

Artistic Representation with Holography

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Abstract. This thesis describes artistic representation and its applications through holography. It highlights the characteristics unique to holography, which are not seen in other techniques, and presents this technique as a form of expression media. It is shown that these characteristics can help achieve considerably more than is possible with a mere three-dimensional image recording medium on account of the flexibility of holography as a medium of artistic expression. In order to emphasize this fact, a few holographic works are presented as concrete examples. Moreover, this thesis provides an insight into the manner in which holography has been applied to architectural space and developed for outdoor environmental art, through some examples of the practical application of holograms, and investigates the future possibilities of this technique.

1. Introduction

Holography is a three-dimensional image recording technique. Since 1978, however, I have not only been utilizing it in three-dimensional image recording but have also been investigating its potential as a medium of artistic expression. The attractiveness of holography as a medium of artistic expression is due to its following three characteristics: realistic three-dimensional image reconstruction, viewing area constraints, and color of light. The first of these characteristics is the most popular, and to add to the attractiveness of this technique, I will describe the significance of the second and third characteristics as elements of a medium of artistic expression by using actual examples. Actual holographic works can be classified into several types according to the type of optical system or photosensitive material used at the time of shooting, and each type of hologram exhibits distinct visual characteristics.

The technique of holography can be further developed if each of the abovementioned characteristics is fully utilized. Thus, the exhibition spaces will not be restricted to normal galleries or museums, and it will be possible to apply holography to commercial and residential architecture as well as outdoor environmental art.

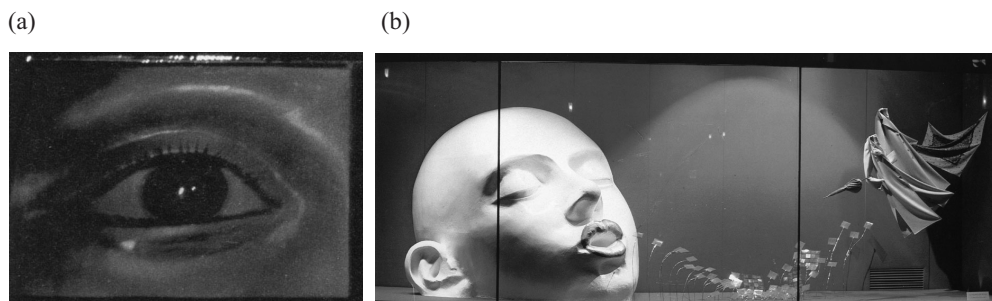


Fig. 1. (a) Image of DCG reflection hologram. (b) Window display of about 60 DCG reflection holograms at night.

2. Practical Holography in Art Works

Holograms can be classified in various ways. Depending on the type of optical system or illuminant for image reconstruction used at the time of shooting, holograms can be divided into reflection, laser transmission, and white light transmission (rainbow) types. Further, on the basis of the recording material used, holograms can be classified into the silver halide, dichromated gelatin (DCG), and photopolymer types, each of which has its own unique color or luster characteristics. The pulsed laser hologram is a type of hologram that has been shot with a pulsed laser, instead of a continuous laser, which records instantaneous scenes shot at the rate of a few dozen nanoseconds per scene. The images produced with this method reveal a world that is impossible to see with the naked eye. Each type of hologram exhibits its own unique characteristics. Some holograms exhibit textural characteristics, for example, in reflection holograms, the reconstructed images are very authentic.

In particular, the DCG reflection hologram exhibits certain favorable characteristics such as a metallic luster or pearl color. The white light transmission hologram (rainbow hologram) is particularly impressive due to the manner in which it displays the color of light. I will now describe the actual works that have utilized each of these advantages.

2.1. *Three-dimensional image*

One of the salient features of holography is the reconstruction of realistic three-dimensional images. Everyone marvels at the magic of nonexistent three-dimensional scenes unexpectedly appearing from a flat piece of film or glass.

