

Construction of Immersive Art Space Using Mirror Display and Its Preliminary Evaluation

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ABSTRACT

We have constructed an immersive space, that gives people a sense of being in a vast, immersive space, by using mirror displays with the functions of both a mirror and a display. In addition, we selected an artwork created by one of the authors and conducted a psychological experiment to evaluate the results of displaying the artwork in the space.

1 Introduction

Art can enrich people's minds, heal their hearts, inspire them, etc. In VR (virtual reality), much emphasis has been placed on technology research that gives people a sense of immersion. However, only a little research has been conducted on the design and construction of immersive spaces that combine art and VR or their evaluation.

We designed and constructed an immersive space suitable for art content to evaluate how art content affects the human mind. The video art of Naoko Tosa, one of the authors, is used as art content for the immersive space. As described later, Tosa's art uses technology to extract beauty hidden in natural phenomena and transform it into video art characterized by abstract and organic shapes. Since many people who have viewed Tosa's art have commented that they feel as if they are in outer space, the characteristics of Tosa's art are best expressed when viewed in an infinite space. Therefore, we constructed a space surrounded by mirror displays to give viewers the feeling of being in an infinite space and having them view her art in that space.

This paper reports on designing and constructing an immersive space constructed using mirror displays. It also reports the results of preliminary experiments on what kind of content is suitable for the space using a small number of subjects.

2 Related Studies and Activities

2.1 Research on immersive spaces in VR

The purpose of VR is to create a space different from reality and to give people an immersive feeling as if it were reality [1]. VR space can be constructed by projecting images into an actual space using a projector or displaying images on an HMD (Head Mounted Display).

2.2 Fusion of VR and Art

Attempts to fuse art and VR occurred with the advent of VR and continue until now. For example, William Latham of Goldsmiths, University of London, has been actively

creating an art-expressed artificial life form called "Mutator VR" [2].

2.3 Construction of immersive space using mirrors

Because mirrors make it relatively easy to create a space that seems endless, mirrored art expression is often used. Well-known examples include Yayoi Kusama's Infinity Mirror Room, where her art is installed in a mirrored space [3].

3 Digital Art "Sound of Ikebana"

3.1 "Sound of Ikebana" creation system

One of the authors, Naoko Tosa, has discovered that by applying sound vibrations to a fluid such as paint and photographing it with a high-speed camera, the fluid creates a shape similar to that of Ikebana (Japanese flower arrangement). This is art creation utilizing fluid phenomena.

Tosa confirmed that various fluid shapes could be generated by changing the shape of the sound, the frequency of the sound, the type of fluid, and the viscosity of the fluid [4]. Tosa further edited the resulting video to match the colors of the Japanese seasons and created a digital artwork called "Sound of Ikebana" [5]. Figure 1 shows a scene from the work.



Fig. 1 A scene from "Sound of Ikebana."

3.2 Characteristics of "Sound of Ikebana"

Tosa has been taking on challenges in a new direction. For example, to express art in the space age, she has attempted to create "Sound of Ikebana" under microgravity [6]. These attempts have led to many comments that Tosa's art expresses the birth of life and the future of life. This led to the idea that Tosa's art is suitable for viewing in an infinite space that evokes the universe and led to the idea of constructing an infinite

space using mirrors and showing Tosa' art in the space.

In addition, many who have viewed Tosa's art content have commented that they feel their creativity is enhanced. If art appreciation leads to increased creativity in the viewer, then an exciting benefit of art can be found. Since such effects are more effective in a space with an infinite expanse, this also leads to designing and constructing a space that gives a sense of infinite expanse and having visitors view Tosa's art in that space.

4 Design and Construction of Immersive Space Using Mirror Display

4.1 Mirror display

As mentioned in 2.3, using mirrors is appropriate for constructing an environment that gives the impression of infinite space. Here, we decided to use a "mirror display" with the functions of both a mirror and a display.

We used a mirror display developed by AGC Corporation and commercialized under the name "Mirrora" [7]. The feature of this display is that it achieves a half-mirror reflectance of approximately 65%, the same level of reflectance as that of an ordinary mirror..

