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Human Sense-Based Simulation-Experience Model for Interactive Art Production

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인터랙티브 아트 제작을 위한 인간의 감각 기반 시뮬레이션-체험 결합 모델

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Abstract Recent advances in science and technology leveraged various artistic tools. Interactive art based on various media technologies became popular in a short period, and is widely appreciated as a new form of art. This new form of art has a different method of expression from traditional art such as painting or sculpture. It aims to strike a balance among the artist, audience, and piece of art through interaction between the work and viewers. Viewers can take part in the creation process, going beyond the conventional way of art appreciation. This paper analyzes interactive art production techniques based on human senses from the artist's perspective. "Simulation-experience model" will be suggested after looking at several example artworks. Charming, which was produced based on this model, will be introduced and its meaning will be analyzed. The objective of this paper is to predict the future of interactive art and changes in the art form by studying interactive art production techniques based on human senses. We believe that the prediction is helpful in understanding the artistic and technological value and the social influence of interactive art in the future.

Key Words : Simulation-experience model, Interactive art, Human senses, Media art, Communication

요 약 현대 과학기술의 발전에 따라 예술의 도구도 점차적으로 발전하였다. 다양한 미디어 기술들을 활용한 인터랙티브 아트는 사람들에게 빠르게 전파되었고, 새로운 예술의 형식으로 인식되고 있다. 인터랙티브 아트는 회화나 조각과 같은 전통적인 예술 표현 방식과는 차이가 있다. 관객과 작품 사이의 인터랙션을 통해 예술가, 참여자와 작품의 사이의 균형을 이루었다. 관객은 작품을 감상하는 것을 넘어서, 작품을 만드는 데 참여할 수 있다. 본 논문은 예술 창작의 관점에서 인간의 감각에 기반한 인터렉티브 아트 제작 기술을 시각적, 청각적, 촉각적 측면에서 분석하고, 관련 사례들을 결합하여 '시뮬레이션-체험'모델을 제안한다. 그리고 제안한 모델을 사용해서 제작한 'Charming'이란 작품을 소개하고, 그 의미를 분석한다. 본 논문은 인간의 감각에 기반한 인터랙티브 아트 제작 기술 분석을 통해 형식의 변화 및 인터랙티브 아트의 미래 발전을 예측하여 예술성, 기술성, 그리고 사회적 영향성에 적용될 수 있도록 비전을 제시한다.

주제어 : 시뮬레이션-체험모델, 인터랙티브 아트, 인간의 감각, 미디어 아트, 교감

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1. Introduction

Throughout human history, interactions have taken place between human beings, between humans and the environment, and between humans and science and technology. Interactive art has also developed based on interaction with various academic fields, reflecting the times.

This thesis covers techniques in producing interactive artworks based on the human senses. Interactive art emphasizes encouraging participation of audiences using five senses as visual, auditory, and tactile senses. It is important to use production techniques that allow communication between artworks and viewers. It is difficult for the audience to read the intention and meaning of artworks if they lack communication. Interactive art techniques based on human senses can help artists create works that can communicate with the audience and also help viewers better understand the work. In other words, the essence of interactive art is the "harmony" between the work, audience, and space.

Production techniques of various interactive artworks were analyzed in this thesis based on research on the human senses. To this end, several examples were looked at to analyze interactive art techniques focusing on visual, auditory, and other senses. The future development of interactive art will be predicted based on this study on different interactive art techniques. The result of this study is believed to present new directions of how artists create new works and how viewers appreciate artworks.

2. Background

2.1 Interactive Art

In modern art, incomplete artworks can be completed with audiences' participation place in a physical or in a virtual space[1]. Some others ask the artist or the spectators to become part of the artwork[2]. Without communication with the audience, accordingly, interactive artworks themselves are incomplete.

The concept of interactivity comes from sociology. Information that is generated by viewers' behavior or words enables the communication between interactive artworks and the audience[3]. According to Maurice Benayoun, a new media artist and theorist, Pliny the Elder stated in his book Naturalis Historia that the first interactive artwork should be the work created during the art contest between Parrhasius and Zeuxis. Parrhasius asked Zeuxis to unveil a curtain to show a painting behind it, but the curtain was a painted one. The gesture of unveiling the curtain gives meaning to the work. This gesture was at the heart of the piece. Some of the earliest examples of interactive art have been dated back to the 1920s, and one of the famous examples is Rotary Glass Plates by Marcel Duchamp. The artwork required the viewer to turn on the machine and stand at a distance of one meter in order to see an optical illusion[4].

