Creation of Fluid Art "Sound of Ikebana" Under Microgravity Using Parabolic Flight

Naoko Tosa[1], Shigetaka Toba[1], Yunian Pang[1], Akihiro Yamada[2], Takashi Suzuki[2], and Ryohei Nakatsu[1(✉)]

[1] Kyoto University, Sakyo, Kyoto 606-8501, Japan
{tosa.naoko.5c,pang.yunian.2c}@kyoto-u.ac.jp,
toba.shigetaka.57z@st.kyoto-u.ac.jp,
ryohei.nakatsu@design.kyoto-u.ac.jp
[2] Toppan Inc., Taito, Tokyo 110-8560, Japan
{akihiro_1.yamada,takashi.suzuki}@toppan.co.jp

Abstract. Art is situated at the center of entertainment; therefore, new art in the future space age is an exciting subject. The authors, led by an artist, have been creating video artwork "Sound of Ikebana," made by giving sound vibration to fluid and shooting it with a high-speed camera. To study its shape under weightlessness, we conducted the generation of the artwork under microgravity realized by parabolic flight. We confirmed that new shapes of the Sound of Ikebana were created. Furthermore, a three-dimensional artwork was created by shooting the phenomenon from multiple viewpoints.

Keywords: Fluid art · Sound of Ikebana · Microgravity · Parabolic flight

1 Introduction

Recently, there have been many topics related to space, such as NASA's landing of an uncrewed spacecraft on Mars in February 2021 [1], Virgin Galactic's Richard Branson and Amazon's Jeff Bezos flying into space of about 100 km in July 2021, a four-day flight to orbit around the earth by four civilians by SpaceX's spacecraft Crew Dragon in September 2021 [2].

Although the day when ordinary people can quickly go out into space is still a long way off, it is necessary to consider our life and society when space travel becomes a reality. How will space travel affect our bodies and spirits in the future when space travel becomes familiar to the general public? It is also necessary to consider how the culture we have built up in our society will change in the space age.

Art has been deeply linked to human spirituality and has been at the center of entertainment since ancient times. Therefore, an essential and exciting theme is what art and entertainment will look like in the space age. What will happen to art and entertainment, how people interact with them in the space age, and whether new art and entertainment that matches the space age will be born are themes that need to be considered now [3].

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We are interested in what art will look like in the environment of weightlessness, which is peculiar to space travel. We have been working on producing fluid art [4], which is art using fluid phenomena. Because fluid behavior is different in zero gravity than in normal gravity, we think studying fluid art in zero/microgravity is necessary.

This paper first describes the concept of fluid art that uses the fluid phenomenon, then the details of a representative fluid art called "Sound of Ikebana" will be described. Then the process of the experiment and the produced art will be described, where the artist herself created artworks under the microgravity obtained by the particular flight called "parabolic flight." It also describes an attempt to create a 3D art object from the obtained 2D art video.

2 Related Works

Art generation in the space age is an exciting theme, and multiple projects are being carried out mainly in the United States and Japan. The MIT Media Lab in the United States has launched the "Space Exploration Initiative [5]" to conduct various experiments under zero gravity. Among them is a project to explore the way of art in the space age. For example, in a project conducted by an artist called "Telepresent Drawings in Space," the theme is how to deliver sensations and emotions in outer space to the ground. The trajectory of an object floating under zero gravity is recorded with a sensor. They try to reproduce the trajectory on the ground and make it an artwork.

In Japan, JAXA (Japan Aerospace Exploration Agency) has a Japanese laboratory called "Kibo" on the ISS, which can be used for scientific experiments and experiments of art creation. From 2008 to 2011, the first call for proposals for art creation in space was opened, and nine experiments were conducted in "Kibo" [6]. From 2011 to 2013, eight themes were implemented in the second phase [7].

These studies have great significance as pioneering research on the new art in the space era. However, in these studies, artists did not try to generate art under zero gravity by themselves. On the other hand, in our project led by an artist, the artist herself tried to generate art under microgravity to study the way of art in the space age.

3 Fluid Art "Sound of Ikebana"

3.1 Fluid Art

The behavior of fluid consists of a large part of natural phenomena [8]. Fluids are known to be able to create beautiful shapes under a variety of conditions [9].

As beauty is a fundamental element of art, it is natural to use fluid phenomena as a basic methodology for art creation. One of the authors, Naoko Tosa, has led a project to create "fluid art" by shooting the behavior of fluids with a high-speed camera. High-speed cameras have traditionally been used to capture a variety of phenomena that occur in brief periods, such as the explosion of physical material, etc. On the other hand, we were interested in producing various beautiful organic shapes using fluids. Then, she found it possible to create an Ikebana-like shape (Ikebana is a Japanese flower arrangement) with a fluid such as paint by giving sound vibration. Figure 1 shows the generation system.