4.2 Design and construction of immersive spaces

We have already confirmed in psychological experiments that art content positively affects the human mind [8][9]. Art content was displayed on large LED and mirror displays in these experiments. We want to confirm whether art content effectively improves people's creativity when placed in a more immersive environment.

Therefore, we decided to construct an environment in which mirrors surround people, and part of the mirrors are the mirror displays, and art contents are displayed there. A hexagonal space surrounded by rectangular mirrors was designed and constructed. The concept is shown in Fig. 2, where the hexagonal space is composed of three sets of mirrors facing each other. It is well known that such mirrors create infinite images by mutually reflecting each other. By having three sets of mirrors, a person inside feels as if he/she is surrounded by countless mirror images of himself/herself. Furthermore, by using the ceiling and floor as mirrors, one feels as if one is surrounded by an infinite number of images of oneself, both above and below.

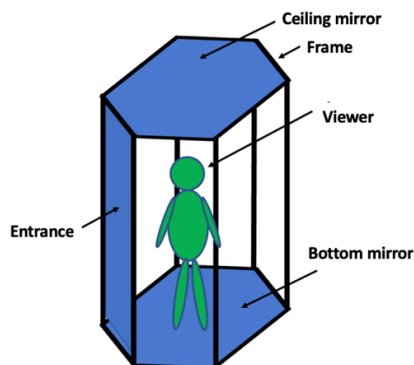


Fig. 2 Conceptual diagram of immersive space.

The six rectangular mirrors that make up this hexagonal space are the mirror displays mentioned earlier and can display images and videos. At the same time, the position of the display is variable in the vertical direction (Fig. 3). This makes it possible to shift the position where the six

mirrors display the image. If the mirrors facing each other have the same image display position, the respective images will interfere with each other, reducing the sense of endless images. By shifting the display position of the images, it is possible to create the effect of an endless series of images without images interfering each other.

The appearance of the constructed immersive space is shown in Fig. 4. Inside this device, even a simple figure can generate a beautiful and immersive environment by continuing back and forth, left and right, and up and down indefinitely (Fig. 5). Figure 6 shows examples of scenes where Tosa's art contents are displayed.

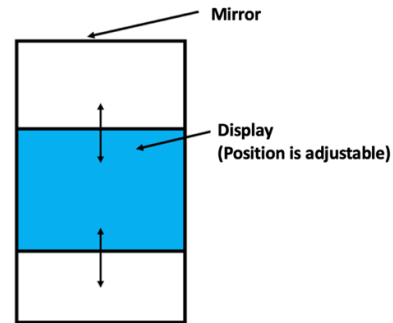


Fig. 3 Configuration of individual mirror display.



Fig. 4 Exterior view of the immersive space (left: exterior view, right: door open).



Fig. 5 Displaying a circle in the immersive space.

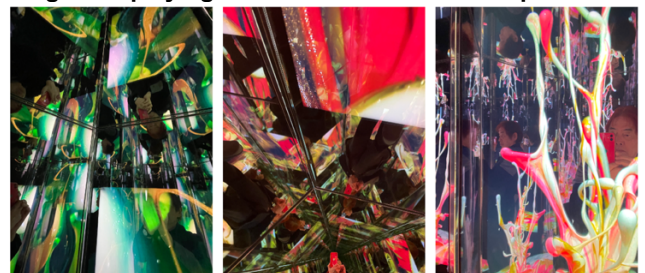


Fig. 6 Art content visible in the immersive space.

5 Preliminary Evaluation of the Immersive Space

5.1 Evaluation concept

As mentioned earlier, there have been many attempts to combine VR and art [2][3], but there needs to be more research to evaluate what kind of feeling such a combination would give to viewers. In this immersive space, we decided to use Tosa's art as the main art content as a first step. The reasons are as follows.

- (1) As mentioned earlier, Tosa's art is based on fluid phenomena. In other words, it is based on physical phenomena. Therefore, it is compatible with the scientific evaluation method.
- (2) Since it is based on fluid phenomena, various variations can be created by changing parameters. Therefore, it is also compatible with the scientific evaluation method by changing conditions.