Fig. 1. Marcel Duchamp, 〈Rotary Glass Plates, 1920〉

Interactive art has become more widely known since the 1960s. Some artists started to

feel that it should not be only pieces of art that hold creativity and that viewers should also participate in artistic creation. Roy Ascott, a British pioneer of media art, was one of the artists who set the early concept of interactive art with his piece Change Painting in 1959. The work consists of glass panels with different paintings as shown in Fig. 2, and viewers can move the panels to see overlapping images. The visual structure based on such a simple interaction represents change and uncertainty of the interactive artwork and bidirectional communication. Frank Popper has written: "Ascott was among the first artists to launch an appeal for total spectator participation"[5].

Fig. 2. Roy Ascott, 〈Change Painting, 1959〉

Artists began introducing video, audio, and other new technologies from the 1970s. Nam June Paik, for instance, live broadcast his audiovisual work Good Morning, Mr. Orwell (1984), experimenting with methods of display and interaction. In the 20th century, with the popularization of computer technology, science and technology developed by leaps and bounds. New media art with advances in science and technology blurred the line between art and technology, and interaction has emerged as an important element in art. As a result, a new art genre was born.

Center for Art and Media Karlsruhe (German: Zentrum fur Kunst und Medien) in Germany is the world's first museum for interactive art. The National Gallery, Tate Modern, and Tate Britain in the UK contributed a lot to the development of interactive art by exhibiting numerous interactive artworks that invite spectator participation. As artists from various countries started to study interactive art that combines technology and art, an increasing number of websites on interactive art were created, and new media art exhibitions became popular. Interactive art has been widely used not only in exhibitions but also in the game, video, and advertisement industries and has risen as a promising sector in this digitized new media era.

Interactivity in new media art means that the audience and the work affect each other, forming a new type of relationship. Such a relationship enlivens art by enabling spectators to participate, interact with the work, engage in the process of creation, and be part of the work. The audience can enjoy more sensory experiences compared to traditional one-way art, and such artworks can create a sense of strong bond with viewers.

Because it is interactive art, each observer makes their own interpretation of the artwork and it may be completely different than another observer's views[6]. Thus, the artist, piece of art, and the audience can form an interactive triangular relationship. Many interactive artists hand over the right of artistic creation to viewers by offering a chance to participate in the work, achieving new artistic results. That is why interactive artists should think about the role and meaning of spectators. Artists can utilize various digital media technologies to provide new sensory experiences to the audience. Artists can take numerous options to realize interactivity in art, thanks to the fast internet and advanced science and technology.

2.2 Evolution of Interactive Methods

One of the characteristics of interactive art is that artworks are designed considering people, especially spectators the most. Interactive artists, therefore, should plan how the work will interact with the audience in the design phase. Interactive art has evolved from simple rule-based interaction to interactions based on wearable technologies, tangible tools, and artificial intelligence, offering an opportunity to appreciate artworks more freely.

In the earliest interactive art pieces, artists set rules and procedures. These rules make the interactive process more natural, but the level of creativity and freedom can be somewhat limited. Viewers should, for instance, stand away from Rotary Glass Plates to feel the effect that Marcel Duchamp planned.

Wearable interaction requests the audience to put on wearable devices to interact with the piece. These devices have data transmission and computing functions. Examples are glasses, helmets, gloves, and clothes. For interactive artworks using virtual reality, VR glasses are a necessary device. Google Glass, for example, has a camera and processors in front of the glasses to project feedback data and content onto the micro display screen on the lens.

Tangible interactions enable the interactive process without wearable devices. Interactive devices commonly used in the art include Kinect, Leap Motion, and the Arduino package. Kinect and Leap Motion can track the human body with infrared light but are limited in terms of detection range and accuracy. The Arduino package, on the other hand, can measure distance and detect vibration, and these sensors help viewers interact with artworks.

Artificial intelligence-based interaction is the result of advances in science and technology and IT. The evolution of technology, whilst encompassing the craft of making, has come to include the tools as well, which have become increasingly scientific[7]. AI is used everywhere, and artists can also combine AI technology with art to produce artworks. In the era of new media art, the fields of technology and art are constantly breaking boundaries and working together closely. Artists have a broad range of technological tools to use for artistic creation, and interactive technologies are continuing to be developed. When interactive tools are used in art, viewers can experience a greater sense of surprise, astonishment, and fun than other art media. Artists should continue to think about which tools to use to create a better piece of art.

