits (Gaia)
	MacArthur	Ignition
1992–3	Connors	Future Gardens II
1993	Lin	The Reincarnation
	Orazem & Lück	Diffracted Wall

(Source: Pepper, A. ed. *The Creative Holography Index*, Monand Press, 1992–1995.)

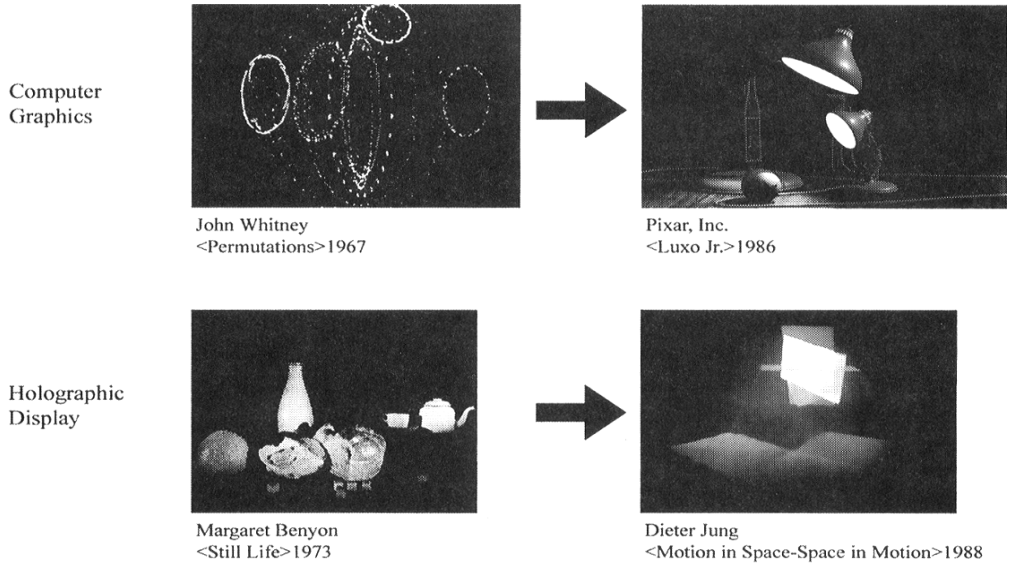

Fig. 1. Opposite transitions in computer graphics and holographic display.

many other factors, for example, their instruments, ways of making art works, and type of people who made the art works. Moreover, this difference was strongly affected by whether computer and holography became a general-purpose information technology.

As visual information technology became popular in various fields, there arose a demand to present realistic figurative images. This demand promoted 3D-CG and image processing technique with optical instruments. Therefore, choices of expressions expanded along with technological developments driven by social demand.

Holography, on the other hand, was a photographic medium from the beginning. Artists were fascinated by three-dimensional realistic images. However, holographic display did not become popular because of technical problems regarding its color, and brightness, and expensive equipments. It is important that holography was invented in the middle of the 20th century, because it was natural for the artists in this era to do experiments and use every available methods in holography. Starting with reconstructing images of realistic objects, artists had many experiments to edit holographic images, which resulted in abstract arts with optical illusion. These developments were not driven by social demand, but were accomplished by artists' efforts to seek an aesthetics of holography itself.

6. Conclusion

Images of computer graphics and holographic display followed opposite directions with respect to transition between abstract and figurative arts. This was the result of the property of media and social aspects. The transition of artistic images of computer was supported by social and industrial demands for technology. But, in holography, the

transition is considered to have been led by artists' experiments and concepts of artistic value of holography.

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