When a speaker is placed facing up, a thin rubber film is put on it, a fluid such as paint is placed on the rubber film, and the speaker is vibrated with sound, the paint jumps up and makes various shapes, and the process is shot with a high-speed camera. Here, a high-speed camera of 2000 frames/second is used. A PC connected to the speaker produces various sounds and vibrates the speaker [4].

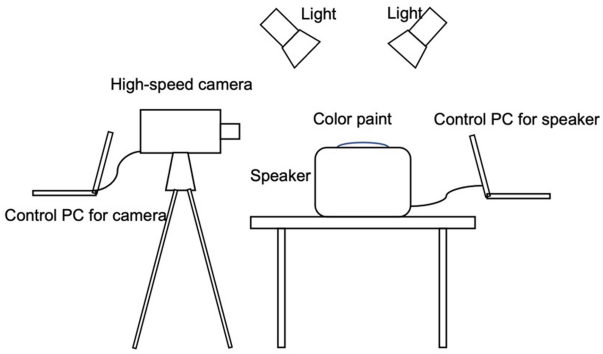


Fig. 1. Fluid art generation system. (©Naoko Tosa)

3.2 "Sound of Ikebana"

Using this environment, we systematically changed sound shape (sine wave, sawtooth wave, etc.), frequency of sound, type of fluid, a viscosity of the fluid, etc., and shot various fluid forms with a high-speed camera. We confirmed that various beautiful Ikebana-like shapes were generated. Tosa created a video art called "Sound of Ikebana [4]" by editing the obtained video image according to the colors of the Japanese seasons. Figure 2 shows several scenes from the artwork. She also used this artwork for projection mapping in Singapore in 2014. Also, in April 2017, as part of Tosa's Japan Cultural Envoy activities, an exhibition was held at Times Square in New York using more than 60 digital billboards [11].

Fig. 2. Scenes of the Sound of Ikebana. (©Naoko Tosa)

4 Microgravity Generation Method

4.1 Parabolic Flight

Parabolic flight means flying on a parabolic flight path [10]. After gaining sufficient speed by a rapid descent, the aircraft is raised, and the thrust is narrowed down to the extent that it compensates for air resistance to perform the parabolic motion. During Parabolic Flight, a microgravity environment of about 10^{-2} to 10^{-3} G can be realized for about 10 to 20 s, so it is used for various microgravity experiments and training of astronauts. One company provides commercial services for parabolic flights [12]. Figure 3 shows the flight curve in parabolic flight and the gravity in each phase.

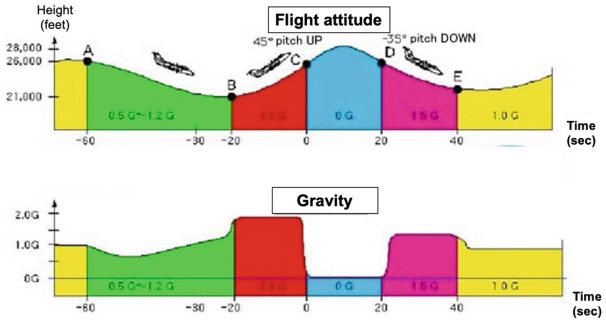


Fig. 3. Parabolic flight.

4.2 Free-Fall

An alternative method of realizing microgravity is free-fall. When an object falls downward, pulled by gravity, it is in a weightless state. In other words, weightlessness can be achieved by creating a freefall state by dropping things from a high place.

In Japan, the Microgravity Laboratory of Japan (MGLAB) in Toki City, Gifu Prefecture, has a free fall distance of 100 m and a free fall time of 4.5 s. This drop tower was evacuated inside the tower to eliminate air resistance and allow the fall capsule to fall freely [14].

Also, the ZARM microgravity experimental facility, called the Bremen Drop Tower, at the University of Bremen in Bremen, Germany, is well known. Its height is 147 m (actual fall distance is 110 m), and if the falling capsule is dropped in a tower that has been evacuated, the weightlessness for almost 4.7 s is realized [15].