2.3 Interactive Art based on Cutting-edge Technology

Interactive art, as the name suggests, is highly interactive and encourages participation and immersion in the audience. That is why interactive art is widely used today on the walls of buildings, museums, exhibition halls, airports, and broadly public spaces.

Fig. 3. HD video in the Japan Pavilion for Shanghai Expo 2010

The ongoing developments in screen technologies advance mobile interactivity, which shifts the analysis of artworks from either their content or form to their use in spatial arrangements for creating screen spaces[8]. In

Shanghai Expo 2010, high-definition video projected on the wall was changed according to the audience's movement. When viewers shake their hands, for example, they can make a phone call or turn on the television on the wall, or the projections can follow the audience. Fig. 3 shows a video where the host makes a video call with her friends in Japan. It shows interactive technologies can be utilized in our daily lives. Interactive technologies can go beyond the realm of art and exhibition to be widely used in our day-to-day lives.

"Brain: The Inside Story," which was exhibited at the American Museum of Natural History for 10 months from November 20, 2020, let spectators observe and recognize their brain from a new perspective through imaginative art, brain scans, and exiting interactive articles on exhibition. Visitors could learn how our brain works by interacting with machines. It was a successful example of how museums can utilize interactive art for education, and it proved that interactive art can be further developed for educational purposes.

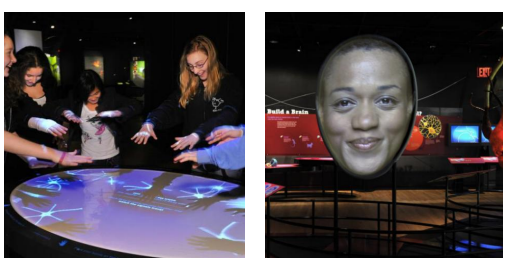

Fig. 4. Brain: The Inside Story(2010), by Courtesy of Canadian Museum of Nature

One of the interactive artworks was designed to help visitors understand how nerve cells interact and are connected to the brain, as shown in Fig. 4. When the viewer touches the table, a nerve-shaped figure appears on the viewer's hand. This nerve is connected to the other nerves around it, forming a complete nervous system. This interactive exhibit can be helpful for viewers in learning how our nerves are connected and how senses are delivered. Also, An exhibition captured the audience's facial expressions with a camera and projects the face onto a unique device. Changes in facial expressions become more obvious when the audience makes exaggerated expressions. It was designed to teach that the human brain regulates emotions and behaviors by comparing different emotions controlled by the brain.

The combination of interactive art and game has become popular in recent years. The case in point is motion-sensing games. Nintendo released its next-generation game console named Wii in 2006, and the game controller for Wii senses motions and reflects the motions on the screen. Wii suggested a new direction for the development of games. After the release of Wii, PS Move of Sony, Kinect of Microsoft, and other motion-sensing games have been developed.

Fig. 5. Microsoft Kinect Sports

Microsoft, for instance, launched Kinetic Sports in 2010. When players stand in front of the TV and raise their hands, the crowd in the hall cheer. Kinect Sports has a variety of sports including billiards, soccer, bowling, boxing, and track and field. As in Fig. 5, users can play sports with their hands or feet. Players can enjoy

sports, work out, feel the joy of exercise, and build up their bodies at home.

The above examples are games that combine art with cutting-edge technologies. Interactive art not only entertains the public but also enriches and makes our lives more convenient. Rapid advances in interactive art will provide both opportunities and challenges in the era of new media. Applications of interactive art will be helpful in various fields.

3. Using Human Senses in Interactive Art

Ever since Morton Heilig developed the Sensorama Simulator [9], using human senses in interactive art has been claimed to be of notable importance. We use our sensory system to feel the outside world. As such, various sensory organs are used when we communicate with artworks. Today, the media are both concerned with engaging with the array of human senses to the extent that they are largely based on the very concept of sensory language[10]. Depending on which sensation and perceptions are used to recognize the artwork, interactive art techniques can be divided into visual, auditory, and other sensory techniques.

3.1 Relationship between Interactive Art and Human Senses

Compared to other forms of art, interactive art has a short history. Although there are many great interactive artworks, the theoretical framework has not been completed due to the lack of systematic academic research on interactive art techniques. Art becomes interactive when audience participation is an integral part of the artwork[11]. Interactive artworks receive various types of input information such as movement or temperature change and make an output using sensors or computer programming. The baggiest feature of Digital Art is to make audiences participate in the artworks. Digital technology to be a direct medium for artworks and through the participation of the audience, the artworks are to be completed with their interaction[12]. In that sense, interactive art is quite similar to digital art.

