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Master's Thesis
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ImageFlowing: Enhance Emotional Expression by
Reproducing the Vital Signs of the Photographer

Keio University
Graduate School of Media Design

Qianqian Mu

A Master's Thesis
submitted to Keio University Graduate School of Media Design
in partial fulfillment of the requirements for the degree of
Master of Media Design

Qianqian Mu

Master's Thesis Advisory Committee:
       Professor Masa Inakage   (Main Research Supervisor)
       Senior Assistant Professor Junichi Yamaoka   (Sub Research Supervisor)

Master's Thesis Review Committee:
       Professor Masa Inakage   (Chair)
       Senior Assistant Professor Junichi Yamaoka   (Co-Reviewer)
       Professor Matthew Waldman   (Co-Reviewer)

ImageFlowing: Enhance Emotional Expression by Reproducing the Vital Signs of the Photographer

Category: Design

Summary

ImageFlowing is an 'alive' photo reproducing the vital signs from the photographer when he/she take the photos, leading the viewers through time and space to the lens' world while shooting. We extending the two dimensional space of the picture into a multi-modal experience from sensory to imaginary, aiming at bonding a closer emotional connection between viewers and photographers. Viewers can catch a glimpse of the photographer's emotional reality when they took the picture based on the encoding of the vital signs(physiological signals). The current design of ImageFlowing encodes the breathing rate of the photographer as light change in the Breathing Frame, the heart rate as vibrotactile feedback on the Heartbeat Bracelet, and their skin temperature and the environment temperature(using Peltier elements) reproduced in the Termal Table, and the data of the vital signs can be synthesized into a special piece of music. We present the prototype as well as a description of several user tests. And we will hold an exhibition to get more feedback from more people.

Keywords:

photography, emotional, vital signs, sense of space, media art

Keio University Graduate School of Media Design

Qianqian Mu

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Thanks to Ziyue Wang for your technical support and accompany on this project from the very very beginning. Thank you for always meeting many requirements of my project unconditionally, like drawing the pictures, writing the code, even like going to Enoshima with me to shooting together etc. Your patience, care, earnestness and trust are the biggest lucky of this project.

Thanks to my parents for supporting me and listening to me all the time. I love you forever.

Chapter 1
Introduction

1.1. Motivation

The reason why we like to share photos, in fact, in addition to sharing screen information, we are more willing to share the emotions when taking pictures. [1,2] For example, I am a photography enthusiast, the reasons why I like to share pictures are the sadness of parting, the joy of being together, the peace of alone, etc. I hope I can share not only the screen but these emotions with others. In fact, there are more photographs intend to present emotional expression from photographers rather than functional photos. Kindberg et al. collected about 303 photos taken with camera phones and classified their uses. As a result, about 84 percent of the photos are emotional photos and 19 percent are functional photos. [3]

Once, I had to use my mobile phone to record when my camera suddenly broke and I encountered a beautiful sunset. However, the picture recorded on the mobile phone is obviously not as stunning as the scenery in front of me. When I was so excited to share with my friends, but as the poor quality of the pictures, the scenery seemed ordinary, and my friends seemed to be unable to understand why I was so excited. At that time, I was a bit regretful and disappointed because I couldn't convey my excited emotions through photos well.

The popularity of SNS shows that, nowadays with the widespread use of digital cameras, everyone becomes an "artist", capturing every aspect of their life by images to express their emotions and to share with their friends. People not only want to record their own emotions, but also want to share them with many people. Even though we live in a connected world, there are more and more people who feel lonely and depressed as it's often difficult to share their emotions in a meaningful way. [1, 2]

However, the existing photographic media lacks access to the psychological state of users. For example, traditional photographic media cannot obtain information such as emotions of the photographer during the shooting, and the transmission of the obtained information is limited to the visualization of sensor data and image effects. Therefore, the data stored as a photographic medium is different from the experience the photographer's feels when shooting.

1.2. Goal

We intend to create a new type of photographic system that will improve the transmission and expression of emotions in images by increasing the function of recording and reproducing emotional information while maintaining traditional photographic functions.

Emotions, according to researchers, are linked to various physiological changes. [4] As a result, we employ vital signs (which indicate key body processes such as heartbeat, breathing rate, temperature, and blood pressure, among other things) as a tool to convey and express emotions. We chose to record the heartbeat, breathing, and temperature that can be influenced externally in a safe manner among a number of vital signs that accompany the feeling of emotion.

The ImageFlowing system can display vital signs data in a multi-modal format, which has been encountered frequently in research on multi-modal interfaces to date. Breathing data, for example, can be translated into an undulating light source, heartbeat data can be converted into a vibrating bracelet, and temperature data can be converted into a Termal Table that simulates the skin and environment temperature. We strive to assist photographers communicate their emotion in a meaningful way and build a tighter emotional connection between viewers and photographers by extending the two-dimensional space of the picture into a multi-modal experience ranging from sensory to imaginative.

1.3. Contributions

In this thesis we present ImageFlowing, sharing vital signs of the photographer when they took the picture with the viewer. The major contributions are: (1)

an approach of recording vital signs from the photographer: by using Heartbeat Wristband, Breathband, Infrared camera, (2) the installation which representing heart rate over a Heartbeat Bracelet, the Thermal Table which can represent skin temperature over a Peltier element and hot wire, and the Breathing Frame which represent the breathing of the photographer over light changes, and all vital signs data can be synthesized into a special piece of music.(3) a discussion of the prototyping process, and (4) insights of the initial user tests.

1.4. Thesis Outline

This thesis has five chapters in total.

- In chapter 1, we give an introduction about the motivation, goal and contributions of ImageFlowing.

- In chapter 2, we summarize the literature review and related work on how physiological changes evoke human emotions, including the motion recognition with heartbeat, breathing, and temperature. Then some products of using heartbeat, breathing and temperature to convey emotions. Finally we summarize the media art with immersion and emotion, and how can photo express emotion with haptic and music.

- In chapter 3, the design and the concept of ImageFlowing will be introduced based on an approach of recording device and system, which can record the vital signs from the photographer by using Heartbeat Wristband, Breathband, Infrared camera. And the reproducing devices and system, which representing heart rate over a Heartbeat Bracelet, the Thermal Table which can represent skin temperature over a Peltier element and hot wire, and the Breathing Frame which represent the breathing of the photographer over light changes, and all vital signs data can be synthesized into a special piece of music.

- In chapter 4, the four development process and experiment from each of the prototype will be included, and we will introduce the exhibition detail of ImageFlowing.

- In chapter 5, we will discusses the limitations and future development of ImageFlowing.

- All the study materials including questionnaires are in the appendix.

Chapter 2

Literature Review

2.1. Physiological changes evoke human emotions

"All emotions use the body as their theater..." Antonio Damasio [1] Pleasure, exhilaration, grief, fear, and fury are just a few of the emotions that color our lives, enhance our experiences, and endow our actions with passion and personality. Emotions play a key role in social interaction, decision-making, perception, attention, memory, and learning, according to research in both psychology and neuroscience.

Researchers argued that emotions are preceded by certain physiological changes. [4] As a result, when we see a deadly snake, our cortex receives signals concerning our beating heart, knocking knees, and so on.

Physical sensations (heart rate, breathing, etc.) and conscious sentiments make up our emotional states (joy, anger, etc.). Peripheral, autonomic, endocrine, and skeletomotor responses all play a role in emotional states. When we are scared, we experience increased heart rate and breathing, dry mouth, tense muscles, and sweaty palms, among other things [5]. According to James-Lange theory [6], the conscious experience of emotion occurs after the cortex receives signals about changes in physiological state.

A variety of strategies involving physiological sensors have been used in the past to recognize human affect. Miniaturized physiological sensors and improved mobile computing technologies have recently made it possible to monitor physiological data continuously using "everyday technology." [7] [8] [9]. Electroencephalography (EEG), heart rate variability, pulse oximetry, and galvanic skin reaction data are all provided by these sensors and have been used to indicate emotional changes. These findings aid in our understanding of the origins of mental health disorders including stress.

Several theories of emotion suggest that comprehending emotions requires an awareness of physiological activity. As a result, physiological signal studies on human affect have been widely conducted and have advanced greatly in many aspects over the last few decades. [10] [11]

Emotion recognition can provide a scientific basis for monitoring of emotional health and screening for emotion-related physiology and mental disease. Emotions are not only expressed through psychological behavioral performance, but also through a series of physiological changes. These physiological changes are not subjectively controlled by humans. Thus, physiological signals can more objectively reflect the true feelings of subjects. Currently, many kinds of physiological signals have been successfully applied to emotion recognition. [12]

2.1.1 Emotion recognition with heartbeat

There has a study shows that heart sound signals can be used for emotion recognition. First, the researchers built a small emotion heart sound database, and simultaneously recorded the participants' ECG for comparative analysis. Second, according to the characteristics of the heart sound signals, two emotion evaluation indicators were proposed: HRV of heart sounds (difference between successive heartbeats) and DSV of heart sounds (the ratio of diastolic to systolic duration variability). Then, they extracted linear and nonlinear features from two emotion evaluation indicators to recognize four kinds of emotions. Moreover, they used valence dimension, arousal dimension and valence-arousal synthesis as evaluation standards. The experimental results demonstrated that heart sound signals can be used for emotion recognition. It was more effective to achieve recognition results by combining the features of HRV and DSV of heart sounds. [12]

Affective videos selected from a standardized Chinese database were used to induce amused, fearful, angry, and neutral emotions, while electrocardiogram and self-rated emotional experiences were recorded. Heart rate was significantly lower in the amused condition than in the angry, fearful and neutral condition. There were no significant differences among the latter three conditions. The root mean square of successive differences, an index of heart rate variability (HRV), was significantly larger in the amused condition than in the fearful, neutral, and angry conditions. It was also significantly larger in the angry condition than in the fearful

condition. There were no significant differences between the fearful and neutral, or angry and neutral conditions. [13]

2.1.2 Emotion recognition with breathing

Breathing is primarily regulated for metabolic and homeostatic purposes in the brainstem. However, breathing can also change in response to changes in emotions, such as sadness, happiness, anxiety or fear. Final breathing output is influenced by a complex interaction between the brainstem and higher centres, including the limbic system and cortical structures. Breathing is important in maintaining physiological homeostasis and co-exists with emotions. The above studies lead to the question of whether anxiety enhances the rate of breathing or vice versa. The centre for these two outputs may be in the limbic system, paticularly in the amygdala. The respiratory-related anxiety potential recorded in EEG activities may be produced in the amygdala or the temporal pole. The temporal pole is included in paralimbic areas involved in evaluation of environmental uncertainty or danger. If anxiety increases the rate of breathing, these areas may be activated before the onset of inspiration. It is assumed that an increase in the rate of breathing is caused by unconscious evaluation in the amygdala and that these two activities occur in parallel. Stimulation of the amygdala produces a rapid increase in the rate of breathing followed by a feeling of fear and anxiety [14] A period of 350–400 ms of RAR after the onset of inspiration may be required for the conscious representation or labelling of the physiological event. Unconscious activation of the amygdala and an uncertain feeling before labelling may represent emotion, and later an interpretation of the physiological event may represent feeling.

2.1.3 Emotion recognition with temperature

Skin temperature is an important physiological parameter in medical diagnosis. It is also affected by human emotions. Ekman et al have proven that fear produces a smaller increase in finger temperature than anger [15]. Levenson et al have found that the finger temperature increases for anger, but decreases for fear [16]. Sinha and Parsons have utilized physiological parameters, such as finger temperature, to recognize emotions, and achieved a 99 percent classification rate [17].

2.2. The design of using vital signs to convey emotions

Emotion recognition can provide a scientific basis for monitoring of emotional health and screening for emotion-related physiology and mental disease. Emotions are not only expressed through psychological behavioral performance, but also through a series of physiological changes. These physiological changes are not subjectively controlled by humans. Thus, physiological signals can more objectively reflect the true feelings of subjects. Currently, many kinds of physiological signals have been successfully applied to emotion recognition. [12] As we pay more and more attention to individual emotions, there are some devices that use vital signs to express emotions.

2.2.1 Heartbeat

1.HeartLink

Pseudo-haptics technology show that if the experimenter listening to their expanded heartbeat while watching the image, whether the heartbeat belongs to himself or the characters, it will gradually becomes indistinguishable. It describes that once people hear the sound from the body, they will unconsciously infer the feelings and intentions reference to their own body reaction. And when they hear the rapid heartbeat, they will imagine tension feelings [18].

HeartLink captures heart rate (HR) data from athletes competing in sports events as a biometric parameter. This can be streamed in real time to viewers with a variety of social connections to the participants. They present preliminary data from a pilot research and a small user study that they did with HeartLink. The pilot research, which took place during a triathlon, focused on putting the technology through its paces. During a charity run, a user survey was undertaken. It looked examined the effects of real-time biometric data visualization on social networks. The phrase 'participants' refers to the athletes who are wearing the biometric sensors, and the term 'viewers' refers to the people who are watching the data from afar. Physiological signals have been utilized to quantify the emotional state (excitement, stress, etc.) of athletes and performers for the intention of sharing them with viewers in studies on sports spectating and television shows.

These studies have confirmed the good impacts of sharing an athlete's or actor's physiological data with viewers, and that doing so helps to build a deep bond between them. These signals are transmitted with viewers in the form of a reflecting number or graph. The pilot study's findings revealed a number of obstacles that must be overcome when developing systems that broadcast real-time biometric data in the wild. System latency and interface design are examples of these concerns. The user study found that broadcasting real-time biometric data made viewers feel closer to one another, even if they were geographically separated from the participants. Participants, on the other hand, were more driven in the event because they felt 'following.' [19] ,as shown in fig2.1.
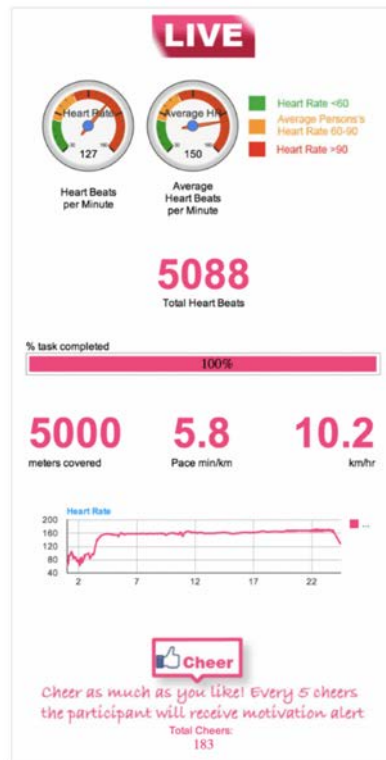
Figure 2.1 source from: HeartLink: Open broadcast of live biometric data to social networks

2.Empathetic Heartbeat Empathy serves as a foundation for considering the feelings of others. It makes it easier for people in society to engage and connect with one another. The participant hears his or her own heartbeat and empathizes

with individuals in movies by misinterpreting his or her own heartbeat as if it were coming from the people in the movie in this experience-based installation termed "empathetic heartbeat." Every human being requires a healthy heart. However, they are unable to distinguish their own heartbeats from those of others. Heartbeats can be shared and used as a tool for empathizing with others around us. The participant acknowledges that we go through life without paying much attention to what's going on inside our bodies, and that our bodies play a vital role in empathizing with others, as shown in fig2.2.