To conduct an evaluation experiment using art content, it is necessary to prepare content to be compared with the art content. We decided to use simple geometric figures as the comparison content. We conducted a preliminary experiment to determine the content by comparing multiple geometric figures through psychological experiments.

5.2 Preliminary Experiment 1

(1) Purpose of Preliminary Experiment 1

The purpose of Preliminary Experiment 1 is to determine the geometric figure content to be compared to the art content.

(2) Geometric figures used in the experiments

We have prepared three types of geographic figures.

Figure 1: The shape is a circle; only the color changes with time.

Figure 2: The shapes change to circles and squares in sequence, along with the colors.

Figure 3: The square shape rotates. The color changes with time, as in Figures 1 and 2.

The detailed characteristics of the geometric figures are listed in Table 1.

Table 1. Geometric figures used in the experiment.

	Color	Geometric figure		
		Figure 1	Figure 2	Figure 3
Time ↓	1 Red	Circle	Circle	Square (Rotating)
	2 White		Square	
	3 Purple		Circle	
	4 Blue		Square	
	5 Green		Circle	
	6 Light green		Square	
	7 Gold		Circle	
	8 Red		Square	

(3) Evaluation items

The evaluation items shown in Table 2 were used, which have been used in our psychological experiments on art and other subjects [8][9]. The evaluation items consist of "Impression" and "Effect."

Table 2. Evaluation Items

1. What did you feel about the content? (Impression)	2. What effect does the content have? (Effect)
Comfortable	I can relax - I cannot relax
Uncomfortable	Ideas come to me - Ideas

Friendly - unfriendly	do not come to me
Beautiful - Not beautiful	Energy comes out -
Calm - Restless	Energy does not come out
Interesting - Boring	I can face difficulties - I
Warm - Cold	cannot face difficulties
Changeable - Not	I get rid of tiredness - I do
changeable	not get rid of tiredness
Luxury - Sober	
Individual - Ordinary	

(4) The process of the experiment

Subjects were placed inside the immersive space mentioned in Chapter 4 and watched the three types of geometric figures for 3 minutes, respectively. After each viewing, the subjects evaluated the content based on a 7-point scale.

(5) Subjects

Sixteen Kyoto University students were used as subjects.

(6) Experimental results

Figure 9 shows the results of the nine evaluation items related to "Impression," averaged over all subjects. Figure 10 shows the results of the five evaluation items related to "Effect," averaged over all subjects.

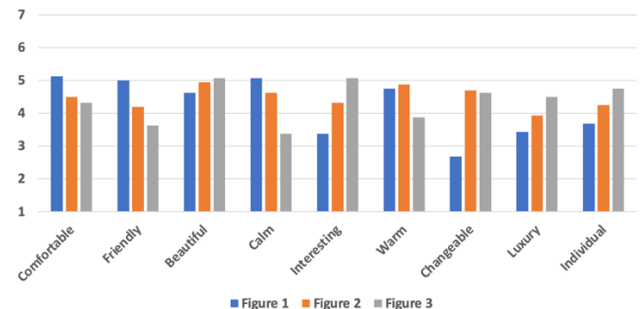


Fig. 9 Evaluation results for "Impression."

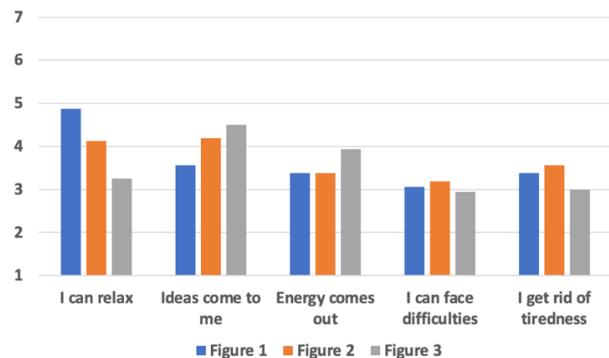


Fig. 10 Evaluation results for "Effect"

To examine whether these differences are significant, a more detailed analysis of variance (ANOVA) with the two factors was conducted. The two factors involved in the evaluation are "geometric figure type" and "evaluation item."