It is necessary to know the artistic and technological aspects of interactive art to fully understand interactive art, a branch of new media art. The combination of art and technology has created a new situation in which the art experience emanates from the artwork's proactive sensitivity to the viewer's activity[13]. The technological aspect means interactive art techniques based on human senses. Everything a human does to or with a computer is human-computer interaction[14]. Interactive art techniques based on human senses, which is the topic of this paper, are about realizing human-computer interaction with art. Sensory organs are the organs that receive stimulation from the outside. Aristotle divided human senses into touch, smell, taste, and sight and said that the brain is served by all sensory organs. The corresponding sensory systems of the visual system (sense of vision), auditory system (sense of hearing), somatosensory system (sense of touch), olfactory system (sense of smell), and gustatory system (sense of taste). Those systems, in turn, contribute to vision, hearing, touch, smell, and the ability to taste[15]. The sensory system helps us recognize information about stimuli like a sensor of a machine.

The relationship between interactive art and humans can be seen as a simulation-experience model. When interactive artists create a piece, they need to simulate human senses. Our sensory organs are used to connect us with interactive artworks, as well as when we interact

with the outside. Interactive art techniques based on human senses are about simulating various human senses. During the production process, interactive artists should plan which human senses will be utilized in their work and how the senses will be simulated.

The audience should be able to use their sensory organs when they experience interactive artworks. During the experience, sensory organs receive stimuli from work, deliver them to the brain, and make responses to the stimulation, and the answers go back to the artwork. Such interaction occurs between the piece and the audience and brings unpredictability and uncertainty to the artwork. It is unpredictable whether there will be any feedback from the viewer and when that will happen. Thus, artists cannot anticipate the outcome or feedback as everything depends on the audience's behavior, and this uncertainty is what makes interactive art interesting. From the production to the experience phase, this simulation and experience model should be the basis of interactive art to complete the work.

3.2 Visual Sense

Interactive artists adopt various techniques based on human senses to create a piece. Visual interactive art techniques are the most important ones among others, as light is believed to be the fastest traveling medium. In addition, we can receive visual information more easily than other kinds of information because visual ones are mostly intuitive.

For visual interactive art techniques, computers process visual information based on visual detection or visual identification. The camera transmits an image to the computer, and the computer checks the image to see if it includes the desired content. If there is, give 'YES' as the feedback and 'NO' if not. This is an art technique based on visual detection. The computer should capture the real-time image through the camera during the interaction, determine the target to be identified on the screen, and give different feedback depending on the image[16]. For techniques based on visual identification, gesture recognition and facial expression identification are commonly used. Visual techniques started to be popular among interactive artists thanks to the release of new technologies such as Kinect and Leap Motion. Since its release, visual identification has been widely used in art.

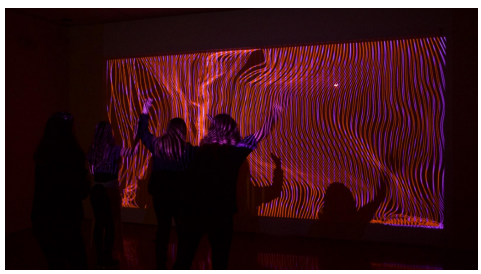

Fig. 6. Cuppetelli and Mendoza, 〈Interference, 2016〉

Fig. 6 is a piece of interactive art titled Interference. This work was produced in 2016 by new media artists Annica Cuppetelli and Cristobal Mendoza. They applied interactive art techniques mainly based on a visual identity system. This installation consists of two video projectors, a center console, a dual-channel system, a video camera, and custom software[17]. Tactile senses were simulated during the creation process, and the viewer's movements are captured with a camera to be sent to the computer. The computer program then changes the parameter after analysis and interpretation to provide feedback to the work. The simulation and experience models are carried out along the process, which shapes the interactive artwork that combines truth and falsity. Beautiful colors and sporty lines add a

sense of movement, fluidity, and rhythmicity to the piece.

Wooden Mirror is a work by Daniel Rozin, a famous new media artist from Israel. He used a computer program to control motors and sensors behind 830 wooden pieces[18]. The camera catches the image of the audience in real-time, and the wooden pieces and the angles move following the captured image to reflect the shade and contour of the spectator. It creates a portrait that moves in real-time as shown in Fig. 7. This work invites spectators to be part of the piece. The visual interactive art techniques behind this work involve the audience in completing the artwork.