Figure 2.2   source from: Empathetic Heartbeat

2.2.2 Breathing

1.AuxeticBreath

AuxeticBreath is an interactive new-media installation that visualizes the breathe. It shows that emotive states are conveyed through breathing patterns. AuxeticBreath has two meanings: it is a psychological metaphor for individuals' emo-

tions, expressed by rhythmic patterns of respiration and variations in light hues; and it is a concrete portrayal of how people perceive breath in today's culture. Using led lights, auxetic structures, and silicone, the installation uses respiration as a conduit for biological and psychological data.

Observing breath from a psychological standpoint reveals physiological responses such as changes in breathing patterns, which are also linked to distinct emotional responses. Each ovule-shaped unit represents one of four types of emotional breathing, with rate matching to inflation/deflation times and depth corresponding to height. Fast and deep breathing were linked to feelings of rage, anxiety, or delight.

Tense anticipation, including focus, fear, and terror, was characterized by rapid shallow breathing. In relaxed resting states, slow and deep breathing was most frequently noticed. Finally, passive moods like despair and calm happiness were linked to slow and shallow breathing. These emotions states are represented through breathing patterns to underline the difficulties of deciphering emotional cues from facial expressions when faces are hidden by masks, as well as the increased concentration on our own breathing as our breath is amplified and highlighted by the masks we wear. [20]as shown in fig2.3.
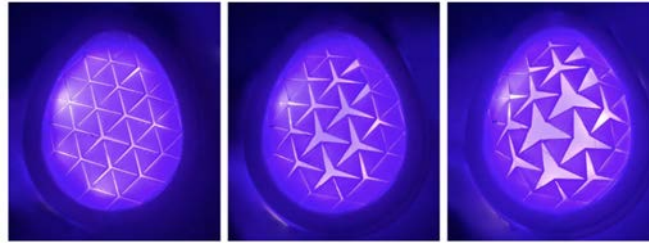
Figure 2.3 source from: AuxeticBreath: Changing Perception of Respirationnbsp;

2.BreathingFrame

BreathingFrame is a breath signal sharing device that supports pairwise remote communication through delivering the physical inflating movement of the other party's breathing on the surface of a digital photo frame.

BreathingFrame consists of a main wooden frame body and a belt. Because the designers intended consumers to feel the device as a real inflated photo frame rather than a prototype, they integrated the hardware elements within the frame

rather than utilizing a separate case for the inflation control sections. To facilitate bidirectional communication, they created two sets of hardware. They put a stretch sensor in a length-adjustable belt that the user would wear around his or her waist to monitor breath signals. The other party's gadget depicts ambient breathing through movements on the latex-sheeted surface of the frame via the actuation of a soundproof-treated air pump and solenoid valve when the belt detects breath movement in the user's abdomen.

The surface of the opposite party inflates/deflates when the first user exhales/inhales. The device monitors ambient sound in each user's space via a sound sensor mounted to the frame, and the picture dims and blinks in response. They were able to lower noise to 48dB (i.e., an average ambient noise level within a home) and prevent interference with the sound sensor by using sound absorption materials that surround the air pump and valve in the back part of the device. In the front of the gadget, there is a controller board, and on the side of the frame is a self-checking button that allows users to check their own breathing with their device. When the user presses the button again, the mode is restored.

Participants could associate the other party on the frame, sense sentimental connectedness and the other party's respiratory movement, and their curiosity was stimulated in a favorable way, according to the findings of their observational study with eight couples. Because it proved efficient at conveying affection and inducing natural belly breathing in users through the use of deliberate breath signal transmission. BreathingFrame can give new forms of telepresence and assist emotional communication by allowing users to share breathing at a distance by applying unconscious but partially controllable breath signals on a digital image frame that is utilized in everyday life. [21]as shown in fig2.4.

3.Breathing Sofa

A pair of interactive breathing sofa systems that can communicate in real time with each other's breath tempo. In the design process, the belt-type pressure breathing sensor was utilized to detect breath signals of the users' abdomens and connect with Arduino. The cylinder was controlled by the driver and speed controller. This cylinder repeatedly compressed a gasbag partially filled with air by the detected breathing signal rate. The sofa was composed of the other gasbag, and the two gasbags were connected by air change tube exchanged air in the pro-

Figure 2.4 source from: BreathingFrame: An Inflatable Frame for Remote Breath Signal Sharing

cess of repeated compression of stepper motor. Consequently, the expansion and contraction of the gasbags in the sofa with the breathing rate were realized. Thus users can feel the breathing rate and the gasbag in the sofa in a partially wrapped state to strength the feeling. The WIFI Serial Server modules were equipped on the two sofas, respectively. The breathing sensor detected the breathing data and then realized the exchange in the cloud database by WIFI Serial Server module through the Internet. Thus one user can really feel the breath tempo of the other. Based on the research result, there is no doubt that most participators could feel the existence of the other party and their emotional interaction through the breathing sofa system. Their views on the breathing sofa experience dramatically changed from doubt to expectation. Finally, they were willing to voluntarily sit on the sofa to share their breath, emotion and the quiet accompany with the others. [22], as shown in fig2.5.

2.2.3 Temperature

ThermOn

ThermOn, which enables users to feel hot and cold sensations dynamically on their body while listening to music. they implemented a headphone-type interface using a Peltier device in which users feel thermal stimuli on their ears, and designed a simple thermal stimulation model for the interface.

Figure 2.5   source from: Breath Is to Be Perceived - Breathing Signal Sharing Involved in Remote Emotional Communication

Two kinds of tests were conducted using a rock song and the results implied that ThermOn serves to (a) change the impression of music, (b) provide comfortable feelings, and (c) alter the listener's concentration toward the music. Moreover, these effects changed based on the methods by which thermal stimuli were added to music, such as temporal synchrony, as well as on the kind of stimuli (warming or cooling). From these results, they concluded that ThermOn system has a potential to enhance the emotional experience when listening to music. [23] , as shown in fig2.6.

2.3. Media art with immersion and emotion

The introduction of technology is able to connect virtual reality, augmented reality and mixed reality to the real world or bring the audience to far away virtual space. Experience in a virtual world helps to feel a new things that people cannot experience in a daily lives. That can be escape from reality and gives mysterious feeling. These virtual world make interaction with user and virtual world. [24]
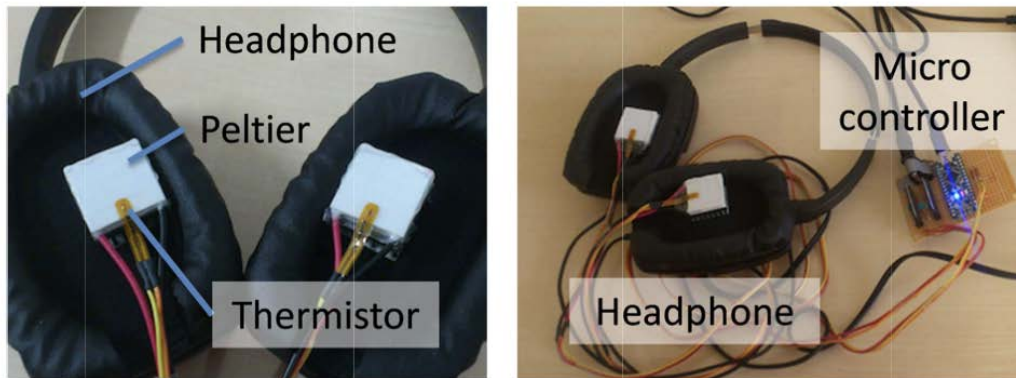
Figure 2.6   source from: ThermOn: thermo-musical interface for an enhanced emotional experience

After Dadaism, modern art expresses itself freely by rejecting traditional painting and sculpture methods. The appearance of new media technology can digitize an art's expressive method, and artists use new media in their art works to create Media Art. Artists were worried about mechanized media in the 1960s, and video art, which began with Nam Jun Peak in the 1970s and 1980s, seized the lead in the art world. However, since the 1990s, new media art influenced by computers has grown in popularity, and not only artists but also computer-savvy engineers are planning new media art development. Almost all audiences who are exposed to media art that uses computer technology are interested in learning a new interface.

Emotion is the most influential factor to the mental life of human. Audiences who watch, use participate to the art works definitely feel something. Emotions are a psychological experiment from internal and external sense by stimulation of human. [24]

2.3.1 Photo and haptic with emotion

It is well known that touching is one of the most powerful means for establishing and maintaining social contact. The fact that two people are willing to touch implies an element of trust [25]. Expressive potential of touch is the ability to

convey and elicit strong emotions. Although current on-line interaction mainly relies on senses of vision, there is a substantial need in mediated social touch. Comprehensive review of research on social touch is presented in [26].

Cultural spaces like art galleries or museums are, in general, not accessible to blind or low vision visitors. Most of them do not have haptic support or when it has, the users do not have the experience to understand adapted art. There is a team which proposes a process to improve accessibility to visual art by for blind people improving knowledge on the creation and interpretation of photography. Initially, a photography workshop was applied to a group of three individuals with different levels of visual impairment. In the first part, researchers explained the basic concepts of photography like composing, lighting, and camera. Then, the participants choose their subjects and captured images. After the workshop, the research team built six haptic plaster pieces. Later, a final meeting and a public exhibition took place to collect users feedback and show their final results. With this process, they provide a path to improve the autonomy of blind people on image reading, photographic production, and haptic perception, giving them tools to interpret not just their captured images, but different visual art, using their own experiences. This work can also be extended to understand the challenges of image/haptic based interfaces for people with low vision. [27], as shown in fig2.7.

2.3.2 Photo and music with emotion

Both images and music can convey rich semantics and are widely used to induce specific emotions. In particular, the musicality of images assists in disrupting the standard ordering of vision as the dominant force of perception in audiovisual forms, giving birth to a specific kind of audio vision in which music and image mutually remediate each other. Many people have frequently merged images into videos attached with related music, using professional softwares, such as Premiere, Ulead Video Studio, and Movie Maker. Matching images and music with similar emotions might help to make emotion perceptions more vivid and stronger. [28]

There is a team which propose to musicalize images based on their emotions. The extract visual features inspired by the concept of principles-of-art can recognize image emotions. To enrich the descriptive power, a dimensional perspective is introduced to emotion modeling. Experiments on the IAPS dataset demon-

Figure 2.7 source from: Art accessibility for blind people

strate the superiority of the proposed method in comparison to the state-of-the-art methods for emotion regression. The music in MST dataset with approximate emotions to the recognized image emotions is selected to musicalize these images. The framework of their method, as shown in fig2.8.and fig2.9.

they draw inspirations from principles-of-art to extract features for image emotion analysis. Experimental results show its superior performance over the state-of-the-art approaches in the emotion regression task.The user study results show its effectiveness and popularity of the image musicalization method. Evaluations demonstrate the effectiveness of the proposed image musicalization method. [29]

17
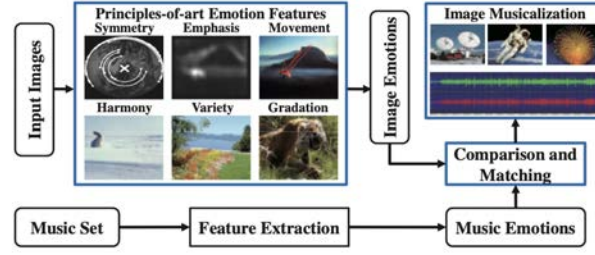
Figure 2.8 source from: related work emotion based image musicalization
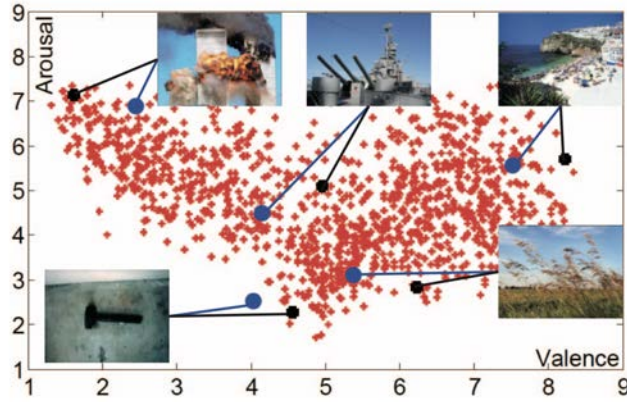
Figure 2.9 source from: related work emotion based image musicalization2

2.4. Summary

Building reliable automated systems for understanding affective dynamics is a challenging problem, as the mechanisms by which emotions are elicited and the characteristics of the related physiological signals are complex. Emotions are multicomponent phenomena, may be expressed in different manners, and can even be withheld over time.

Even though there are many technologies that can help users convey emotions through vital signs, but there is no design that simultaneously expresses the photographer's heartbeat, breathing and temperature through listening, touch, and vision.

Chapter 3
Concept Design

To record and reproduce the vital signs of the photographer, the overall system of ImageFlowing need to consist of the recording vital signs system and the reproducing vital signs system, the recording system can record the data of the heartbeat, breathing and the temperature, the reproducing system can invert the data into auditory, haptic and visual things which can let the viewers feel the vital signs from the photographer.