2.1.1 *Natural three-dimensional image*

The best way to experience a natural three-dimensional image is by using the hologram of an eye (Fig. 1a). In 1980, I exhibited my artworks that involved holograms in the show window of the Wako department store located in the center of Tokyo (Fig. 1b) (KATSUMI, 1981). I installed about 60 DCG reflection holograms, each with dimensions of 10 cm × 10 cm. The holographic images were sections of a face, and 20 of them were eyes. The show window was located at the southwest corner of an intersection. During daytime, the

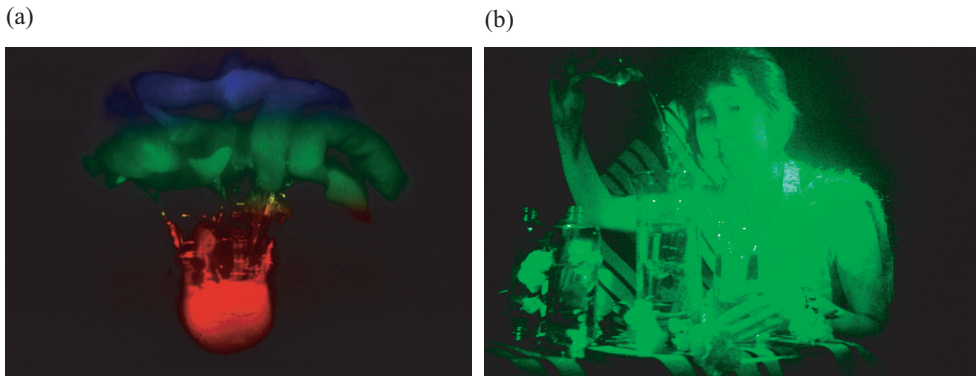


Fig. 2. Pulsed laser holograms. (a) *Crystal White*, (b) *Self-portrait*, 2000.

holograms appeared bright and clear due to sunlight.

When spectators looked at the window display, they thought they saw someone's eyes, and only then they realized that the eyes were holographic images. When people moved, these eyes did not follow them; however, after a while, they realized that another eye was watching them. They interacted with these eyes. It was amazing to watch the reactions of the people in front of the show window (ISHII, 1990).

There were two reasons to select eyes as the subject of the holograms for this window display. First, we can easily sense someone's eye, even when we cannot directly see him or her. Second, these three-dimensional eyes were visible from various directions. The eyes directly faced us when we stood in their line of sight, but they did not follow us when we moved away. It was possible to escape from the view of these eyes; this effect is unique to holograms.

This example was a good opportunity to introduce holograms to many people. I am sure that the people enjoyed these holograms.

2.1.2 Frozen time

A pulsed laser hologram records an instantaneous scene in three dimensions. The flash of the ruby laser used to prepare the holograms lasts for a few dozen nanoseconds. The exposure time is significantly shorter than that in high-speed photography.

Crystal White (Fig. 2a) is a rainbow hologram, 30 cm × 40 cm, 1979, of a breaking egg (Encyclopedia of Practical Photography, 1982). This master hologram was shot using a ruby laser. In the reconstructed image, the egg white does not appear fluid; it looks like a piece of glass, which would produce a sharp sound upon tapping. Further, we are able to see optical effects through the white. On shifting our viewpoint, we can observe different optical effects through the white, just as if it were a real object (Catalogue, 1983).

Self-portrait (Fig. 2b) is a laser transmission hologram, 50 cm × 60 cm, 2000–2002, where water was poured into a glass bottle containing two different transparent liquids, namely, water and oil. In the course of pouring the water, the boundary plane between the two liquids with different specific gravities was broken. In this hologram, all the liquids



Fig. 3. Complete view of *Visible Temperature α*, holographic installation, mixed media, overall dimensions of 240 cm × 800 cm, silver halide reflection holograms.

froze; the oil and water in the glass bottle look like solid crystal glass (Catalogue, 2001) and not liquids.

In everyday life, we are unfamiliar with such scenes. They portray a completely different aspect of our real world. Thus, it is considered that our eyes are extended with holograms.

2.1.3 Reality

On the other hand, soft-textured materials such as feathers or wool differ from the abovementioned liquid state. Using pulsed holograms, we can sense the soft touch with the help of realistic three-dimensional images, despite the fact that only visual information is available.

My artwork *Visible Temperature α* (Fig. 3) comprises reflection holograms, each with dimensions of 30 cm × 40 cm, 1987; they exhibited various textures, such as those of feathers, wool, cotton, hemp, synthetic fiber, steel wire, and nails. This work shows that a realistic holographic image make us realize the sense of touch similar to real objects.