Fig. 7. Daniel Rozin, 〈Wooden Mirror, 1999〉

After this piece, Daniel Rozin explored many different materials and built interesting new pieces. For example, he made Weave Mirror, Fan Mirror, Penguins Mirror, and PomPom Mirror. A Kinect sensor replaced the camera in Penguins Mirror and PomPom Mirror, and interactive language based on visual detection enabled the real-time interaction between the audience and artwork. Visual interactive techniques were used earlier than any other techniques, and part of the reason is that visual techniques are easier to achieve the artist's purpose. The interaction with viewers, together with intuitive visual stimuli, lets the audience have a unique experience. Artists, however, should think about how to encourage spectators not just to pass through nor neglect the meaning behind the work when visual interactive art techniques are used.

3.3 Auditory Sense

Humans rely on the auditory system the second most to detect external objects, and we can hear the sound as sound waves travel through the auditory system. Auditory information can directly stimulate the human brain. We respond differently depending on the pitch, note, and chord. Interactive artists use art techniques based on auditory senses, which are mainly divided into two forms: sound detection and sound identification. Auditory interactive art techniques are rarely used alone but commonly used in combination with other techniques based on other senses.

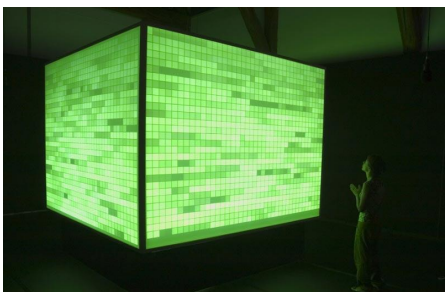

Fig. 8. Trafik, 〈Sonik Cube, 2006〉

Trafik, a French creative studio based in Lyon, designed an interactive artwork that visualizes sound named Sonik Cube in 2006. It was exhibited at the Sound and Visual Exhibition, an exhibition for international sound devices. The work simulates the auditory sense and lets spectators interact as the cube glows when it receives sound. The computer analyzes the characteristics of the viewer's sound to convert them into visual images in real-time. They are expressed in different colors and brightness on the surface of the cube. Fig. 8 shows the cube turned bright green as a result of an interaction

with the audience. This work also uses computer programming software. The studio explained that they gave unique beauty to the work with complexity and diversity.

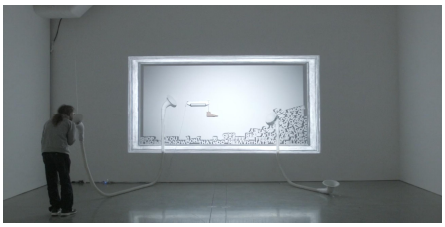

Fig. 9. Neil Mendoza, 〈Robotic Voice Activated Word Kicking Machine, 2006〉

The Robotic Voice Activated Word Kicking Machine is an interactive artwork by Neil Mendoza who adopted auditory interactive art techniques. This piece includes a tube, a microphone, a speaker, a projector, a speech recognition program, and OpenFrameworks software. As shown in Fig. 9, what viewers speak in front of the microphone is collected and converted into words by the speech recognition system. When the software starts, it launches a web browser and creates a WebSocket connection to it. When someone starts speaking, the software sends a message to the browser to tell it to start speech recognition, explains Mendoza. When a word is near the foot, the computer sends a message to an Arduino telling it to kick[19]. In this work, the most important feature is the auditory interactive art technique based on speech recognition. Audio is visualized by auditory art techniques, facilitating the human-machine interaction.

3.4 Other Senses

Interactive art techniques are not limited to visual and auditory ones, and other human senses are also used in art techniques. Examples include tactile and olfactory senses, and techniques based on tactile senses are more commonly used. When artists use techniques based on other senses, they utilize a variety of equipment to convert signals from the audience into electronic ones and feedback directly or indirectly to the work.

Fig. 10. TeamLab, 〈Forest of Resonating Lamps, 2016〉

TeamLab is an international group of artists working to combine art, science, technology, and nature. The group created a piece of interactive art titled Forest of Resonating Lamps in 2016. This artwork reminds the audience of the existence of themselves and others. The installation consists of lamps made of Murano Glass, LED, and sensors[20]. The sensors attached under the lamps detect the viewer. Fig. 10 shows how it looks. When a viewer stands near a lamp, it emits a bright light and quickly transmits the information to the surrounding lamps. Then, as a result of the chain reaction, the lamps near the viewer are all turned on. If there is a light from the other side, it tells the existence of somebody standing there. The audience can notice each other's existence. The mirrors that make up the floor and walls connect the real world and expand the space.

