Creation of Fluid Art “Sound of Ikebana” under Microgravity Using Parabolic Flight

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Abstract
Art has been at the center of human spiritual life, and therefore, 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 zero gravity, we conducted the generation of the artwork under microgravity realized by parabolic flight. As the sound source, we used the birth cries of newborn babies, which also symbolize the future. We confirmed that a new shape that has never existed is created. Furthermore, a three-dimensional artwork was created by shooting the phenomenon from multiple viewpoints.

Keywords: Fluid art, 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]. This means that space travel was carried out quickly, especially with civilians.

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 think about how the culture that 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, what art and entertainment will look like in the space age is an essential and exciting theme. 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].

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 significantly different in zero gravity than in gravity, we think it is necessary to study fluid art in zero/micro-gravity.

This paper 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 a project called "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 an experiment 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. However, they automatically record the trajectory of objects under zero gravity, or they had an astronaut act for art creation. Therefore, these studies are still in the early stage of creating new art in the space age.

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. Water flow, wave behavior, ocean currents, etc., are typical examples [8]. Fluids are known to be able to create beautiful shapes under a variety of conditions. One example of a fluid phenomenon is the "milk crown [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].

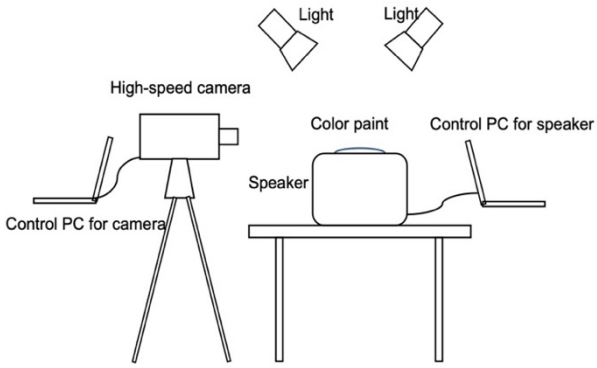


Figure 1: Fluid art generation system.

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 shape was 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 several shows 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].

Figure 2: Scene of Sound of Ikebana.

3.3 "Sound of Ikebana" using birth cry

The birth cry of a newborn baby is a sound that indicates the birth of life and gives people hope for the future. In that sense, using the birth cry to create the Sound of Ikebana matches the concept of art creation under zero-gravity for the future. Therefore, we challenged the art creation using the birth voice as the next challenge. In the past production of the Sound of Ikebana, we used sine waves as a stable vibration source, so it was necessary to adjust various parameters such as the volume

of sound and the viscosity of paint when using the birth cry. However, as a result, we succeeded in creating the only Ikebana art that expresses the energy of the birth of life. Figure 3 shows several examples of the Sound of Ikebana using birth cries. In the experiment of art creation under micrograviy, we used the birth cry as the sound source.

Figure 3: Examples of Sound of Ikebana using birth cry.

4 Microgravity generation method

4.1 Parabolic Flight

Parabolic flight means flying on a parabolic flight path [12]. 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 micro-gravity environment of about 10-2 to 10-3G can be realized for about 10 to 20 seconds, so it is used for various micro-gravity experiments and training of astronauts. Figure 4 shows the flight curve in parabolic flight and the gravity in each phase.

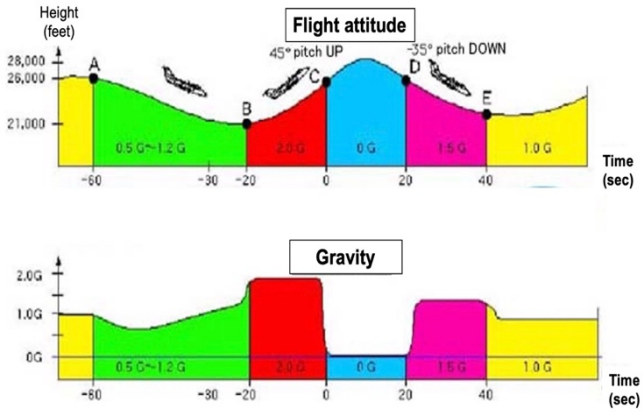


Figure 4: Parabolic flight.

4.2 Free-fall

When an object falls downward, pulled by gravity, it is in a weightless state (actually, it is not entirely weightless due to air resistance). In other words, weightlessness can be achieved by creating a free-fall state by dropping things from a high place.

The ZARM microgravity experimental facility, called the Bremen Drop Tower, at the University of Bremen in Bremen, Germany, is well known. Its height is 147m (actual fall distance is 110m), and if the falling capsule is dropped in a tower that has been evacuated and evacuated, weightlessness for almost 4.7 seconds can be achieved [13].

The generation of the Sound of Ikebana occurs in a short time of less than one second. At the same time, the generation of microgravity of about 0.5 seconds can be realized by a small-scale free fall system with a height of around 2m. Utilizing this feature, we have developed a small-scale free-fall system in our laboratory and experimented with creating the Sound of Ikebana creation under microgravity [13].