2.2. Limited field of view

2.2.1 Multi channel hologram

Self-portrait—Body Wrapped with Fabric— (Fig. 4) is a multi channel hologram, 100 cm × 80 cm, 2000–2002. This hologram comprises about 20 different images. Each image has its own limited field of view. Reconstruction images of the hologram appear to occupy their own positions in space. Each scene appears different when observed from a different viewpoint. When our viewpoints shift vertically upward or downward, we can see a change in the color combination of the hologram. When our viewpoints shift horizontally from left to right, we observe different images.

We can materialize three-dimensional collages by using this method.

Whenever we encounter holograms, we unconsciously interact with them. This is one of the most attractive aspects of holography in the form of an art medium.



Fig. 4. *Self-portrait—Body Wrapped with Fabric—*: multicolor multi-channel rainbow hologram with pulsed masters.

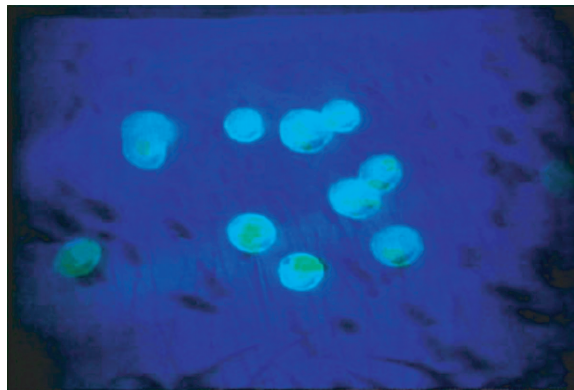


Fig. 5. *Floating II*: computer-generated multicolor rainbow hologram.

2.2.2 Computer-generated holograms

Floating II (Fig. 5) is a computer-generated hologram, 110 cm \times 120 cm, 1998. These images were developed using three master holograms; one of them was created using computer graphics. The master hologram of the balls was a holographic stereogram synthesized from a series of computer graphics, which were obtained sequentially from different directions. There were about 120 images with a view angle of 60° between them. The images of the balls were animated from different horizontal viewpoints.

2.3. Color of light

Color is another salient feature of holography. For reconstructing images, a hologram needs to be illuminated with light. The reconstructed image of a white-light-transmission

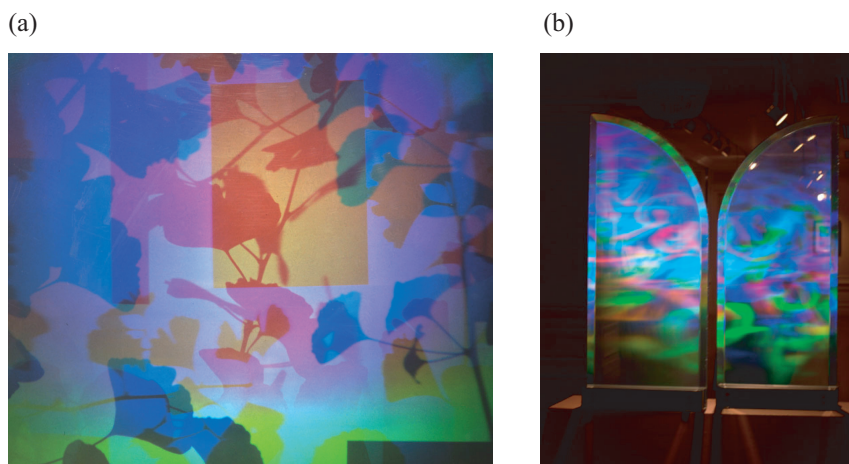


Fig. 6. Multicolor rainbow hologram, shadowgram. (a) *Still Alive*, (b) *Photon Drawing Series*.

hologram resolves white light into the spectrum of colors, then reassembles and reconstructs the spectral colors. Spinning colors of light-like threads impart a malleable form like clay. Such an image can be realized using holography.

Still Alive (Fig. 6a) is a multicolored shadowgram, 50 cm × 60 cm, 1989. The subjects were the silhouettes of real sprigs of a ginkgo tree, behind which a diffuser was set. The reconstructed silhouettes, which are not flat, occupy a real three-dimensional space. Three different images are recorded multiple times. Using a similar method, subjects that were traces of brushwork instead of real sprigs (Fig. 6b) were selected. Here, flexible films were used; the trace areas were transparent and the region outside the subject area is blackened in order to cut off the light from diffuser. These holograms are laminated with glass, the size in each with dimension of 57 cm × 23 cm, 1997.