Fig. 11. Caitlind rc Brown, Wayne Garrett, 〈Cloud, 2016〉

Cloud is an interactive sculpture that consists of 6,000 light bulbs created by Canadian artists Caitlind r.c. Brown and Wayne Garrett. Chain switches and domestic light bulbs together form the cloud shape[21]. Fig. 11 shows the shape of the sculpture. Spectators are invited to control each bulb by pulling the switch. That is how they can interact with the artwork. When viewers gather and collaborate, they can mimic lightning on the sculpture.

Fig. 12. The Light of Time-Pottery Life Land, 2019

The Light of Time-Pottery Life Land is China's first new media art exhibition for pottery. In this exhibition, a virtual animal named Hai lives in the South Sea exhibition hall. Hai is an animal made up of many well-known pottery pieces. The walls of the exhibition hall are composed of large screens that display a virtual world under the South sea. Viewers can choose on the touch screen different types of pottery that they like to make their version of Hai. As shown in Fig. 12, the pottery selected by the viewer sinks into the sea and forms part of the body. This piece of art lets the audience create Hai. Tactile interactive language was used in this work to guide the audience into the underwater world. The objective of this piece is not only to let the audience appreciate the work but to make them part of it. This allows visitors to experience the work firsthand and enjoy it as a creator.

Our sensory organs are not separated but interconnected. Various sensory organs transmit information to the brain, which helps our body feel the sense. If artwork is too simple, it cannot give the audience a true experience of two-way exchange nor show the beauty of the work. That is why artists should consider both the artistic value and connectivity as well as the way of interaction when creating a piece of art. Not only that, artists need to constantly think about and modify the interaction method from the audience's perspective so that participants can actually be part of the work and enjoy it. For sure, for interactive art to be further developed, more artists and scientists are required to constantly study and make efforts. Then, interactive artists can achieve a perfect combination of technology and art.

4 Applying Study Results in Creating "Charming" based on Human Sense

This paper has so far defined interactive art techniques based on human senses and studied examples. Based on the study results, I produced a piece of interactive art titled Charming considering the study results.

4.1 Concept

A Kaleidoscope that I used to play with as a child gave an inspiration. Kaleidoscope is a combination of beautiful Greek words, kalos (beauty), eidos (image), and scope (view). Each word can summarize the main qualities of the kaleidoscope. It was invented in 1817 by Sir David Brewster, a Scottish scientist, and inventor[22]. The optical instrument has colored glass at one end and a prism in the middle. At the other end is glass with holes. It presents a beautiful symmetrical pattern when viewed from the end. The mirrors are placed in a tube and reflect an object as a colorful pattern. A rotating kaleidoscope presents changing images. Charming was inspired by the world inside a kaleidoscope and the people who play with it.

〈Charming〉 differs from ordinary kaleidoscope in shape and size. The main body

of the work is a giant kaleidoscope that can put a person inside, rather than just a tiny kaleidoscope in your hand. It means that humans' understanding has a range, and all the beautiful things found are in the range. People can experience the charm of 〈Charming〉 to the fullest, or they can go out and find a broader and more enchanting world. When people walk into 〈Charming〉, a giant kaleidoscope, they can see different images according to their other gestures. The work wants to convey the meaning that life is like a kaleidoscope, rotating in different people's hands, reflecting different patterns and brilliance. People can make their lives more colorful because of what they do or make their lives less bright because they do nothing.

4.2 Production Process

Firstly, we need to link Processing and Kinect. We chose Kinect V2 because it has a better color resolution and depth resolution than Kinect V1. In addition, each Kinect has a range of detection. Kinect V1 ranges from 0.8 to 4.0 meters, and Kinect V2 has a range of 0.5 to 4.5 meters. It does not significantly impact 〈Charming〉, but a wider range of detection will give viewers a better experience. Kinect V2's depth sensor obtains depth information by reflecting the projected infrared rays in a Time of Flight (TOF) manner. After acquiring depth information, gestures can be recognized and extracted by identifying the hand state and the joints of the hands. Once Kinect is connected using the Kinect library in processing, the next step, drawing the picture, can be performed.