3.1. Overview

Figure 3.1 ImageFlowing's feature
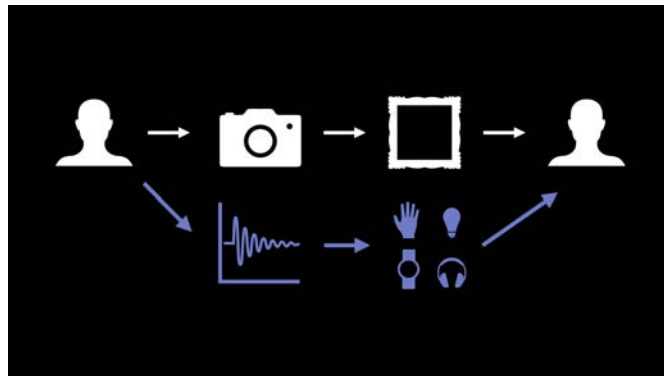
ImageFlowing is an 'alive' photo reproducing the vital signs from the photographer in the moment, leading the viewers through time and space to the lens' world while taking the pictures. Through the ImageFlowing, viewers can sense the picture together with the breathing, heartbeat and skin temperature. We extending the two dimenisonal space of the picture into a multi-modal experience from

sensory to imaginary, aiming at bonding a closer emotional connection between viewers and photographers.
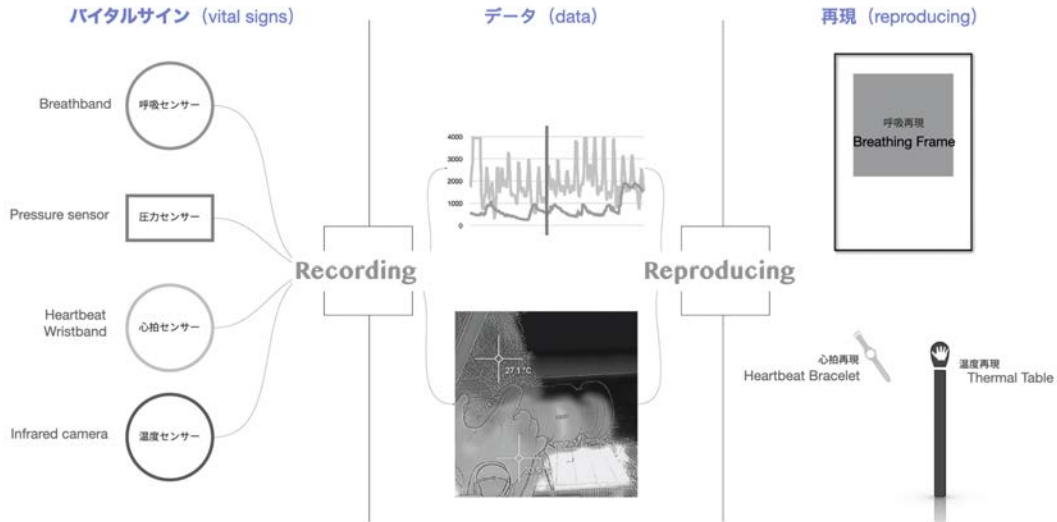
Figure 3.2 Recording system:concept of the system

3.2. Recording device and system

In terms of recording vital signs, a pressure sensor was placed on the camera shutter to collect time-series information, while Heartbeat Wristband and Breathband were worn by the photographer to collect real-time heartbeat and breathing signals. And a infrared camera was prepared to record the temperature, as shown in Fig3.3

3.2.1 Heartbeat Wristband

Heartbeat Wristband can record the heartbeat data of the people. A pulse sensor is used in the heartbeat device for get reliable pulse reading in real-time. Meanwhile, a little display screen is set on the device for observation of the heartbeat signal. The normal data is displayed in green while marked data by pressure
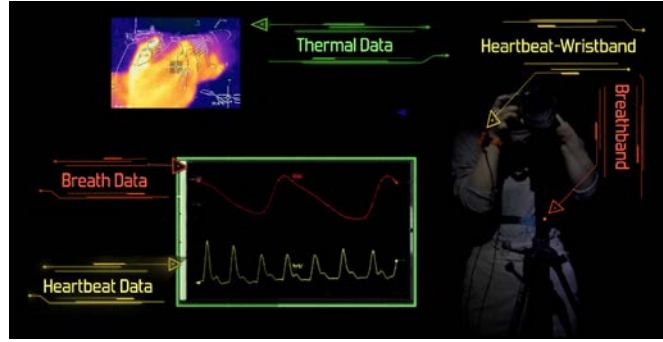
Figure 3.3 Recording system:outlook of recording

Figure 3.4 Recording system:heartbeat wristband

sensor is in red. The device can be put on wrist like wearing watches and pulse sensor is placed on little finger on account of a minimum of operation disturbing.

3.2.2 Breathband

The Breathband can record the breath data of the people by measuring the variation in the width of the thorax or abdomen when breathing. This is achieved by making the belt of a non-stretchable material, with the exception of a small section of which if it is made of stretchable material (elastic textile) with a string of conductive rubber that changes it's electrical impedance when stretched.Since this is the only part that can be stretched, this section will reflect the expansion or contraction caused by breathing [30]. The device is based on an ESP32 module that allows straming the data over Bluetooth or Wi-Fi. The analog measurements

Figure 3.5 Recording system:breathband

are done using a Wheatstone bridge and an operational amplifier in differential configuration. The device is shown in Fig3.5.
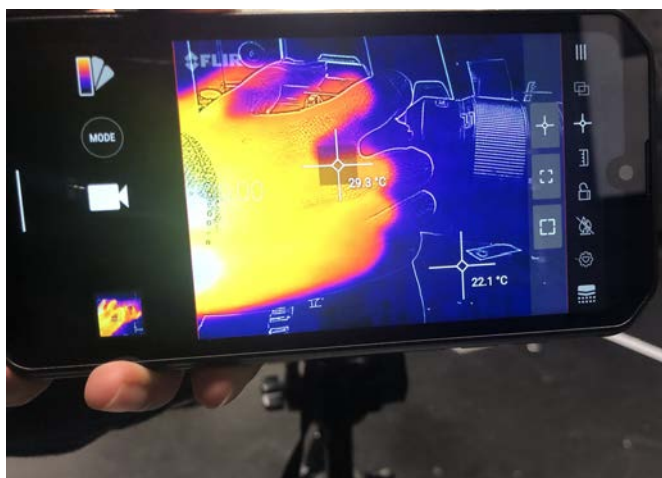
3.2.3 Infrared camera

Figure 3.6 Recording system:infrared camera

Temperature was measured via an infrared camera. as shown in Fig3.6.And we use it to record the environment temperature data and skin temperature data.

3.2.4 System of recording

Figure 3.7 Recording system:interface of recording

When a photographer pressed the shutter, the recording system would receive and record the vital signs for 10 seconds before and after through WiFi connectivity. The computer would receive and record the real-time heartbeat, breathing, and shutter pressed information through WiFi connectivity with a sampling rate of 50Hz. The time when the shutter was pressed would be marked to the data collected, as show in Fig3.7.
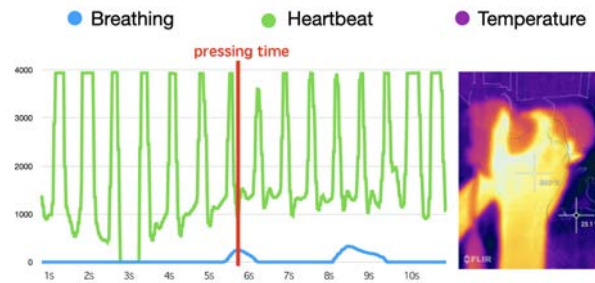

Figure 3.8 Recording system:recording data

The corresponding continuous analysis signal was the output. The instantaneous voltage in the signal would change continuously according to the change of the sensor. And the vital signs with the time mark to each photo was plotted after data processing through python, as show in Fig3.8.

3.3. Reproducing devices and system

In terms of the reproducing devices of immersive sense of space from the photographer len's world, we created a multi-modality space that inspires the viewer abundant experience and sparks from sensory to imaginary. Tactile is a powerful conduit for emotional connection building [31]. We assume that reproducing and sensing the temperature from skin/environment and vibrotactile from heartbeat could extend the emotional space from the two-dimensional to the three-dimensional and bond the photographer with the viewer closer.
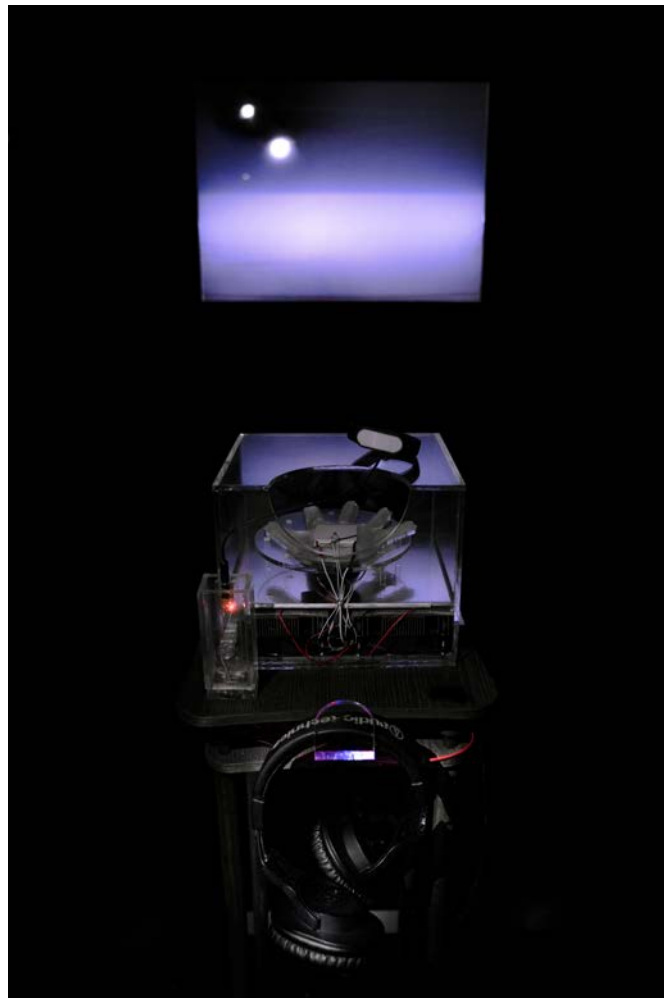

Figure 3.9 the reproducing device of ImageFlowing

We designed the Heartbeat Bracelet that can reproduce the recorded heartbeat vibration, the Thermal Table that we can feel different temperatures(skin and environment) from it, and the Breathing Frame that can simulate respiratory rate through the changes of light intensity. And we use vital signs as the material of music to combine the data of respiration, heartbeat and temperature into a piece of music, as shown in Fig3.10 and Fig3.9

Figure 3.10 the way experiencer uses the device

3.3.1 Heartbeat Bracelet

Wearing the Heartbeat Bracelet with the plug of the strap inserted into the socket of Termal Table, the viewer can feel the heartbeat vibration when the photographer shoots this work, as shown in Fig3.11 and Fig3.15 . The recorded segment of blood volume pulse is demonstrated using a haptic bracelet with an ERM (Eccentric Rotating Mass) actuator. Bracelet has a cable terminated with a 3.5mm phone connector that needs to be plugged in a corresponding socket on a side of the thermal table. Actuation of the haptic motor is controlled by an ESP32

Devkit-C board that outputs the heartbeat waveform using Sigma-Delta modulation. Sigma-Delta signal is controlling a DMG3404 MOSFET that is directly connected to the actuator. Device automatically detects when the phone plug is present and starts playing the waveform. As soon as the plug is detected, device broadcasts a corresponding message over Wi-Fi to all other devices described further. In addition it signals the Max for Live patch with an OSC message to start the playback of the corresponding audio.

Figure 3.11 the Heartbeat Bracelet

3.3.2 Thermal Table

The Thermal Table is the main hub of the system. It consists of a mini Windows PC controlling music, thermal setup that renders the thermal conditions of the moment when the picture was taken and has the 3.5mm phone socket described above that serves as the interaction trigger. The whole table is presented in Fig. 3.9. All the cabling and power supplies are located in the bottom of the table. Top part of the table is a transparent acrylic box with a hole for the user's hand
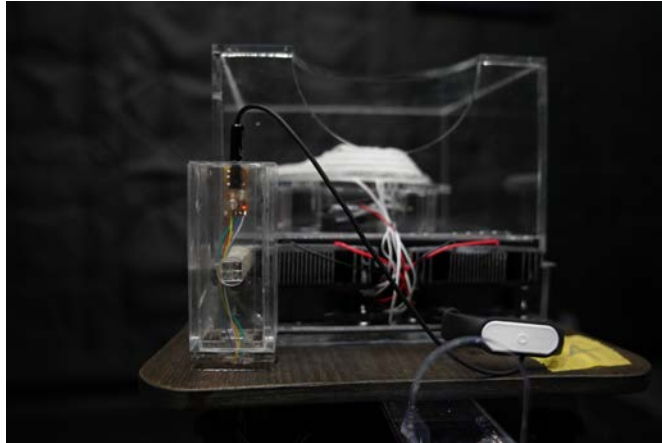
Figure 3.12 the outlook of Heartbeat Braclet

and a representation of the photographer's hand made of acrylic inside of the box. The users can feel the skin temperature of the photographer and the ambience by touching the hand inside of the box.

Temperature of the air inside of the box and the hand are controlled and set to match the conditions of when the photograph was taken. Air temperature is controlled by a set of 4 60 Watt Peltier thermoelectric coolers (TEC). TECs are built into an assembly with an aluminium plate serving as the bottom of the box and heat exchange radiators with active airflow from 4 12V fans on the opposite side. The whole assembly is rated at 240 Watts. With the typical efficiency rating of a TEC of 60-70%, this gives us about 150- 170 Watts of active heat pumping, Which is more than sufficient to achieve set temperatures inside the box. In addition the air in the box is moved by a blower, creating the sensation of a gentle wind inside of the box and increasing active air circulation, helping with heat exchange, as simple convection was not sufficient to create the desired sensations. Temperature of the air in the box is measured at the outtake of the blower.

The hand in the box is warmer than the air in 4 out of 5 cases. For the 4 setups heating of the hand is achieved using Nickel-Chrome alloy wire placed at on the palm. Temperature of the hand is also continuously measured. The only setup where the hand temperature is colder than the air uses another TEC module with a small radiator and an additional blower. Otherwise the setups are identical, as

27

well as the implementation of the temperature control.