Multicolored holograms are recorded multiple times with three different master holograms, which correspond to red, green, and blue, so that the reconstruction of each master hologram shifts to the appropriate vertical direction.

3. Application to Architectural Space

3.1. Hologram with sunlight

A large format reflection hologram *Beyond the Window* (Fig. 7) was installed in a meeting room in a basement. A circular window was created in one of the walls. The hologram was installed inside the wall such that it was visible through the window. The circular window had a diameter of 120 cm. A circular hologram with a diameter of 160 cm, slightly greater than that of the window, was installed on the wall behind the window, at a distance of 30 cm from the plane of the window.

This round hologram comprised four original squares (80 cm × 80 cm) of silver halide reflection holograms because it was difficult to prepare such a large-scale circular

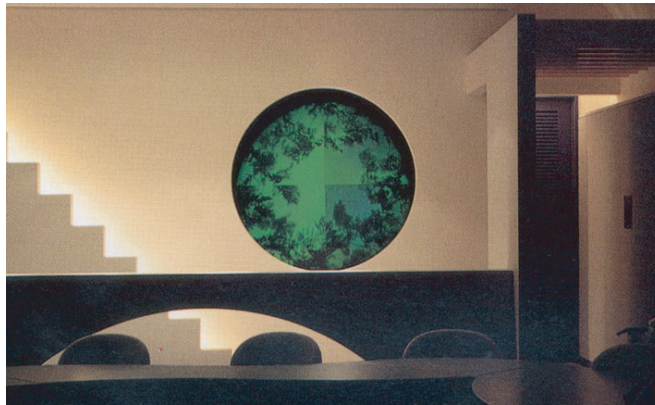


Fig. 7. *Beyond the Window*: silver halide reflection hologram.

hologram with a diameter of 160 cm. These four pieces of film were aligned and sandwiched between two layers of glass and laminated, thereby forming a single piece of glass. The lamination process was extremely difficult because four individual pieces of film were combined as a single piece for display. The film base had varying thermal expansion coefficients along its width and length, making it extremely difficult to maintain an optimum alignment between the attached pieces. Lamination would have been rather convenient if the piece were constructed from a single large hologram.

The image of the hologram is the shadow of a branch from an actual tree. The image has a depth of approximately 40 cm. The hologram is illuminated with sunlight conducted through an optical fiber, and a lens approximately 15 mm in diameter was set at the end of the fiber, fabricating a nearly ideal point source device. In comparison with conventional point sources employing lamps, the abovementioned point source is extremely small; the reconstructed image of the hologram is extremely sharp and clear (ISHII, 1993, SPIE).

Another example, *Aya*, is an architectural decoration in the atrium of a public building in Isahaya city, 1997. This installation was composed of 24 DCG holograms (each with dimensions of 35 cm \times 35 cm) and 10 pieces of dichroic mirrors (each with dimensions of 100 cm \times 100 cm) laminated with intensified glass were hung from the ceiling, where sunlight entered the atrium. Depending on the variation of the ambient lighting conditions, such as fine or cloudy weather and daytime or nighttime, the impressions of the hologram changed.

3.2. Large format art holograms installed in the Centennial Hall, Tokyo Institute of Technology

In January 2003, art holograms called *Murmur of Aqueous*, 1995, were installed in the Centennial Hall, which known as a modern geometric structure, located at the TIT Ookayama campus (ISHII, 2003a). The holograms were set in the corner of the main hall with a high ceiling (about 7 m in height) and a large glass wall facing south on the ground floor. For better lighting conditions, a shading screen was placed between the glass wall and holograms.

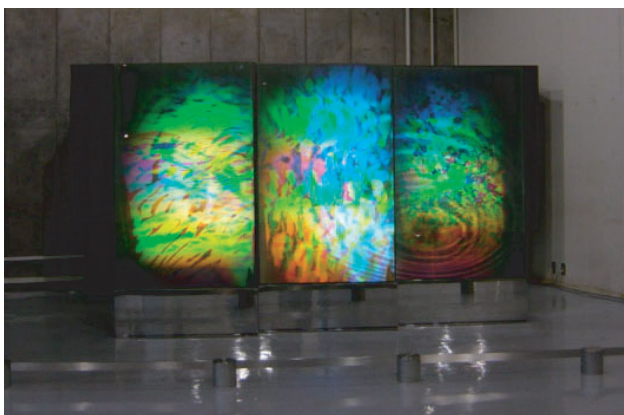


Fig. 8. *Murmur of Aqueus*, 1995: holographic installation with water effects, multicolor rainbow hologram.