To better express the relationship between the kaleidoscope and people, the author used a method where different hand gestures result in changes in the image to simulate how the audience would control the changes in the kaleidoscope.

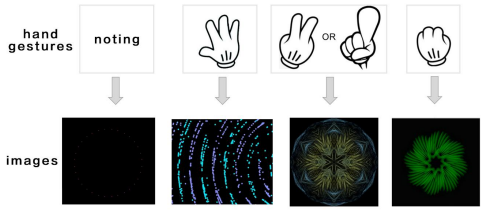

Fig. 13. Reacted images by hand gestures

First, the images were designed and paired with hand gestures. The author designed four images in total because Kinect can control only three gestures in maximum. Fig. 13 shows each gesture and graphic content. The first image appears when there is no hand gesture at all. The graphic content shows pink dots constantly contract and expand around the center point. Just as the kaleidoscope even without being manipulated, there is still a symmetrical scene. The second is the image that appears when a participant makes a paper gesture of rock paper scissors. The audience can change the position of the center point of the blue and purple dots by moving their hands. The graph is the only asymmetrical one, where the seemingly chaotic origin is moving around the origin. But, just like people's lives, no matter how messy they are, they can always find a pattern. The third one is for scissors or the index finger, and the twelve symmetrical shapes move following the gesture. This moving hexagon can move along with our fingertips, but it changes slowly in color and shape. It means that even if we can manipulate and intervene in something, there is always a part that we can't control. Lastly, when the audience clenches their fists, the image depicts eight identical shapes that move in the same direction, and the graphics and colors vary depending on the hand gesture. The color changes in the image, but the color matches every moment. Fist means controlling. Here, the gesture of the fist symbolizes control. Even if we

can't control and change everything, we can't ignore the importance of ourselves.

After designing the images, the first thing to do was to write classes in Processing create the images. At this stage, those graphic images had their variations but were not affected by Kinect. After the classes were all written, the frame for the code was completed. After that, Kinect should be connected to the code of different classes. The final code was completed after repeated testing and modifications.

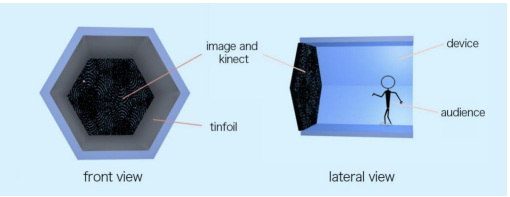

Fig. 14. Arrangement of devices

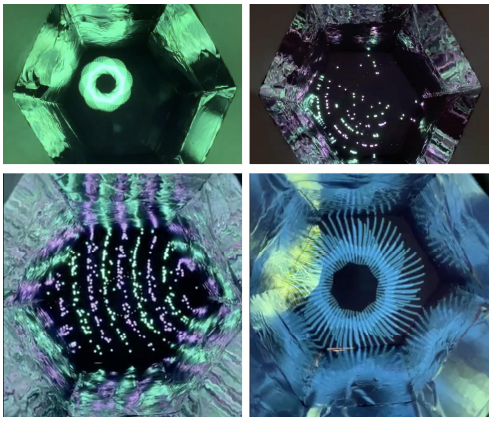

Fig. 15. The effect on display with a smaller model

After writing the code, the images were projected onto the wall, and external devices were added to make the work more interesting and impressive. The tinfoil was selected as the material for the external device after comparing many different materials. The device looks like the hexagonal shape of the kaleidoscope. Fig. 14 shows how the external device looks like. The piece was completed after several tests. To make it easier to see the effect, I made a smaller model to see the effect. Fig. 15 shows the effect of a smaller model.

4.3 Analysis of Human Sense-based Production Technology

This piece of art was produced based on Kinect and Processing. Also, it mainly depends on visual interactive art techniques. Kinect should identify the presence of an audience first, and if anyone is there, the hand should be identified. The next step is to capture and judge what gesture was made. As mentioned above, Kinect can recognize up to three gestures. For that reason, four graphic images were designed considering the case where no audience or hand gesture is recognized. Depending on the recognized hand gesture, different graphic images are projected on the screen as feedback. Changes in these shapes are set by class code in Processing.

Charming is based on an interactive art technique based on visual identification which allows the audience to change the image on the screen with hand gestures. Such a technique was applied to give the feeling of a kaleidoscope. As people can change the view through the kaleidoscope by rotating it, viewers can change their gestures in front of this artwork to see different images. The kaleidoscope is generally a small size that can be held in our hands, but in Charming, external devices were used to enlarge the size, and the reflection of tinfoil makes viewers feel like they are entering a new world inside the kaleidoscope.