This Device is controlled by an ESP32 module with a number of power MOS-FETs. 4 IRF 7413 30A-rated MOSFETs control each of the 4 TECs in the table. In addition there are 3 DMG3404, one for the 4 fans of the TEC assembly, one for the blower inside the box and one for the palm temperature control. Device is continuously sampling the temperature of the palm and air in the box, resulting in a control loop, allowing to maintain stable and precise temperatures. Temperatures are measured using miniature thermocouples with a filtering capacitor. To simplify the power routing on the controller board we split the TEC into 2 120W channels that are powered with independent power supplies. This reduces overheating of the connectors and other components. The PCB design is presented in Fig.3.13.
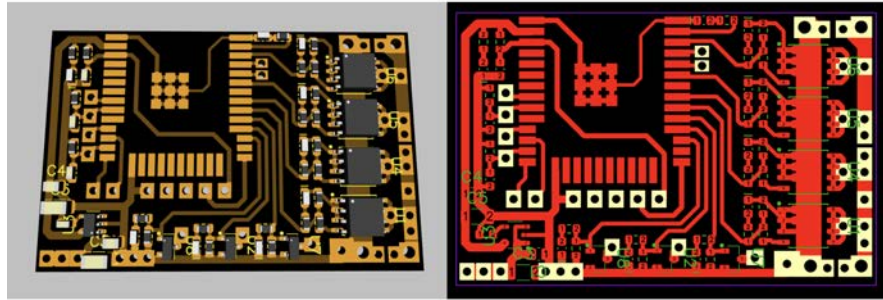

Figure 3.13 the board of Termal Table

3.3.3 Breathing Frame

When the viewer watch the photo, they can feel the photographer's breathing rate from the change of light intensity and change speed, as show in Fig.3.9. The curve representing the breathing of the photographer is modulated though PWM and is set to control the brightness of the LEDs inside of the frame, providing varying intensity of the backlight for the picture.
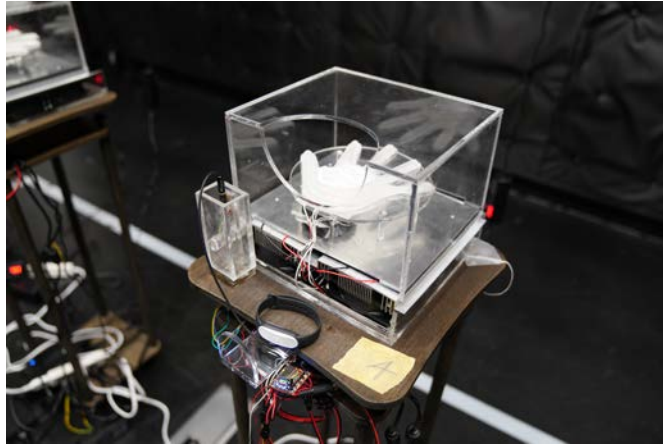
Figure 3.14 the outlook of termal table.JPG

Figure 3.15 Hot wire is on the hand model to present the skin temperature

The Breathing Frame's internal structure is as follows: LED strips are is placed behind the picture, to provide even backlight. Certain chosen sections of the photograph are additionally backlit by additional CREE power LEDs. LED brightness is modulated using 5KHz PWM signal with duty cycle set to match the 0 to 1 normalized pre-recorded breath curve. PWM signal is actuating a pair of DMG3404 MOSFETs, one per each type of LEDs: spotlight power LEDs and LED strips. Device is controlled by an ESP32 module that awaits for the UDP message from the corresponding heartbeat bracelet and then turns on the backlight and reproduces the breath curve.
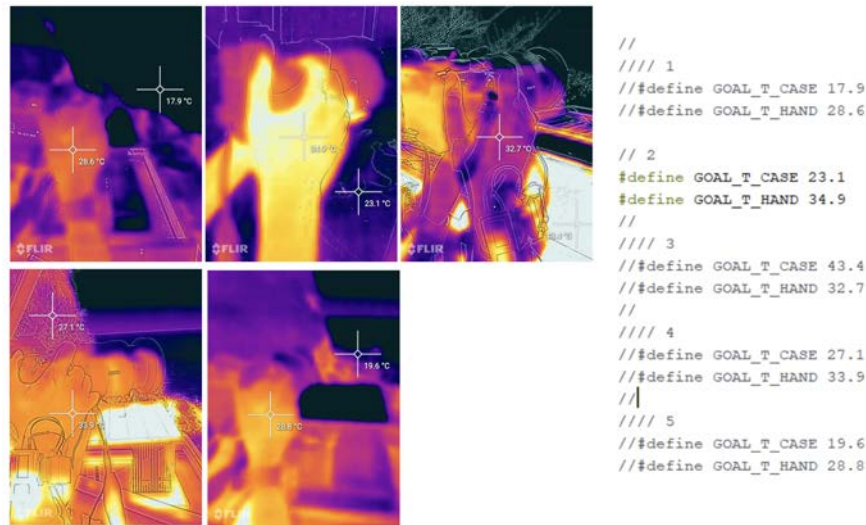
Figure 3.16 the code of control the temperature of the termal table

3.3.4 Vital signs of the Music

The music/sonification of this work was developed through the use of Max/MSP and Ableton Live software applications. To begin with, we took the recorded heartbeat, breathing, and temperature data and converted it into CSV files, which are easier to import into Max/MSP. For the heartbeat data, we created an element in max/MSP which would detect when the heartbeat data surpassed a set point in the data (generally 3500), and then used this to send out a bang which would trigger a modified water droplet sound. This gave us the rhythmic content of the heartbeats in a more abstract sonic representation. In order to utilize the breathing data, we assigned the flow of the breathing patterns to the gain slider of a series of custom composed synthesizer patterns. This would create volume swells which aligned with the breathing patterns. Although this was a desired effect, we took it one step further and used the same breathing data to determine when melodic structures would become more or less dense. Using both approaches gave a more sonically and musically pleasing effect in relation to the photographs. Finally, we used the temperature data to determine the overall sonic aesthetic in terms of synthesizer sounds. For the colder temperatures, we chose thinner synthesizer patches, whereas the warmer temperatures were conveyed through denser synthesizers. Ultimately, this exploration into the sonification and composition

of music in conjunction with the photographs and physiological data has proven to be quite novel and we will continue to develop and explore this multi-modal approach. as shown in Fig3.17 and Fig3.18
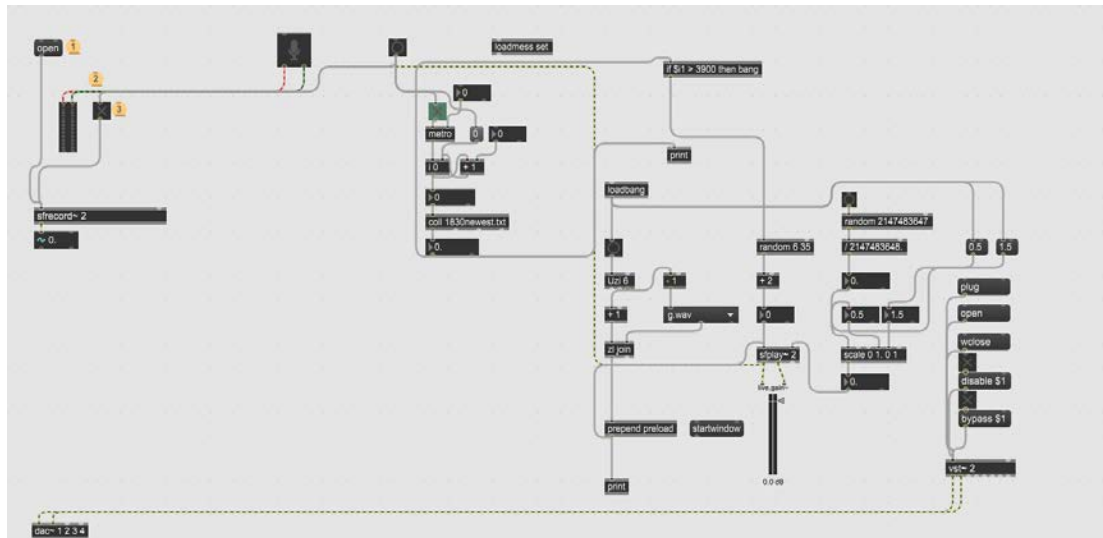

Figure 3.17 the heartbeat patcher

3.3.5 System of recording

Because we hope there is no wire interference between the Breathing Frame and the Thermal Table, so they are connected by WiFi. After wearing the Heartbeat Bracelet, the experimenter first puts on the headset, and then inserts the plug on the side of the heartbeat Bracelet into the socket of the Thermal Table. The socket has a switch function. After the socket is inserted, all devices start at the same time. The LED light in the Breathing Frame starts to operate after receiving the signal of WiFi connection, the heartbeat Bracelet starts to vibrate, and music starts to play in the headset. When the experimenter pulls out the socket, all devices stop working. The touch sensing device on the temperature table starts to operate after the experimenter touches the hand model.
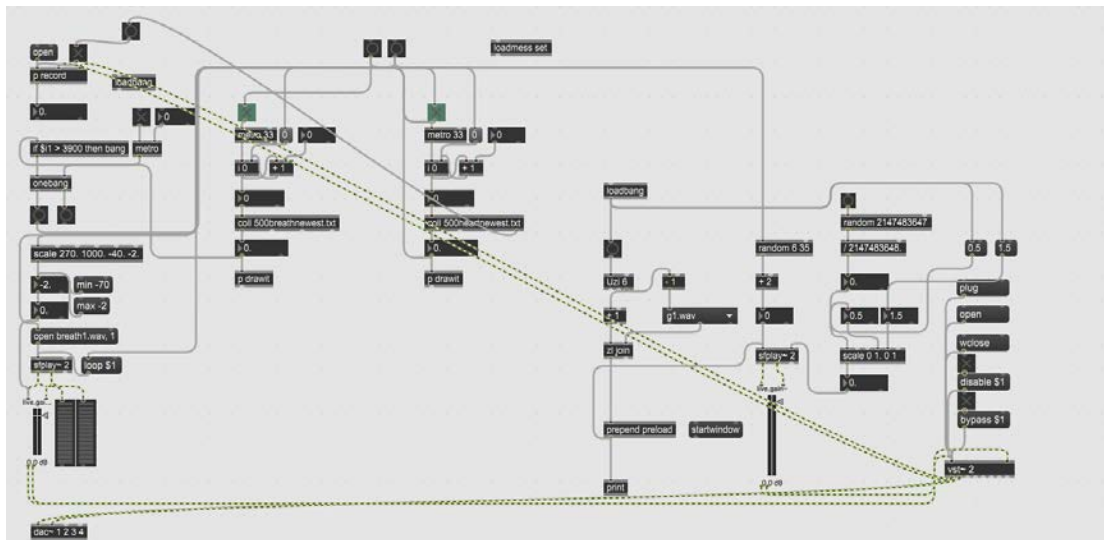
Figure 3.18 the full Max patcher

Chapter 4
Proof of Concept

4.1. Overview

ImageFlowing can reproducing the vital signs from a photographer or the photographed in the moment. Through the ImageFlowing, viewers can sense the picture together with the breathing, heartbeat and skin temperature. We extending the two dimenisonal space of the picture into a multi-modal experience from sensory to imaginary, aiming at bonding a closer emotional connection between viewers and photographers. The user needs to wear a heartbeat sensor strap and a breathing sensor first. When the shutter is pressed, the ImageFlowing recording system will receive and record the heartbeat, breathing data and shutter press marks for 20 seconds before and after the shutter is pressed. And we use the infrard camera to measure the temperature. The ImageFlowing rendering system can display vital signs data in a multi-modal form. For example, breathing data can be converted into a light source that seems to be undulating, heartbeat data can be converted into a bracelet that vibrates, and temperature data can be converted into a touch panel that simulates the current temperature. And all vital signs data can be synthesized into a special piece of music.

4.2. Prototype

In the following, we describe the background of ImageFlowing, the prototyping stages, the experiment results and feedback from user study we implemented in the installment.
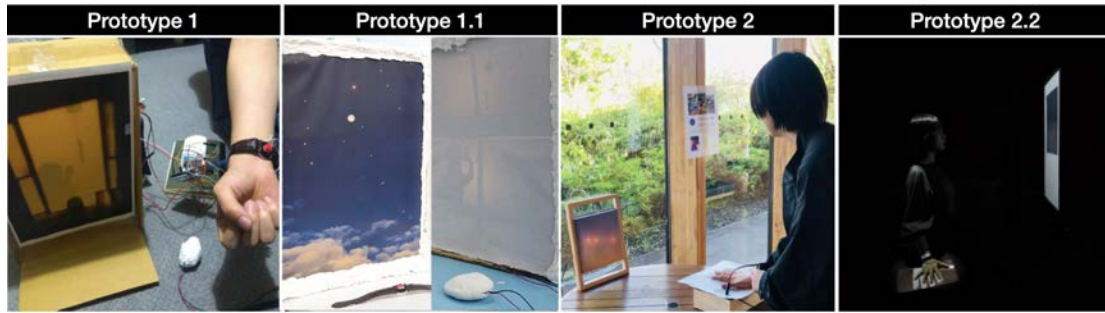
Figure 4.1 Prototyping Progression

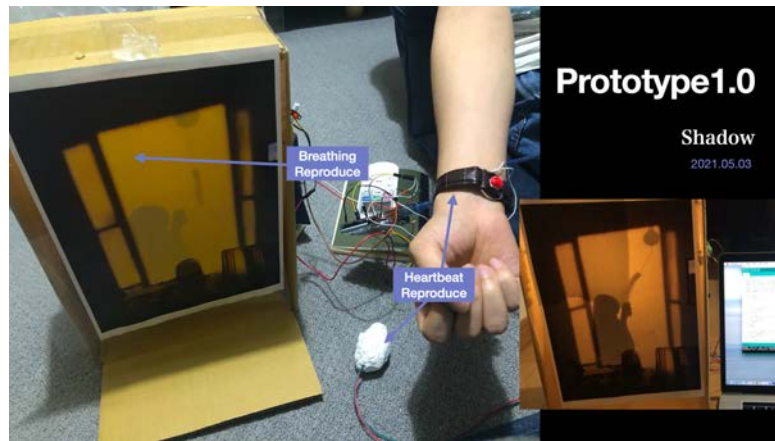## 4.2.1 Prototype 1.0 [heartbeat+breathing]

Figure 4.2 prototype1.0 Shadow.jpeg

The prototype 1.0 has two vital signs data, the heartbeat and breathe. It does not use the photographer's real breathing and heartbeat data. The focus prototype is on exploring and designing the reproduction form of breathing and heartbeat.

Breathe with the wind chimes blown by the wind and the light and shade of the sun, and heartbeat with a vibrating bracelet, as shown in Fig4.2. The fan installed inside the picture can generate wind to blow the wind bell through code control, and the LED lamp can simulate sunlight to control the brightness of the picture through code. The vibration module in the bracelet can simulate the heartbeat of photographer.

Feedback:

- Since the place of vibration is closer to the pulse, the design of installing a vibration module on a device similar to a watch strap allows people to fully feel the feeling of heartbeat vibration.

- Using light to express the breathe is more impressive than the fan. The fan has good effect, but it covers a large area and is easy to produce noise.