Murmur of Aqueus, 1995, is composed of three large format holograms; each of these is a multicolored rainbow hologram with the following dimensions: $H = 174.5$ cm and $W = 108$ cm. Each hologram film is laminated between two pieces of glass ($H = 210$ cm, $W = 108$ cm, and $T = 8$ mm + 8 mm). A heavy stainless steel stand is fixed on the floor at the base of the glass.

In Fig. 8, the reconstructed images of holograms, which are shadowgrams made from brushwork, are shown. Behind the holograms, a flat water vessel ($H = 10$ cm, $W = 330$ cm, and $D = 210$ cm) with three mirrors at the bottom is set on the floor. Further, we prepared a device that produced ripples on the water surface in such a manner that water drops fall from the top and a small object floating on the water moves irregularly. Thus, the lights used for hologram reconstruction reflect from these mirrors and impart vividness to the reconstructed images. The images with ripples can be seen in Fig. 8.

This hall is open to the public, providing a good opportunity to widely introduce the application of art holography.

Finally, I would like to introduce my idea for *Murmur of Aqueus*, 1995.

Images such as rainbow on a palm and spinning colors of light-like threads that impart a malleable form like clay can be realized using holography. Each trace of brushwork from the drawing hand appears to be floating in three dimensions. Like streams of light in frozen time, its appearance changes all the time, depending on the viewpoint. This image is reproduced by the light reflected from the water and integrated with the ripples. The presence of time and light can be sensed.

4. Application to the Natural Environment

4.1. Open-air space

4.1.1 Open-air sculpture

The large-scale sculpture *Encounter II* (Fig. 9a) was my first outdoor artwork; it involved a rainbow hologram and sunlight (ISHII, 1985) (ISHII, 1993a). This work was

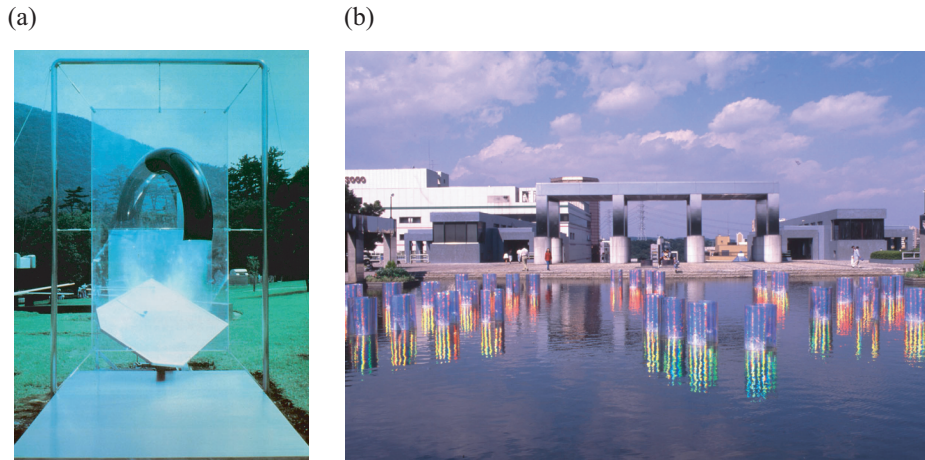


Fig. 9. (a) *Encounter II*: open-air sculpture, 30 cm \times 375 cm \times 410 cm. (b) *Apollonian Gift Series*: 30 m \times 30 m, each holographic grating object, 100 cm \times a circle with a diameter of 60 cm.

accepted in the art competition of the first Henry Moore Grand Prize Exhibition at the Hakone Open Air Museum (1979).

Half of the ring was a real object and the other half was a reconstructed image of the hologram. In this work, I was interested in the contrast between the real and unreal as I have been from the day I took interest in holography. The hologram was illuminated by sunlight that was reflected from the mirror, which automatically tracked the sun. The size of this rainbow hologram was 80 cm \times 100 cm, which was one of the largest in the world at that time.

Sunlight is an ideal light source for the rainbow hologram because it is a point source of light. In sunny weather, a hologram reconstructs bright images, irrespective of the brightness during the day. On the other hand, during cloudy or rainy weather, there is no image on the because scattered light does not reconstruct the image. Everyone who was not able to see the reconstructed image complained about my work. They had never encountered outdoor artworks such as the abovementioned ones that involved weather conditions; it was a completely new concept for them.