5 Creation of fluid art under microgravity

5.1 Basic methodology

To create art under zero gravity, we worked on an experiment in which the artist took the initiative in creating the Sound of Ikebana under microgravity. As we have already carried out the experiment based on free-fall [13] of the parabolic flight and free-fall described before, we adopted the parabolic flight. 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" [15]. 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 impressions and comments on why it looks Japanese from many people. 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 [16].

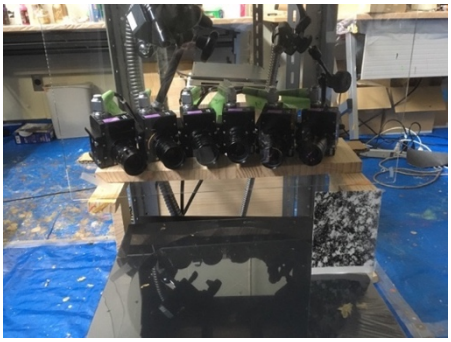
To realize 3D restoration, researchers have studied a method to create a 3D model based on images taken from multiple directions [17][18]. There are two methods of using multiple still cameras and multiple high-speed video cameras as a shooting method. The method of performing synchronous

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. Fig. 5 shows the developed generation system. The system uses a high-speed multi-camera system called MEMRECAM manufactured by NAC. The camera part (Mcam V004) has a shooting speed of 2000 frames/second with 2M pixels. Six units were installed surrounding the speaker. For complete 3D restoration, it is necessary to shoot from 360 degrees. Since a workspace such as setting paint is required, we decided that six high-speed cameras surround the speaker at about 120 to 180 degrees.

a. Front view



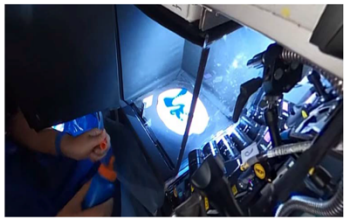
b. Side view

Figure 5: Sound of Ikebana generation system for parabolic flight.

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 with almost no failure by following the practiced procedure in the actual parabolic flight.

a. The airplane used for the parabolic flight

b. The scene when microgravity is realized



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

Figure 6: A scene of Sound of Ikebana creation during an actual parabolic flight.

In an actual parabolic flight, the microgravity of about 20 seconds was achieved 8 to 10 times. Figure 6 shows several scenes of the fluid art creation during the parabolic flight.

5.3 Sound of Ikebana under the parabolic flight

As mentioned earlier, one parabolic flight allowed us to experience microgravity about ten times. Moreover, the flight was carried out twice over two days. Except for the failure, the Sound of Ikebana was created 18 times. Therefore, it was possible to obtain a video image of 6 positions x 18 times. Figure 7 shows how the actual Sound of Ikebana images changes as time passes. Also, Fig. 8 shows an example of an image at a specific moment of a video taken from 6 positions.

Figure 7: An example of how the Sound of Ikebana changes its shape depending on time.

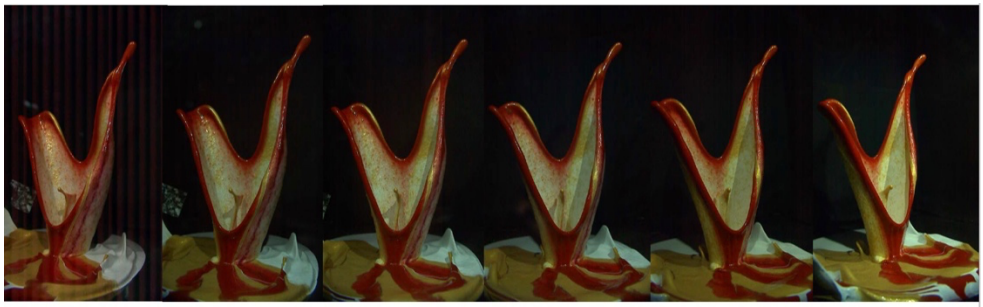


Figure 8: An example of images shot from multiple positions.

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

・Under 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 up higher and creates a more extended shape.

・The paint that jumps up to a certain height under 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 it does not fall under microgravity, the appearance of jumping and spreading looks more sophisticated.

Figure 9: An example of the 3D Sound of Ikebana

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. 9.

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 decided to use the birth cry of a newborn baby as the sound source. The birth cry was used because birth means the birth of life and its future, which nicely matches the space-age concept.

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" and "birth and future of life."

We are planning 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. Such new applications will be exhibited at the World Expo in Osaka in 2025.

Acknowledgment

We thank NAC Inc. for lending us multiple high-speed cameras during the preparation and execution of the parabolic flight, especially to Mr. Yamamoto of NAC for his continuous support.

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