5 Creation of Fluid Art Under Microgravity

5.1 Basic Methodology

To create art under microgravity, we worked on an experiment where the artist took the initiative in creating the Sound of Ikebana under microgravity. Of the parabolic

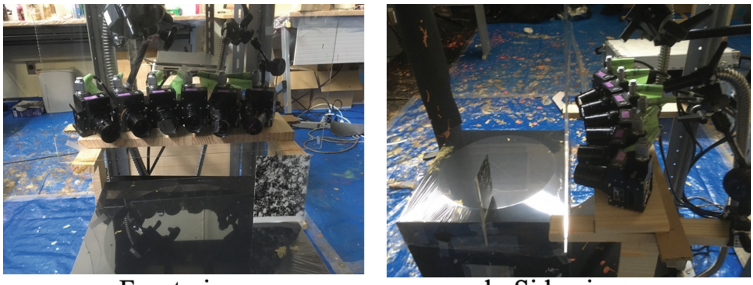
flight and freefall described before, we adopted the parabolic flight, which can generate microgravity for a certain period.

At the same time, in addition to shooting the image of the Sound of Ikebana under microgravity and making it a two-dimensional video art, we challenged an attempt to realize it as a three-dimensional object. The Sound of Ikebana has been evaluated many times as "Japanese" and "Japanese beauty is expressed" [16]. By making the Sound of Ikebana a three-dimensional object, it can be exhibited in various places as three-dimensional art. The shape can be examined from various directions. Then it is possible to receive many people's impressions and comments on why it looks Japanese. Based on this idea, we decided to restore the 3D shape of the Sound of Ikebana and make it into a 3D object using a 3D printer [17].

To realize 3D restoration, researchers have studied a method to create a 3D model based on images taken from multiple directions [18][19]. There are two methods of using multiple still cameras and multiple high-speed video cameras as a shooting method. The method of performing synchronous shooting using multiple still cameras can be developed at a relatively low cost, but the timing of pressing the shutter becomes a problem. We first constructed a system using multiple still cameras and conducted various experiments in this research. However, we found that it is challenging to obtain shooting results that are beautifully shaped depending on the timing of pressing the shutter. Based on the above considerations and preliminary experiments, we decided to conduct an experiment in which shooting is performed using multiple high-speed cameras.

5.2 Sound of Ikebana Creation Using Parabolic Flight

In order to create the Sound of Ikebana during parabolic flight, it is necessary to develop a small-size generation system shown in Fig. 1 to bring on board. Furthermore, to make the Sound of Ikebana into a three-dimensional object, it is necessary to have a system equipped with multiple high-speed cameras. Figure 4 shows the developed generation system. The system uses a high-speed multi-camera system. The camera part has a shooting speed of 2000 frames/second with 2 M pixels. Six units were installed surrounding the speaker. Since a workspace such as setting paint is required, we decided that six high-speed cameras surround the speaker at about 120 to 180°.



a. Front view b. Side view

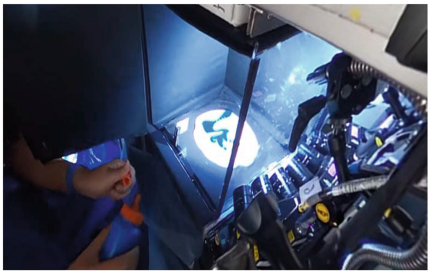
Fig. 4. Sound of Ikebana generation system for parabolic flight. (©Naoko Tosa)

In order to create the Sound of Ikebana during the parabolic flight, it is necessary to set paints quickly, drive speakers, and shoot with multiple high-speed cameras. All the participants in the experiment, including the artist Naoko Tosa, are new to parabolic flight. In order to minimize failures in an unfamiliar environment, we installed the generation system in the laboratory and carried out training simulating an actual flight. We practiced setting a new film on the speaker, setting paints on it, driving speakers and starting shooting in synchronization with them, and cleaning after shooting with the same time intervals as the actual flight. By practicing this about 50 times, it was possible to perform each procedure skillfully in a short time. It was possible to create and shoot the Sound of Ikebana almost without failure by following the practiced procedure in the actual parabolic flight.

In an actual parabolic flight, the microgravity of about 20 s was achieved 10 times. Figure 5 shows several scenes of the fluid art creation during the parabolic flight.

a. The airplane used for the parabolic flight

b. The scene when microgravity is realized



c. The scene of the “Sound of Ikebana” creation under microgravity

Fig. 5. Sound of Ikebana creation scenes during an actual parabolic flight. (©Naoko Tosa)

5.3 Sound of Ikebana Under the Parabolic Flight

As mentioned earlier, one parabolic flight allowed us to experience microgravity ten times. Moreover, the flight was carried out twice over two days. Except for two failures which was caused by the inaccurate timing among the three members, the Sound of

Ikebana was created 18 times. Therefore, obtaining video images of 6 positions x 18 times was possible. Figure 6 shows how the actual Sound of Ikebana images changes as time passes. Also, Fig. 7 shows an example of an image at a specific video moment taken from 6 positions.