4.2.2 Prototype 1.1 [heartbeat+breathing]

The prototype 1.1 still has two vital signs data, the heartbeat and breathe. It still use the simulation photographer's breathing and heartbeat data. The focus is on exploring and designing the reproduction form of breathing and heartbeat. At the same time, we hope to explore the factors related to the degree of emotion that can be felt by the photographer. This experiment produced two prototypes, they have different forms of reproducing vital signs

- "Starry Sky": Breathing is represented by the interlaced flashing frequency of different stars. The heartbeat is expressed through the same heartbeat bracelet as prototype1.0, as shown in Fig4.3.

- "Daylight": Breath is expressed through the same light and fan as prototype 1.0, and the heartbeat is expressed through a larger vibration module in the shape of a semicircle, as shown in Fig4.4

Through the experiment, we hope to verify the following conjecture:

1. Breathing or the heartbeat which one can the experiencer more easily understand.

2. In which way the heartbeat expresses it is easier for people to understand.

3. Whether the degree of being able to feel emotions is related to age.

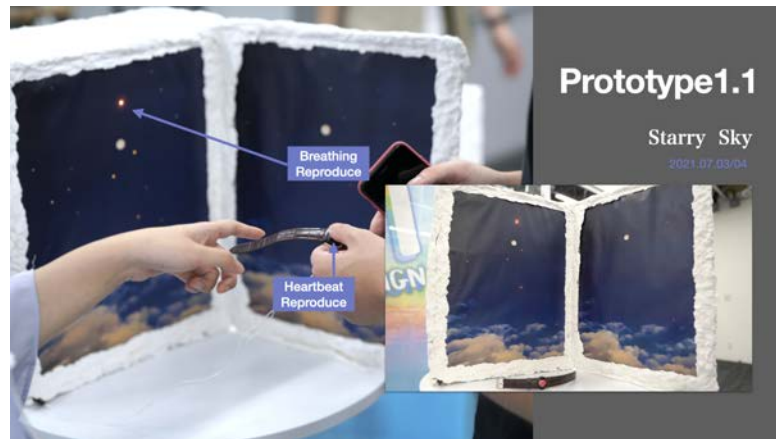4. Whether the degree of feeling emotionally is related to the degree of loving photography.

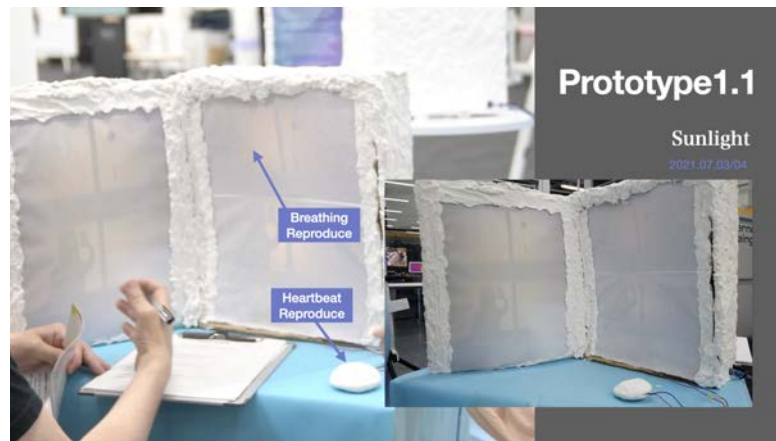Figure 4.3 prototype1.1 Starry Sky.jpeg

Figure 4.4 prototype1.1 Sunlignt.jpeg

The prototype was displayed for two days, and a total of 44 participants experienced the two devices. They need to freely experience the device and fill out a questionnaire. According to the statistics of their answers to the questionnaire, we can draw the following conclusions

1.**The experiencer can better feel the emotion from the breathing device.** From the degree of breathing or heartbeat we can feel, we set a threshold from 1 to 5, where 1 means not feeling it at all, and 5 means it can feel it at all. We averaged all the results and compared them. According to the results, the average breathing rate is 4.2, which is slightly higher than the average heartbeat
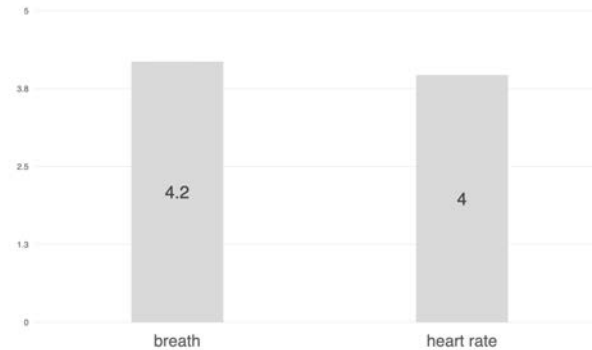
rate of 4, as shown in Fig4.5

Figure 4.5 the degree of evaluation of breath and heartbeat

2.**The evaluation of heartbeat bracelet is better than a larger vibration module**. In this experiment, we used two ways to transmit the heartbeat, one is through a bracelet that can imitate heartbeat vibration, and the other is a larger vibration module that can be held by the palm of your hand. We analyze the results by letting the experiencer score after the experience. The threshold for the score is 1 to 5, with 1 being completely understand, and 5 being completely understand. We take the average of all scores. According to the results, the average value of the bracelet that imitates the heartbeat vibration is 4 points, and the average value of the larger vibration module is 3 points. So we have the conclusion that the evaluation of heartbeat bracelet is better than a larger vibration module, as shown in Fig4.6

3.**There is no obvious relationship between age and the degree of feeling emotions**. Among the 44 participants, 52 percent were 20-25 years old, 34 percent were 25-30 years old, 5 percent were 30-35 years old, and 9 percent were 45-50 years old, as shown in Fig4.7

When we analyzed the correlation between age and the degree of feeling emotions, we found that there is no absolute correlation between them, as shown in Fig4.8

4.**There is no obvious relationship between the degree of fondness of photography and the degree of feeling emotions**. According to the questionnaire analysis of the experiencers, we can have a conclusion that there is
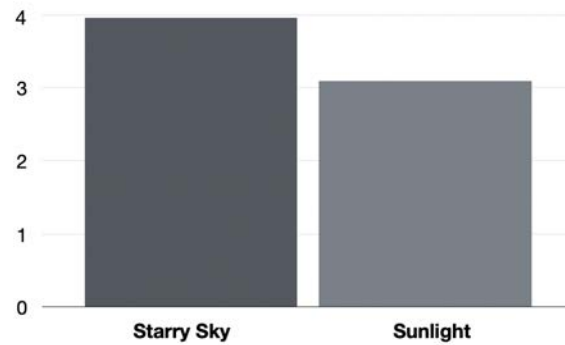
Figure 4.6 The degree of feeling emotions from heartbeat device

no obvious relationship between the degree of fondness of photography and the degree of feeling emotions, as shown in Fig4.9

At the end of the questionnaire, the experiencer is free to expressing there thoughts, there handwriting feedback as shown in Fig4.10, and the organized answer is as shown in the Fig4.11

We got about 25 feedback from them. 19 people think that ImageFlowing is interesting and supportive, about 3 people are neutral, and 3 people are skeptical about the design of ImageFlowing.

Here are some representative comments

supportive comment

"*Adding different dimensions into photos is a great way to build connection.*"

neutral comment

"*Photos became guardians, making people feel the strong possibility of the existence of a powerful fourth dimension.*"

skeptical comment

"*I like the movement, It looks beautiful, but I don't know if it helps me to understand the feelings of the photographer.*"

Although this experiment has obtained a relatively satisfactory evaluation, there are some areas for improvement in the experimental design:

1. The accuracy of the 5 thresholds is not high enough, and then at least 7 thresholds will be added in next experiment.
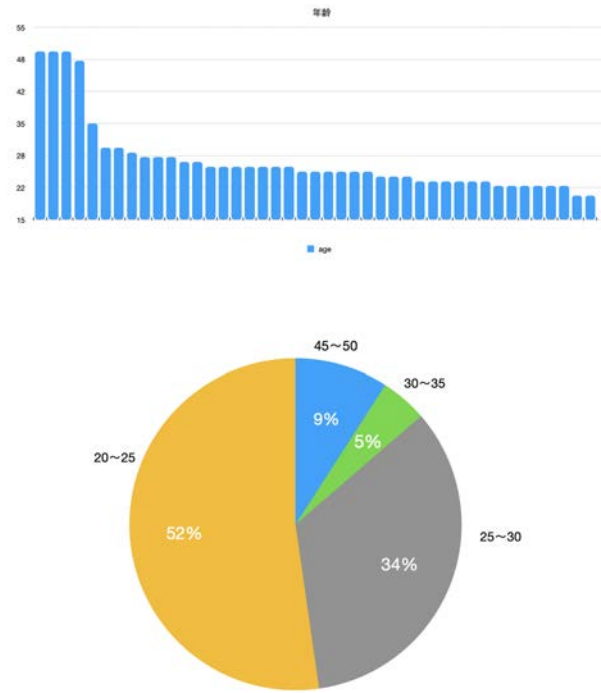
Figure 4.7 the age of experiencer

2. The work of this experiment mainly explores the quality of the reproduction effect. The photographer's real vital signs are not added. The real vital signs will be added to explore whether the photographer's feelings can be spread more effectively through the reproduction of the vital signs.

4.2.3 Prototype 2.0 [temperature+heartbeat+breathing]

In this prototype, a thermally conductive hand model is added to represent the temperature of the hand. The vibration bracelet is improved to make its vibration closer to the heartbeat, and a plug is added on the vibration bracelet. The heartbeat can be felt when the plug is inserted into the socket, so as to enhance the interactivity of the experience, as shown in Fig4.1(Prototype 2). The prototype was displayed in Karuizawa Oga Hall for one day, and the evaluation of temperature experience was slightly higher.

"When I felt the temperature of the photographer, I seemed to hold his hand
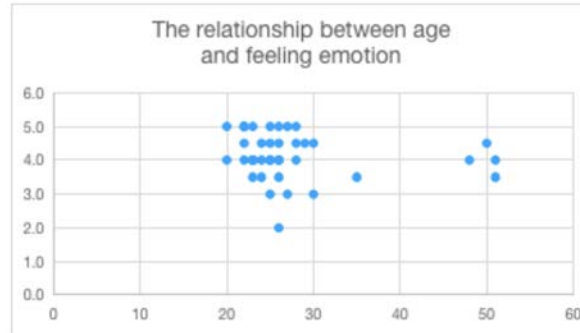
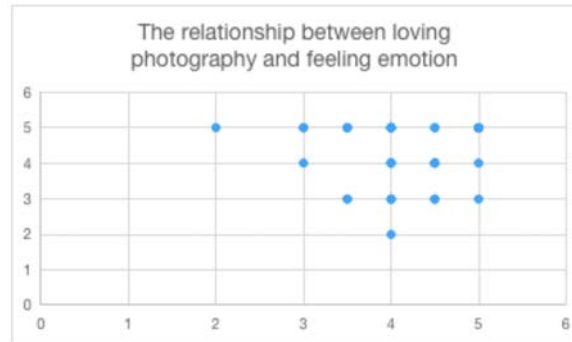Figure 4.8 the relationship between age and the degree of feeling emotion

Figure 4.9 the relationship between loving photography and the degree of feeling emotion

tightly and very close to the photographer. It seemed that he/she was right beside me."

"The moment I started the heartbeat reproduction device, I felt a strong heartbeat and got frisson for a moment."

"It feels like I'm more connected with the photographer."

4.2.4 Prototype 2.1 [temperature+heartbeat+breathing]

In this prototype, we reproduced the breath, heartbeat and temperature when I took the photo in Jiangzhi Island at five o'clock, the photo and the data of vital signs as shown in Fig4.13.

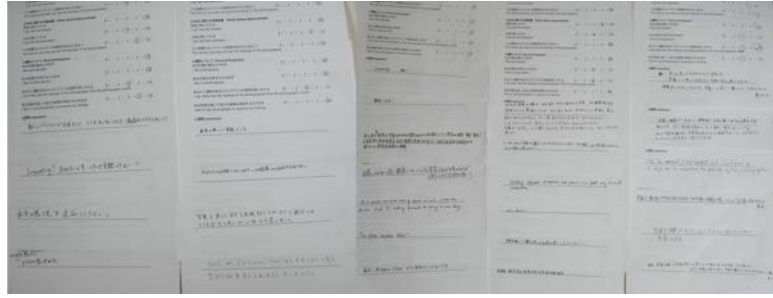Breathing still uses the light and dark changes of LED light to express the

Figure 4.10 prototype1.1 handwriting feedback

breathing frequency and depth. The heartbeat still uses a slightly vibrating bracelet. The temperature uses a hand model made of a hot wire and a copper plate controlled by the module to represent the skin temperature and ambient temperature at the time, the Peltier device which can control the temperature is installed at the lower part of the copper plate.When the user insert the plug of the heartbeat bracelet into the socket of the Termal Table, the heartbeat module starts to vibrate, touch the hand on the hand model to feel the temperature, and the Breathing Frame is directly connected to the power supply and works all the time, as shown in Fig4.15 and Fig4.14

The experiment invited 16 experimenters, including 5 men and 11 women.

Group A: 8 people experienced ineffective ordinary photos.

Group B: 8 people experienced photos with ImageFlowing device.

The experiment was conducted in school's media studio. In order to avoid the interference of environmental factors and better create the sense of immersion, we turned out lot of the light to created a darker environment. Participants in the experiment need to fill in the questionnaire on the first page to answer the basic information before experience. After completing the first page, they can freely go to the front of the work to watch. After experience, they need to fill in the questionnaire on the second page. In order not to interfere with the immersive experience of the experimenters, we only taught them how to use the device before entering the space, so that they could experienced all by themselves. The whole process was recorded with a camera.