The results showed that there was no significant main effect among geometric figures for "Impression" ($F(2, 30)=0.824$, $p=.415$). Also, for "Effect," the results showed no significant main effect among geometric figures ($F(2, 30)=0.123$, $p=.849$).

These results indicate that any of the three types of geometric figures can be compared with art content.

5.3 Preliminary Experiment 2

(1) Purpose of Preliminary Experiment 2

In Preliminary Experiment 2, we compared the selected geometric figures and art content based on the results of Preliminary Experiment 1.

(2) Contents for experiments

Since Preliminary Experiment 1 showed no significant differences among the three types of geometric figures, we selected Figure 2 as the geometric figure to be compared with the art content in Preliminary Experiment 2.

(3) Experimental results

Figure 11 shows the results of 9 evaluation items related to "Impression," averaged over all subjects, and Fig. 12 shows the results of 5 evaluation items related to "Effect," averaged over all subjects. (Figures 11 and 12 also show the result of ANOVA described later.)

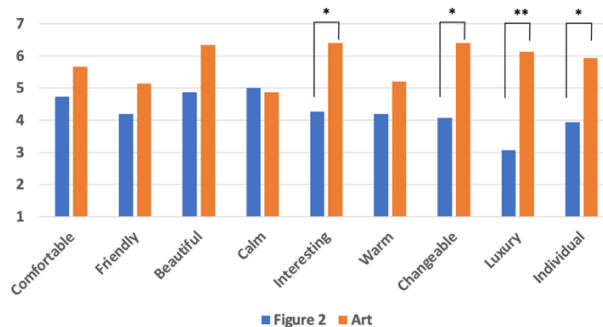


Fig. 11 Evaluation results for "Impression"

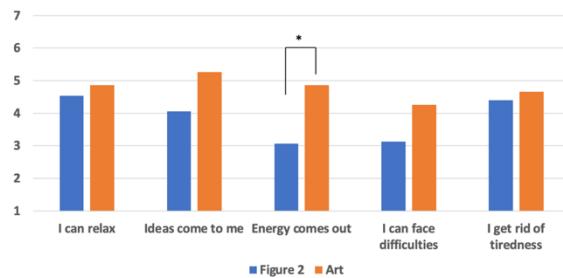


Fig. 12. Evaluation results for "Effectiveness"

The art content received higher rating values than the geometric figures. To confirm whether these differences are significant, a more detailed analysis of variance of the two factors (two-way ANOVA) was conducted.

The results showed that there is a significant difference concerning the main effect among the contents concerning "Impression" ($F(1, 14)=27.223, p<.01$). For "Effect," the results also showed that there was a significant difference between the contents concerning the main effect ($F(1, 14)=8.862, p=.010$).

Then, for "Impression" multiple comparisons were conducted using the Holm method. The results showed that there was a significant difference at the 1% level for "luxury" and a significant difference at the 5% level for "interesting," "changeable," and "individual." Also, for "Effect" multiple comparisons were conducted using the Holm method. The results showed a significant difference at the 5% level for "energy comes out." These results are superimposed on Figs. 11 and 12.

6 Conclusion

Our experiment confirmed that art has a calming and inspiring effect on people's minds [8]. At the same time, art is also expected to have other effects, such as enhancing people's creativity. We received such comments from the audience when we exhibited the artworks of Naoko Tosa, one of the authors. Based on the comments we have received, we concluded that an immersive space with mirrors, which gives a sense of infinite space, is suitable to demonstrate the effects of Tosa's art. To confirm this, we designed and constructed a hexagonal immersive space composed of mirror displays with the function of a mirror and a display.

We also conducted a preliminary experiment to select appropriate content for comparison when evaluating Tosa's artworks in the space. We created three types of geometrical figures with different shapes, color changes, and movements and conducted a psychological experiment to compare them. The results showed no significant difference between the three types of content. Based on these results, we selected one of the geometric figures and conducted a comparative evaluation experiment using a small number of subjects between the selected geometric figures and Tosa's art content. The results show that Tosa's was evaluated significantly higher than the geometrical figure. We plan to conduct a more detailed experiment using many subjects based on this preliminary experiment. Also, in addition to psychological experiments, physiological experiments will be carried out.

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