In this work, the design of the device and the design of graphic changes are the simulation of manifestation, which makes the work likes a kaleidoscope through the device and graphic changes. However, the work amplifies the size of the kaleidoscope, that is, the size of stepping

into the kaleidoscope world. At the same time, Kinect is used to achieve the effect of human-machine interaction and enhance the experience of the experiencer. Put the whole process together, and it is a simulation-experience model process.

4.4 Works Analysis

Due to the nature of interactive art, this aspect of technology is an essential part to integrate the artist's representation with the spectator[23]. Interactive art is different from traditional art in that the purpose is to express ideas and involve spectators in the experience. The difference is the method for delivering the idea. Interactive artists utilize cutting-edge technologies to create new concepts and formats. Interactive artworks stimulate the viewer's sense of sight, hearing, and touch to deliver and transfer the information and receive feedback. In this process, all the sensory system gets involved in appreciating the work.

Artists should thoroughly consider the medium, objects, and the whole artwork as much as possible. Artist the analysis of the collective, artifact-mediated, and object-oriented activity system demands the fullest consideration as a unit[24]. Technology and interactive techniques are just the means of production, but interactive artists have somewhat limited room for creation. Therefore, interactive artists should think long and hard about what techniques they will use in creation.

Take Kinect used in Charming as an example. Kinect is a visual identification-based technology that allows artworks to interact with machines. Kinect is used primarily to recognize people or gestures and to calculate the distance between a person and a device. Kinect shows limitations and issues with the current level of technology. The RGB camera in the middle of Kinect records the video with the color it captured. The other two cameras on the left and right collect depth data (which is the distance between the object on the screen and the camera) using an infrared projector and an infrared CMOS camera, respectively. The RGB camera is capable of resolutions of up to 1,280 by 960, and the infrared camera is 640 by 480. One of the shortcomings of Kinect is the latency in the calculation. It can only sense objects at close range, and its identification can be wrong even if the object is within the range. These issues affect both artworks and the experience of the audience.

These issues will be gradually improved and completely solved with the further development of interactive art. Advances will be made in other devices such as the weight sensor, voice sensor, radar system as well as Kinect. Interactive devices will become less noticeable, and interactive experiences can then go beyond technological limitations.

5 Conclusion

Interactive art is the result of advances in art and science and a combination of art and technology. As interactive art constantly blurs the boundaries of art, science, and our everyday life, the audience can experience multi-dimensional convergence. That is why audience experience, behavior, and thoughts are important elements of interactive artwork. Art techniques in interactive art can integrate various artistic elements in line with technological development and realize the full potential of art.

This paper analyzed visual, auditory, and other sensory interactive art techniques, and proposed the simulation-experience model which can be a reference for artists. In the simulation-experience model, technology plays a

role in simulating human senses in interactive works. With the advancement of interactive technology, audiences have more diverse senses when participating in the work, allowing them to experience the work better by increasing their participation. In contrast to the human, the computer presently is very disadvantaged in its ability to perceive or understand what is necessary for high-level interaction with the human[25]. For that reason, artists should consider the technological aspect first. That is the "Simulation" part of the simulation-experience model. The ability to simulate human senses well is critical to the ultimate effectiveness of the interactive work. There are occasions where they need to choose one technology and give up others during the design and production phase. Or they may have to compromise and give up several things they want to express. Even so, Artists should not just emphasize techniques and neglect the artistry of the work.

Art production technologies in interactive art will be certainly further developed as technologies continue advancement. As technology advances, sensors will be more accurate than today, accelerating the data reception, operation, and transmission process. Then, there will be almost no latency in responding to the movements of the audience. If the technology is improved to that extent, the audience will not recognize the existence of interactive devices and will be easily immersed in the work. This means that the audience can have a better experience only if the simulated part is better designed.

Interactive art provides a new art experience as an interesting combination of art and technology. Also, as it can be applied and displayed in a variety of ways, not only artworks but also commercial advertisements based on interactive art have proved great influence. We are still exploring interactive art, and this form of art lacks a theoretical system and mature art models. For its development, a new driving force is needed to expand and innovate the art form. Art production techniques based on human senses will serve as a guide for interactive artists when creating new pieces of art. When new media technologies emerge, they will bring about further advancement in interactive art. The future of interactive art will be beyond our imagination.

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