4.1.2 *Apollonian Gift Series*

As mentioned above, I created outdoor artworks involving holograms in 1979. At that time, one matter of concern was the durability of the recording material. The holography film employed a silver halide photographic material. The film was sandwiched between two polycarbonate plates and shielded from moisture. However, a few years later, I found that the hologram image disappeared because of damaged gelatin. I stopped creating outdoor works involving holograms until holographic grating films were mass-produced. The new material used was a plastic sheet. Thereafter, I resumed preparing outdoor artworks.

Apollonian Gift Series (Fig. 9b) was installed in the pond at Parthenon Tama, Tokyo.



Fig. 10. *Requiem*: holographic installation, 200 cm × 500 cm × 400 cm, multicolor rainbow hologram.

These holographic grating objects divided the sunlight into spectrums, which changed colors according to the movement of the sun, the viewpoint, and the weather. As the sunlight shone brighter, their colors became more brilliant. One noteworthy feature of this work is that the color reflected from the water surface differs from that from the object. When it was windy, the color on the water disappeared because of ripples.

These holography installations are fairly new artworks that involve environmental conditions in outdoor sculpture; in this case, natural factors are taken into account, such as the sun movement, wind, and weather in addition to the viewpoint. Previously, there were artworks that involved electricity, water, and wind power as the energy source; however, no work actively involved sunlight till now, except my installations (ISHII, 2003b).

4.2. *Experimental space: Underground*

4.2.1 *Marble hall, Kamaishi mine*

The holographic installation *Requiem* was installed in a deep underground space—a marble hall in the Kamaishi mine in 1993 (Fig. 10). This installation was a part of the project that researched a new geofrontier. The space was an old mine that produced white marble with 90% purity and located 300 m underground. It resembled a marble palace whose walls and ceiling were wild rock surfaces under high rock pressure. According to the floor plan, this space comprised many small rooms that were squares of approximately 7~8 m. This installation is a combination of actual hard rock and virtual holographic images, contrasting materials, and mono- and multicolored lights. This combination produced images that were never realized before in conventional architectural spaces on the ground such as museums or art galleries (ISHII, 1996).

Such an unconventional underground space did not accept ordinary art as in the past. As mentioned above, holographic arts depend on their surrounding environment, which is an integral part of the artworks. The combination of such an underground space and this new medium was sufficient to excite us in the creation of new artworks.

4.2.2 Retretti Art Center

The Retretti Art Center is a unique underground facility in Finland that not only has an art gallery space but also a concert hall, restaurant, and cafeteria. It is located about 400 km north of Helsinki; various rooms both large and small have been dug in the granite bedrock like a labyrinth. The exhibition spaces utilize their wild beautiful rock surface. In 1994, the exhibition *Point of View* was held at this center. I was invited to take part in this exhibition. Artists from various countries such as Finland, England, France, Canada, United States, and Japan participated in this exhibition using different art media (Catalogue, 1994).

The holography installation *Spinning Thread of Light* was my entry in this exhibition. The holograms, which were hung from the granite ceiling, were reconstructed by using light reflected from mirrors; these mirrors were installed in a pool placed behind the holograms. Ripples appeared on the holograms because of the moving water surface. The idea of combining the hologram and water occurred to me when we inspected the place before the exhibition. In addition to this work, mixed-medium installations were exhibited; they were holographic installations with sound effects.

5. Conclusion

The examples described in this thesis have conclusively shown that the various characteristics of holography enable new expressions that cannot be realized through the existing mediums of expression. These characteristics can be applied to materials used in architectural spaces in order to express colors in different ways from ceramic walls or paintings. Works that are produced using holography vary in appearance according to the lighting environment. With regard to outdoor works, some environmental art works have been produced using factors including sunlight, time, weather, and climate. Outdoor art works that make use of factors such as electricity, water, and wind do exist, but the ones that are integrated with sunlight were only realized through holography. Therefore, holography can prove to be a tool in various applications and is not restricted to the field of recording media. However, if it is to find a practical application on a wide scale, it must possess a level of durability that complies with architectural criteria, and much improvement has yet to be made in this regard. I am determined to create more holographic works in order to establish holography as a medium of artistic expression, which may find wide-ranging applications and open up various possibilities that will attract research into the various problems associated with this technique.

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