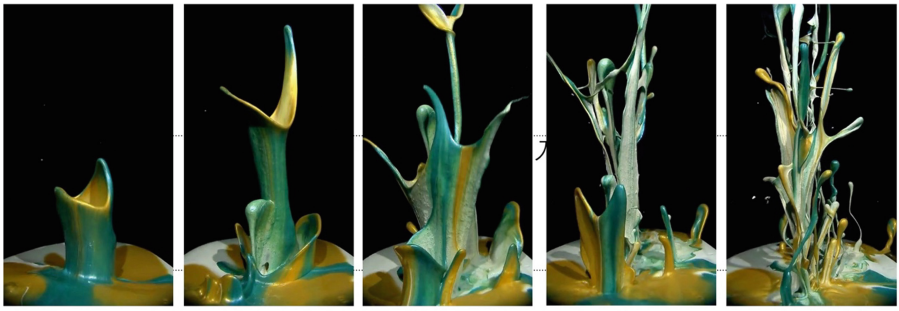


Fig. 6. An example of how the Sound of Ikebana changes its shape depending on time. (©Naoko Tosa)

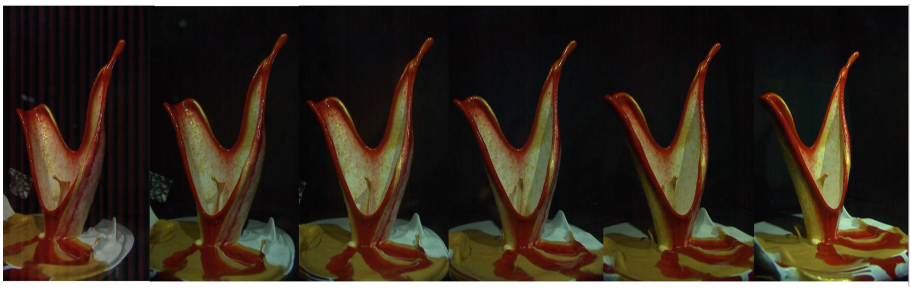


Fig. 7. An example of images shot from multiple positions. (©Naoko Tosa)

We found that the Sound of Ikebana generated under microgravity has the following characteristics compared to the case under normal gravity.

- Under normal gravity, the height at which the paint jumps up is suppressed by gravity. However, under microgravity, as there is no such restriction, the paint jumps higher and creates more extended shapes.
- The paint that jumps up to a certain height under normal gravity starts to fall after that, creating a shape in which the jumping-up paint and the falling paint are mixed and sometimes look messy. However, since the paint does not fall under microgravity, the appearance of jumping and spreading looks more sophisticated.

5.4 Three-Dimensional Materialization of the Sound of Ikebana Under Microgravity

Various studies have been conducted on creating a 3D model from images from multiple viewpoints [18, 19]. Also, there are several commercial software. We used a software

called "TORESYS 3D™" commercialized by Toppan Inc. Then, using the obtained 3D model, it is possible to generate a 3D object with a 3D printer. An example of the completed 3D Sound of Ikebana is shown in Fig. 8.

Fig. 8. An example of the 3D Sound of Ikebana created using a 3D printer. (©Naoko Tosa)

6 Conclusion

As the space age arrives, it is essential to consider new art in the new era. One of the authors, artist Naoko Tosa, has created a video artwork called "Sound of Ikebana" based on the fluid phenomenon by giving sound vibration to liquids such as paints and shooting them with a high-speed camera. We are interested in what shape this art would produce under zero/microgravity.

We adopted parabolic flight to create microgravity and conducted an art creation experiment of the Sound of Ikebana, led by Tosa, using parabolic flight. Also, we challenged making the Sound of Ikebana as a 3D object by shooting the phenomenon using multiple high-speed cameras.

Under microgravity, the fluid expands more dynamically and does not fall due to microgravity. Then we obtained more sophisticated, beautiful, and organic shapes of the Sound of Ikebana under microgravity than in ordinary gravity. As a result, we have obtained new 2D and 3D art that expresses the "space-age."

As our future research, we will carry out detailed comparison between two types of the Sound of Ikebana; one created under normal gravity and the other created under microgravity. And we will clarify the difference both from scientific and artistic point of views.

We plan to exhibit this new art as 2D and 3D art so that people can appreciate its original and organic shape. Furthermore, we consider using it for art and the shape of vehicles and architecture in the future society.

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