We analyzed this experiment from the following points

1.The degree of feeling the photographer's emotions

oppose
1. プロダクトとしては非常にエモーショナル、でも感情として伝わるかはわからない。
2. 視覚と触覚だけじゃなくて、撮影者が写真を撮った時、多分五感を全部使ったかな、そして、本の型を変えて、もっと面白い型が欲しいです。SNSで写真をみんなに共有するのはネットの便利さは一つ、このデザインはこのメリットが失われたじゃないですかな。
3. I like the movement, It looks beautiful, but I don't know if It helps me to understand the feelings of the photographer.

neutral
4. 再生の表現を追求してください
5. いつも街で写真を撮ることが大好きなのですが、その背景にある感情を伝えられるのは面白いと思いました。
6. 写真表現の感情と装置が感じた感情は比較的近い（個人が感じた感情、穏やかさ、幸福）写真表現の感情と実際の感情のコントラストが大きい例があれば、体験者の興味と撮影者の感情の理解を促進することができると思います。

support
7. 亡くなった祖母が撮れた幼き頃の自分の幸せそうな写真。その撮影者である祖母はどんな感情だったのか、もう二度と会えない大切な人の感情を時を超えて知ることができたら、もう一度会えるような気持ちになるかもしれない。いつもそばにいてくれた、見守ってくれている気持ちになるかもしれない。写真がお守り、人を強くするような四次元的な存在になる強い可能性を感じました。
8. Adding different dimensions into photos is a great way to build connection.
9. 星空最高だ。
10. 写真を通じて撮る側の気持ちが感じて面白い
11. 非常に面白い、脈拍を体験した時不思議な新鮮さを感じます。
12. 色々を考えるきっかけをもらった研究です、写真と心音の組み合わせの可能性を感じられました。結婚式のウェディングフォトを、写真と心音と一緒にして、面白いだと思いました
13. 写真に様々な刺激を付加するのは、その写真の情景が思い人で記憶に残りやすいと思いました。
14. 感情を体験してもらう、という方法が面白かったし、共感できた。
15. 普段、写真をとって風景を残そうと思うことはあまりないのですが、その時々の自分の状態を残せるなら、写真を撮りたくなるかもしれないと思います。
16. 非常に面白いと感じ、将来にもしこのような装置があれば、世界の新たな可能性をもたらすはずだと思います。
17. As a people who loves taking photos as well, I like this device. And I'm looking forward to using it one day.
18. The photo became alive!
19. 面白い取り組みですね、ぜひ実用化して欲しいです。
20. 発想が新しくて素敵でした。
21. 写真を通じて自分を表現することかより可視化され、とても面白い取り組みだと思いました。
22. Snsやコマーシャルフォトなる面白いと思う、芸術的要素を入れたれたら、もっと面白い。
23. 新しいアルバムができそうで、とてもワクワクしました！商品化されたら欲しい！
24. 心拍を感じるとドキドキ感がました。
25. Interesting!面白いです、色々実験してください！！

Figure 4.11 The feedback of prototype1.1

After they experience, there is question "I can feel the photographer's emotion (min= 1 max= 7)", as shown in Fig4.16

The average point of GroupA who experienced ineffective ordinary photos is 3.12, the average point of GroupB who experienced photos with ImageFlowing device is 5.14. So the GroupB who experience with ImageFlowing device think they can feel the photographer's emotions better.

2. Accuracy of feeling the photographer's emotional level

After viewing the photos, GroupA + GroupB in the experiment need to answer how they felt the photographer's emotion in taking the photos. The questions are as show in Fig4.17

I also filled out the questionnaire based on the mood state recorded in the memo after the shooting. The answers are as shown in the Form4.1

People in GroupA who watch ordinary photos are more likely to be affected by the surrounding dark environment, therefore, one thing they have in common is that they generally feel that the photographer's emotions are biased towards sadness, heaviness, calmness, and loneliness, as show in Fig4.18

People in GroupB who watch ImageFlowing can better imagine the photogra-
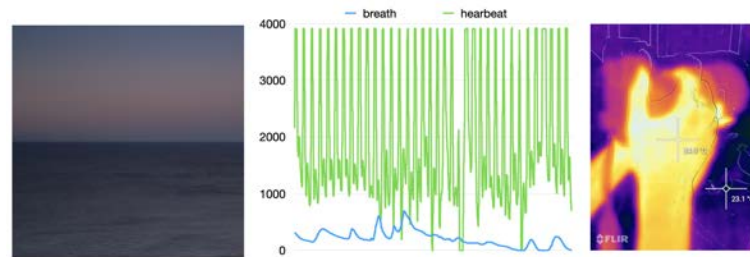
Figure 4.12 prototype2.0 cloud.jpeg

Figure 4.13 prototype2.1 photo and data

pher's emotion from feeling the photographer's vital signs, as show in Fig4.19

We compared the average value of each answer of GroupA and GroupB with the deviation value of my own answer, and we can find that the deviation value of GroupB is significantly smaller than GroupA, as show in Fig4.20. Therefore, people who watch ImageFlowing draw a more correct conclusion about the photographer's emotion.

3. ImageFlowing's which device that can make the viewer feel the photographer's emotion most. The experiment set up three devices, Heartbeat Bracelet, Breathing Frame and Termal Table. According to the results (the maximum value is 7), the average emotional value of the photographer felt by the Heartbeat Bracelet is 5.14, the average emotional value of the photographer felt by
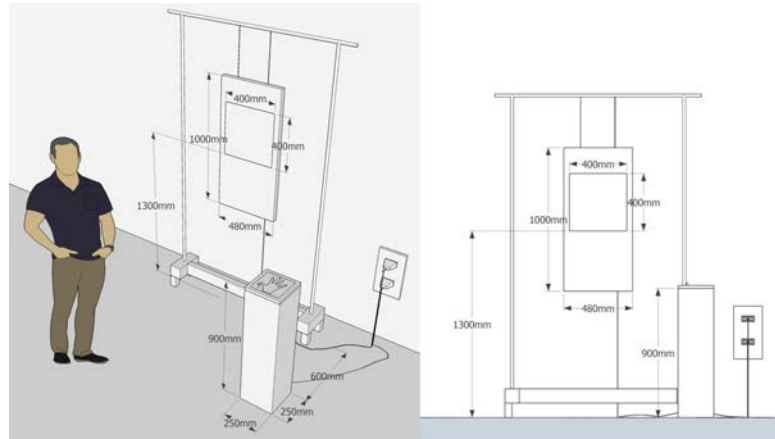
Figure 4.14   prototype2.1 sketch
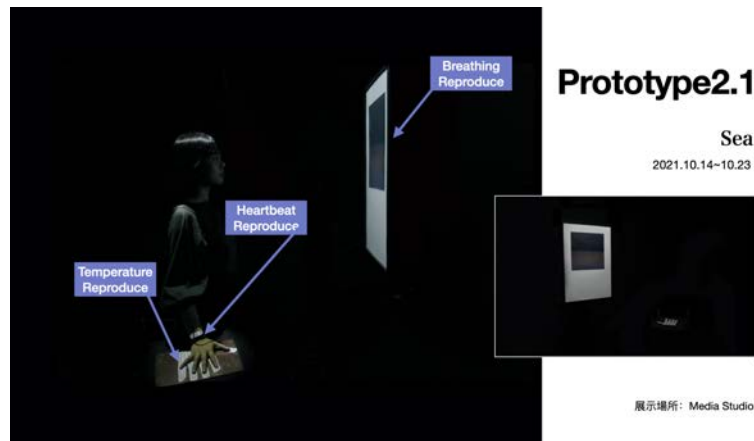
Figure 4.15   prototype2.1 sea.jpeg

the Breathing Frame is 4.7, and the average emotional value of the photographer felt by the Termal Table is 5.7.

So we came to the conclusion that temperature can make people feel the emotions of the photographer more.

4. According to the playback displayed by the camera, the viewing time is different. GroupA watches for an average of 10 seconds. GroupB watched for an average of 1 minute.

The conclusions are as follows:

1. Imageflowing will make the viewer feel that the photographer's mood is

Figure 4.16 The degree of feeling the photographer's emotions

Table 4.1 my answer of emotion in the questionaire

Options	My answer
sad is 1/ happy is 7	5
calm is 1/ excited is 7	6
heavy is 1/ relaxed is 7	4
lonely is 1/ blessed is 7	6

closer to the photographer's own mood.

2. Imageflowing can more accurately let the experiencer feel the emotion of the photographer when shooting

3. Imageflowing will make viewers watch about six times as long as ordinary photos.

4. The Termal Table can make the viewer feel the photographer's mood more than the Heartbeat Bracelet and Breathing Frame.

Overall, the participants think the ImageFlowing is a fresh and impressive artwork when they experienced it. Most of them agree that the device of ImageFlowing can bring them a more immersive experience, and by feeling the photographer's vital signs, it can promote them to feel the photographer's emotion. The following evaluations were obtained through the interview

"I think the warm feeling and the strong pulse from the wrist band conveyed a positive/warm feeling. However, the photograph made me feel that the photographer was trying to convey a sad or less positive emotion. These two combined together kind of caused concern that whether I understood the photographer correctly."

Figure 4.17 questions to analyze the accuracy of feeling the photographer's emotional level

"I think the environment helps it a lot, to be put in the darkness make the surrounding looks like a part of this work. The warm of the hand putting device makes me empathy the most."

Also there are some improvements in the experimental:

1. In this experiment, only one work was used as the experimental object, and the number of references was relatively small.

2. This experiment can draw a conclusion that the surrounding environment has a greater influence on the experience of the work, so there are fewer references for experiments in one environment.
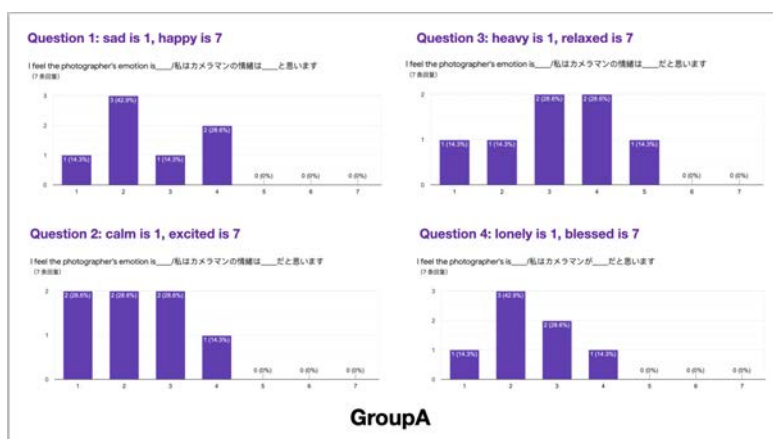
Figure 4.18 GroupA's judgment of the photographer's emotions
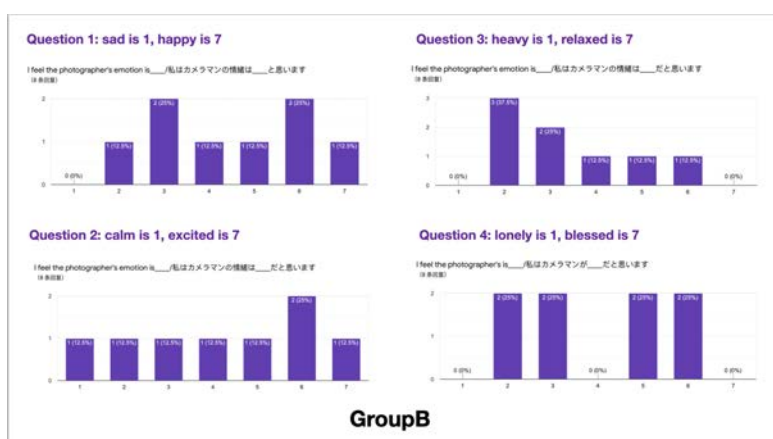
Figure 4.19 GroupB's judgment of the photographer's emotions

4.3. Exhibition

ImageFlowing had an exhibition at Place M gallery in Shinjuku from December 20, 2021 to December 26, 2021. The series of works is the theme of the Sea, other works with ImageFlowing equipment and on-site photography experience.

4.3.1 Recording

The series work's shooting location was set in Jiangzhi Island, and the shooting time was September 20. Since we have to shoot from early morning to night, we

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	Photographer's emotion	The average point of GroupA	The average point of GroupB
I feel the photographer's emotion is___ sad is 1, happy is 7	5	2.571428571	4.714285714
I feel the photographer's emotion is___ calm is 1, excited is 7	6	2.285714286	4.428571429
I feel the photographer's emotion is___ heavy is 1, relaxed is 7	4	3.142857143	3.285714286
I feel the photographer's is___ lonely is 1, blessed is 7	6	2.428571429	4.428571429

Figure 4.20 Accuracy of feeling the photographer's emotional level

have prepared a detailed schedule, including the equipment we need to carry and the time for shooting, as show in Fig4.22

We arrived at the shooting site at 4:30 a.m and began to prepare for shooting. At 5:00, 5:30, 11:30, 17:30 and 18:30, I took the photos with the recording equipment of ImageFlowing, and the data of my heartbeat, breathing and temperature were recorded. And I used a memo to record my emotions at that time, as show in Fig4.23 and Fig4.24 and Fig4.25

We did a pre-exhibition in the media studio, and the series of works on display and the display status as show in Fig4.26

I used the ImageFlowing device to record the breathing and heartbeat of the members, and we will reproduce these data in the photos as part of the exhibition works, as show in Fig4.27

4.3.2 Exhibition situation

The whole exhibition is divided into three parts. The first part: the works of the five sea. The second part: other works of ImageFlowing. The third part: Bring the ImageFLowing equipment on site to feel the image changes with the changes of breathing and heartbeat. At the same time, Because some visually impaired people love photography and art, maybe this installation can help them better express their emotions through photography, we invited some visually impaired
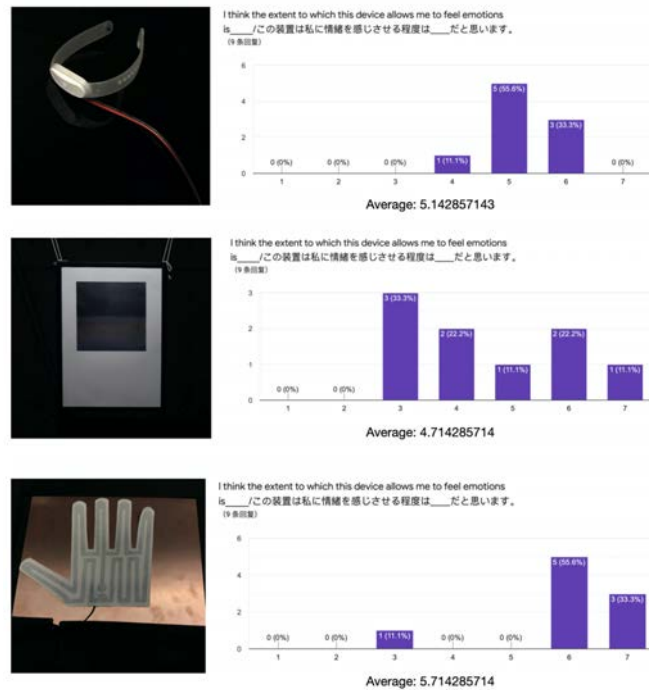
Figure 4.21 different device and their evaluation

people to experience ImageFlowing.

There had about 100 people came to the venue and experience the ImageFlowing, and we interviewed them received the feedback like this:

I think it's interesting that I can't see it at all because I'm totally blind, QIAN-QIAN's heartbeat rhythm and emotions when taking the photos can be understand and recognize for the next time, without preconceptions seems I ccan feeling the emotion.

For normal photos it can only give me a simple thrill, iust can recalls my own memories and experiences. But such a multi-dimensional three-dimensional feeling is I'm going back to your situation,It's you who told me a story.

I'm looking at this picture and I'm breathing with you, as if I could feel that you really existed in that scene, taking pictures with a camera.

You are in this space and all you may see is darkness, but you will feel that the stars around you in infinite motion, The sound of the sea is like in the universe, It feels like it's wrapping me.

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Figure 4.22 detailed schedule

The sound of the sea and breathing, there is a person's everything, Although not in my mother's arms, But can feel calm and healed

The one took at 5:30 pm made me feel the most comfortable, you should be the most comfortable, Your mood, your skin temperature, your heartbeat is the most comfortable.

When taking the first picture, I feel that you are anxious and a little confused

It feels like you turned the photo into a movie, static things become dynamic, It's immersive or like watching a movie.

We can draw the conclusions from the interview: 1.Some of the viewer can feel the same feelings as the photographer from ImageFlowing. 2. Compared with ordinary photos, ImageFlowing can enhance the emotional connection.
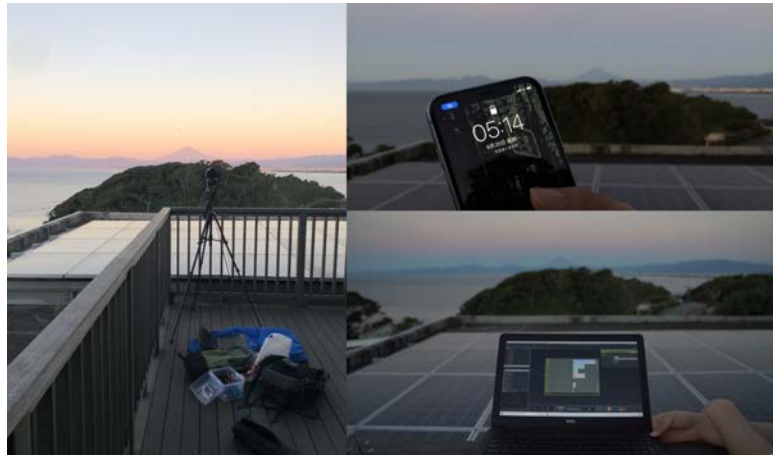
Figure 4.23 enoshima scenery

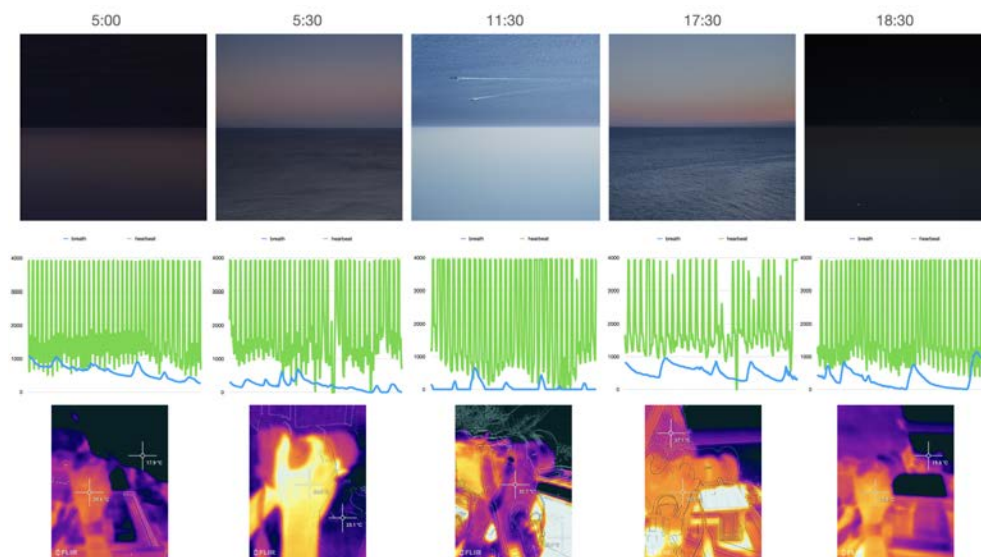Figure 4.24 enoshima with device

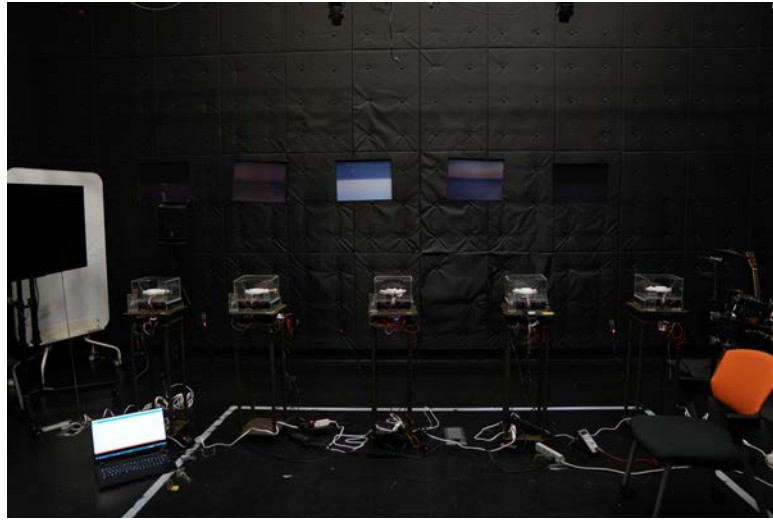Figure 4.25 the photo of enoshima with vital signs

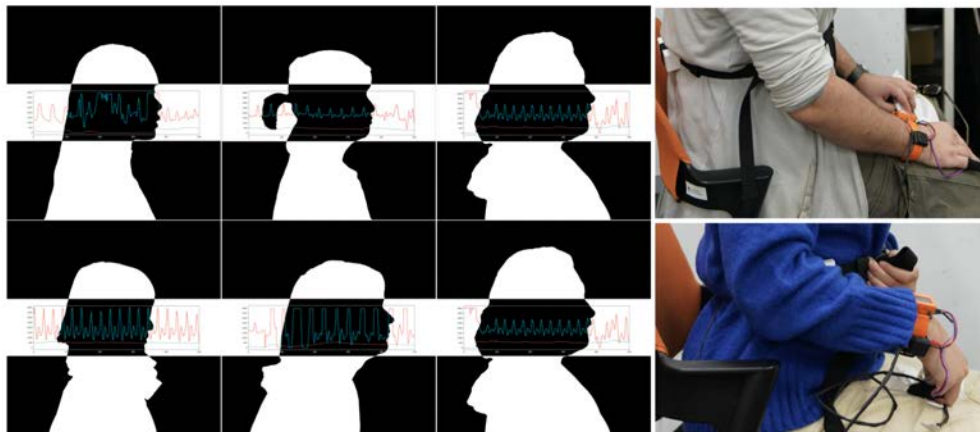Figure 4.26 pre-exhibition in media studio

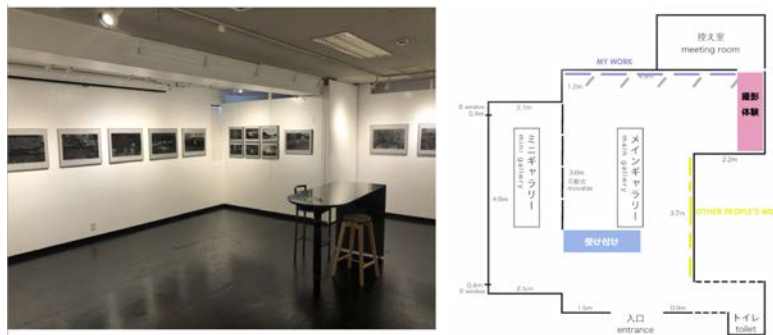Figure 4.27 our portrait with the breathing and heartbeat data

Figure 4.28 the gallery of exhibition

Figure 4.29 the outlooking of exhibition
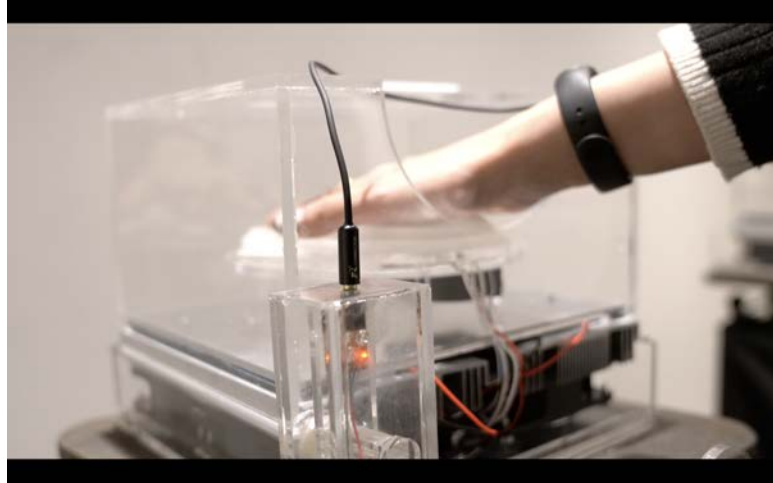

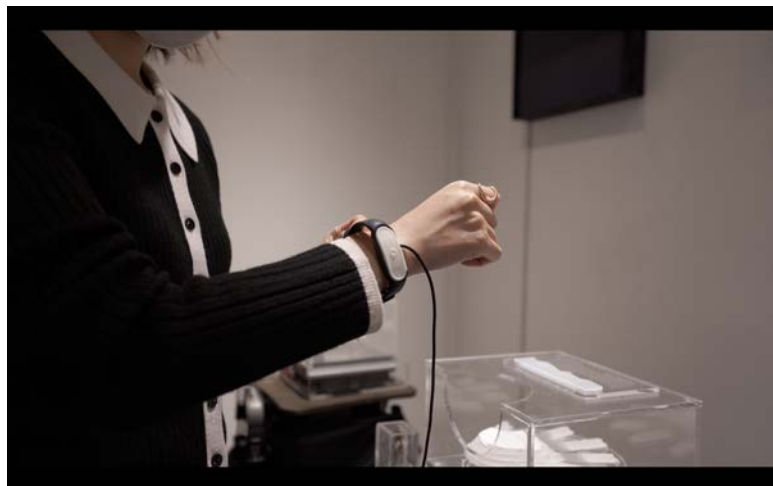Figure 4.30 interview

Figure 4.31   the termal table

Figure 4.32   the Heartbeat Braclet

Figure 4.33 the headphone

Figure 4.34 ImageFlowing with visually impaired people

Chapter 5
Discussion and future work

This paper introduces ImageFlowing, a novel approach from the photography processing system to the final effect of the immersive 3D space, reproducing the emotional expression from the photographer shooting in site which brings a brand new experience from sensory to imaginary for the viewer.

The feedback of the user study from the initial exhibitions shows that Image-Flowing got relatively high expectations from the participants. But the mechanisms by which emotions are elicited and the characteristics of the related physiological signals are complex. Emotions are multicomponent phenomena, may be expressed in different manners, and can even be withheld over time. In the future, we will use more accurate experiments to verify the accuracy of ImageFlowing in enhancing feelings.

And in order to make its value more recognized, we will have different attempts in the future.

1. Optimize recording equipment. Simplify the computer used to record data into a mobile phone operable program The heartbeat sensor is simplified to be worn in the shape of a lightweight ring, and the infrared temperature detection camera is changed to a temperature sensor to realize that the heartbeat, respiration and temperature can be recorded at the same time when the shutter is pressed.

2. Explore more ways to reproduce vital signs data. The current equipment for reproducing breathing, heartbeat and temperature is in a separate state. Later, you can try to integrate breathing, heartbeat and temperature.

3. Invite more photographers to experience the ImageFlowing equipment and realize more optimization from recording to reproduction.

4. Try to invite more people with visual impairment to experience ImageFlowing, and try to develop more photo systems that help them express their emotions

We hope that ImageFlowing can let more people sharing their moving moments and feelings, and these moments and their life can be living forever in the pulse moment.

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Appendices

A. Questionnaires of prototype1.1

Configuration File for Detecting Failures

```
<config>
<system>
<class>DefaultCompareClass</class>
</system>
<evaluate>
<compare_single_observation_point>
<function method="compareMax" recital="Temperature maximum threshold value"
type="Temperature"> <argument class="double">40.8</argument>
</function>
<function method="compareMin" recital="Temperature minimum threshold value"
type="Temperature"> <argument class="double">-41.0</argument>
</function>

<function method="compareChange" recital="Temperature change amount error"
type="Temperature"> <argument class="double">17.0</argument>
<argument class="int">1</argument>
</function>

<function method="compareConstant" recital="Temperature constant error"
type="Temperature"> <argument class="int">1</argument>
</function>
</compare_single_observation_point>

<compare_neighbor>
<function method="compareNeighbor" recital="Temperature neibor error"
```

```
type="Temperature"> <argument class="double">2.0</argument>
</function>
</compare_neighbor>


<compare_wide_area>
<function method="compareWide" recital="RainFall wide area error"
type="RainFall"> <argument class="double">10.0</argument>
</function>
</compare_wide_area>
</evaluate>
</config>
```

デジタル写真表現力の拡張体験アンケート

性別　男・女・ほか
年齢　（　　）歳

次の質問について、そう思ったかどうかを5段階で答え、該当の数字に○をつけてください
1＝全くそう思わない（Not at all）　　5＝その通りだと思う（Absolutely it's true）

1.星空の写真装置について　Photo device of Stars
呼吸が感じられる　　　　　　　　　　　　　　　　　【1　－　2　－　3　－　4　－　5】
I can feel the breathe

心拍が感じられる　　　　　　　　　　　　　　　　　【1　－　2　－　3　－　4　－　5】
I can feel the heartbeat

この装置はカメラマンの感情を知るのに役立つ　　　　【1　－　2　－　3　－　4　－　5】
This device can help me feel the feelings of the photographer

2.日光に関する写真装置　Photo device about sunlight
呼吸が感じられる　　　　　　　　　　　　　　　　　【1　－　2　－　3　－　4　－　5】
I can feel the breathe

心拍が感じられる　　　　　　　　　　　　　　　　　【1　－　2　－　3　－　4　－　5】
I can feel the heartbeat

この装置はカメラマンの感情を知るのに役立つ　　　　【1　－　2　－　3　－　4　－　5】
This device can help me feel the feelings of the photographer

3.撮影について About photography
私は写真を撮るのが好き　　　　　　　　　　　　　　【1　－　2　－　3　－　4　－　5】
I like photography

私は写真を共有するのが好き　　　　　　　　　　　　【1　－　2　－　3　－　4　－　5】
I like to share photos

私はよく撮影作品からカメラマンの感情を感じされる　【1　－　2　－　3　－　4　－　5】
I can often feel the feelings of the photographer from the photographic works

私は写真を通じて自分の感情を表現するのが好き　　　【1　－　2　－　3　－　4　－　5】
I like to use photography to express my feelings

4.感想 Impression

_____

Figure A.1   prototype1.1 questionaire.png

First questionnaire/アンケート1

Fill in before looking at the photos/写真を見る前に記入してください。

*必填

1。　number（番号）　*

_____

2。　Gender（性別）

请选择所有适用项。

☐ Female
☐ Male
☐ Prefer not to say
其他: ☐ _____

3。　Age（年齢）

_____

4。　I love taking pictures/私は撮影が大好きです

请仅选择一个答案。

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

Figure A.2   prototype2.1 questionaire for eight people who use ImageFLowing decive1

5。   I am a professional photographer/私はプロのカメラマンです。

请仅选择一个答案。

◯ yes
◯ no

6。   I think taking photos is ＿＿/私は＿＿写真を撮ります

请选择所有适用项。

☐ To record what we see/画面を記録するために
☐ To share what we see/画面をシェアするために
☐ To record our emotion/感情を記録するために
☐ To share our emotion/感情をシェアするために
☐ others/ほか

7。   I hope I can ＿＿ from other people's photos/他の人の写真から＿＿欲しいです

请选择所有适用项。

☐ Get visual enjoyment/視覚的な享受を得る
☐ Feel the photographer's emotions/カメラマンの感情を感じる
☐ Gain experience/見聞を広める
☐ Learn photography skills/写真の技法を習う
☐ Feel the spiritual /思想を感じる
☐ others/ほか

Figure A.3   prototype2.1 questionaire for eight people who use ImageFLowing decive2

8。   I can always ____ from other people's photos/他の人の写真からよく____

请选择所有适用项。

- ☐ Get visual enjoyment/視覚的な享受を得られる
- ☐ Feel the photographer's emotions/カメラマンの感情を感じられる
- ☐ Gain experience/見聞を広められる
- ☐ Learn photography skills/写真の技法を習う
- ☐ Feel the spiritual /思想を感じられる
- ☐ others/ほか

9。   I hope others can ____ from my photos/私は他人が私の写真から____欲しいです

请选择所有适用项。

- ☐ Get visual enjoyment/視覚的な享受を得ることが
- ☐ Feel the photographer's emotions/カメラマンの感情を感じることが
- ☐ Gain experience/見聞を広めることが
- ☐ Learn photography skills/写真の技法を習うことをが
- ☐ Feel the spiritual /思想を感じることが
- ☐ others/ほか

10。   Please click the link below to complete the TEQ test and fill in the corresponding score/下記のリンクをクリックしてTEQテストを完了し、対応する点数を記入してください。
https://psychology-tools.com/test/toronto-empathy-questionnaire

Second questionnaire/アンケート2   Please fill in after looking the FLOWGRAPHY/ FLOWGRAPHYを見てから記入してください。

Figure A.4   prototype2.1 questionaire for eight people who use ImageFLowing decive3

11。   I feel the photographer's emotion is____/私はカメラマンの情緒は____と思います

请仅选择一个答案。

	1	2	3	4	5	6	7	
sad/悲しい	◯	◯	◯	◯	◯	◯	◯	happy/楽しい

12。   I feel the photographer's emotion is____/私はカメラマンの情緒は____だと思います

请仅选择一个答案。

	1	2	3	4	5	6	7	
calm/落ち着く	◯	◯	◯	◯	◯	◯	◯	excited/興奮

13。   I feel the photographer's emotion is____/私はカメラマンの情緒は____だと思います

请仅选择一个答案。

	1	2	3	4	5	6	7	
heavy/重い	◯	◯	◯	◯	◯	◯	◯	relaxed /気楽

14。   I feel the photographer's is____/私はカメラマンが____だと思います

请仅选择一个答案。

	1	2	3	4	5	6	7	
lonely/孤独	◯	◯	◯	◯	◯	◯	◯	blessed/幸福

Figure A.5   prototype2.1 questionaire for eight people who use ImageFLowing decive4

15。   I can feel the photographer's emotion____/私はカメラマンの情緒を感じる程度は_____

请仅选择一个答案。

	1	2	3	4	5	6	7	
weakly/弱い	◯	◯	◯	◯	◯	◯	◯	strongly/強い

16。   I think the extent to which this device allows me to feel emotions is_____/この装置は私に情緒を感じさせる程度は____だと思います。

请仅选择一个答案。

	1	2	3	4	5	6	7	
weakly/弱い	◯	◯	◯	◯	◯	◯	◯	strongly/強い

Figure A.6   prototype2.1 questionaire for eight people who use ImageFLowing decive5

17。   I think the extent to which this device allows me to feel emotions is____/この装置は私に
情緒を感じさせる程度は____だと思います。

请仅选择一个答案。

	1	2	3	4	5	6	7	
weakly/弱い	◯	◯	◯	◯	◯	◯	◯	strongly/強い

Figure A.7   prototype2.1 questionaire for eight people who use ImageFLowing
decive6

18。   I think the extent to which this device allows me to feel emotions is_____/この装置は私に情緒を感じさせる程度は____だと思います。

请仅选择一个答案。

	1	2	3	4	5	6	7	
weakly/弱い	◯	◯	◯	◯	◯	◯	◯	strongly/強い

19。   I think the design of Flowgraphy is easy to understand/Flowgraphyのデザインは分かりやすいと思います。

请仅选择一个答案。

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

Figure A.8 prototype2.1 questionaire for eight people who use ImageFLowing decive7

20。   I would like to use Flowgraphy to take and share photos/私はFlowgraphyを使って写真を
撮って共有したいです。

请仅选择一个答案。

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

21。   Please tell me your other feelings about this work/この作品の他の感じを教えてください

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Figure A.9   prototype2.1 questionaire for eight people who use ImageFLowing
decive8

Figure A.10 the poster of ImageFLowing
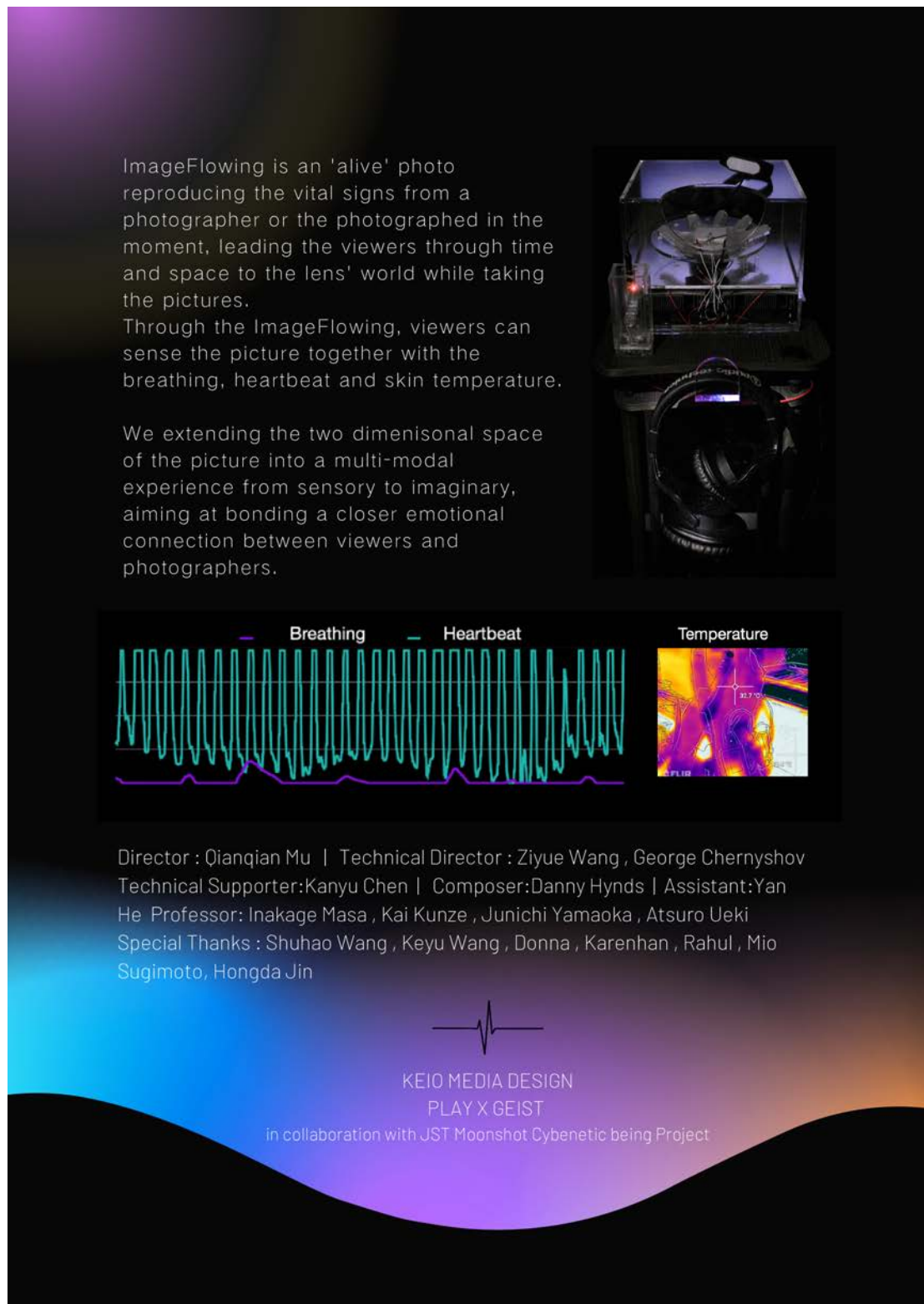
Figure A.11 The poster of ImageFLowing 2

Figure A.12   the special website page of inviting visually impaired people1
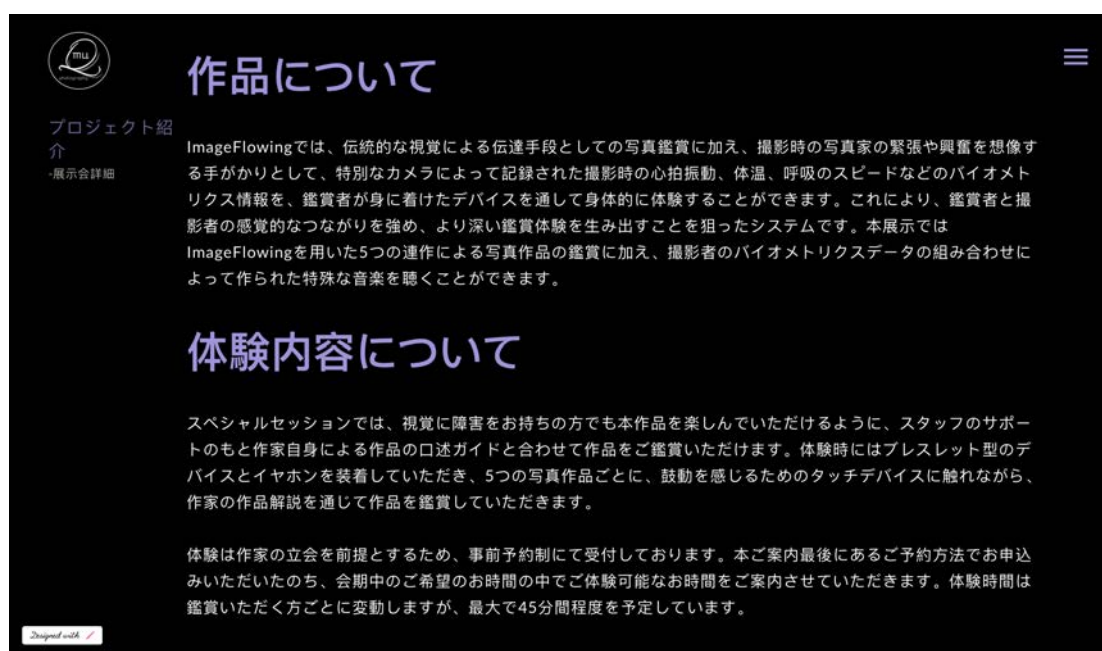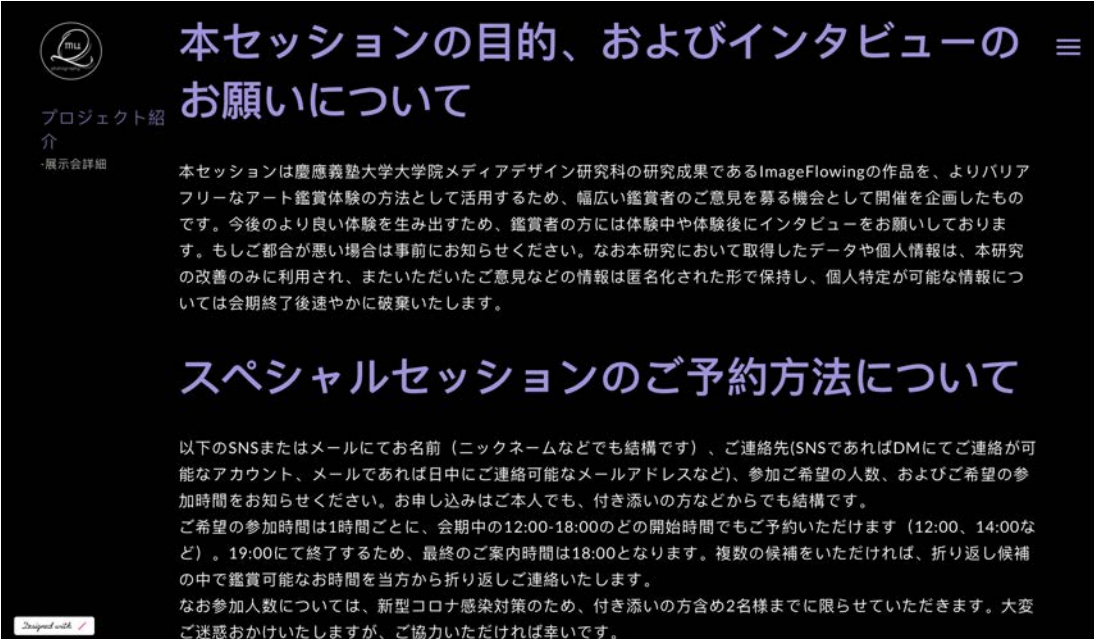
Figure A.13   the special website page of inviting visually impaired people2

Figure A.14 the special website page of inviting visually impaired people3

Figure A.15 the special website page of inviting visually impaired people4