System and Users' Responses of Touch Light Through the Leaves: A Tactile Display for Light and Shadow

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ABSTRACT

You can feel something good when light falls through the trees into the upturned palms of your hands. With this visual-tactile display, users can sense that shadow and feel the transition between light and shadow. "Touch Light Through the Leaves" has two versions; 1) High resolution with a computer version that consists of a camera and 85 vibration units, 2) Stand alone version that consists of light sensors and 16 vibration units. People who have experienced this display report weird, new sensations. In their daily lives, light and shadow are perfectly ordinary, but when they feel light and shadow directly on their palms, they are "touched" by light for the first time. We exhibited "Touch Light Through the Leaves" for more than one thousand persons, and got a lot of feedback. They were well accepted and enjoyed "Touch Light Through the Leaves".

Index Terms: H.5.2 [User Interfaces]: Haptic I/O—;H.5.2 [User Interfaces]: Prototyping—; J.5 [TArts, fine and performing]: —

1 INTRODUCTION

You can feel something good and comfortable when you turn your palms up and the light falling onto your palms through the trees. "Touch Light Through the Leaves" begins from an imagination which we can touch the light through the leaves. In this paper, we propose "Touch Light Through the Leaves". It is a novel tactile camera display which can change visible information into tactile. It is not only a sensor of light and shadow but also a tactile display. You can feel the transition of light and shadow by your palms directly with it. You can touch the light and also can be touched by the light.

We have developed "Touch Light Through the Leaves" by two methods. The first one is using a camera and the second one is using light sensors to detect light and shadow. We also use pager motors for cell phone to generate tactile feedback.

We have also demonstrated "Touch Light Through the Leaves" at an international conference [10] for more than a thousand persons and got a lot of feedback. We discuss their responses of "Touch Light Through the Leaves".

2 RELATED STUDIES

"Touch Light through the Leaves" is a visual-tactile display that changes from visual information that is light and shadow, into tactile information. In terms of changing modality, there is an artwork named "Sound-Lenz" [5] that changes visual information to audio information. You can bring a hand-held size "Sound-Lenz" device and hold it over light, you can hear the sound based on the frequency of the light. You can find light around your life as a different sound. There is a mobile application for visually-impaired persons named "vOICe" [9]. The vOICe is an application on the Android OS. When you take scenery around you by a camera of your cell phone, the vOICe detects colors from the camera and describes them in words. "Emotional Touch" [4] is also proposed that changes from force and acceleration sensor information to tactile information using a speaker.

Paul Bach-Y-Rita proposed a visual-tactile display in general in 1969[2]. In 1970, the TVSS (Tactile Vision Substitution System) [3] was proposed that can stimulate a usrr's back with 400 vibration units. A tactile display for tongue with an electronic stimulation [6] was also proposed. It brings visual information to tactile information in your mouth. The device for your forehead that can transmit visual information by electric stimulation was also proposed[7].

In terms of a tactile display for conveying information for visually impaired persons, the Optacon (Optical Tactile Converter) is one example. It consists of a small camera and pin display. It can convey information for blind people. The DotVIew[8] is also commercialized that can visualize images using pixel pins.

There are many handheld tactile devices. The tactile devices using mobile device such as PDA were proposed[11][12]. The handheld devices that can generate tractional feeling was also proposed[1].

"Touch Light through the Leaves" aims to develop a tactile device for conveying fluctuations of light and shadow, not for images or characters mentioned above.

3 SYSTEM OF "TOUCH LIGHT THROUGH THE LEAVES"

This touch display can change from visible information to tactile information. It can transmit the light and shadow to your palm directly as a tactile. Requirements of "Touch Light through the Leaves" are 1) to generate tactile feedback based on fluctuation of light and shadow, 2) handheld size that is suitable for put on a user's palm. When we think about a presentation of light and shadow, the device should be able to generate movements of light and shadow that is the difference and differential of strength of light.

We divide system of "Touch Light through the Leaves" into two parts; 1) sensor to detect light and shadow, 2) tactile display. A camera and a light sensor are candidates of sensor for light and shadow. This tactile display is not required high resolution enough to images and characters. It is required generation of tactile movements. It can realize array of vibration motor units.

In this paper, we have developed two system of "Touch Light through the Leaves"; with a camera version and with light sensors version. The comparison of two system is shown in Table1.

Table 1: 2 systems of "Touch Light through the Leaves"

	with a camera	with a light sensor
Sensor for light and shadow	One camera	16 light sensors
Number of tactile point	85	16
Pitch between tactile points	9 mm	19 mm
Electronic power source	outside	inside (batteries)

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3.1 System of “Touch Light through the Leaves” with a Camera

“Touch Light through the Leaves” with a camera system uses a camera to detect light sensor and vibration motors to generate tactile feedback. Whole views of “Touch Light through the Leaves” is shown in Fig.1. It consists of a camera and vibration units with in the same device. The camera can detect light and shadow. The vibration units change them into tactile with image processing and control each units with vibration motors. The size of this display is like a palm size in order to hold by a hand. The display is a cylindrical form. The height of the display is 170 mm and the diameter is 120mm. The weight of this display is about 800g. This portability is required to experience under various conditions.

The overview of system is three parts: 1) Tactile display: a camera and a tactile display, 2) PC: image processing and determination of vibration units, 3) Control unit: controlling vibration units. Each part is connected by USB or MIDI. Fig.2 shows the system image. A user brings and holds only a tactile display for experience.

For a tactile display, we put 85 vibration units at the bottom of the device. For the vibration units, we used 85 vibration motors (vibration motor: 6dl05wa by Linkman). One unit consists a vibration motor with a plastic polyvinyl chloride cap with 6.0 mm diameter. Each unit has 6.5 mm diameter. Each unit is distributed with 9.0 mm pitch. With 85 vibration units, it can stimulate a whole palm.

On the top of display, we put screen material in order to make shadow on it. A camera detects this shadow and light. For a captured image, we do noise reduction, image binarization, and determine vibration points. The area of shadow or light determines vibration points. Process of image processing is shown in the display of the computer (Fig. 3). When you want to touch shadow, vibration units of shadow area will vibrate. When you want to touch light, vibration system works opposite by a parameter.

“Touch Light through the Leaves” with a camera uses a computer for image processing, thus it has cables between the camera of the device and the computer, and between the device and the control box that changes from MIDI signal to control signal of vibration motors. Thus users can only move within the length of cables. Vibration motors are controlled by a matrix control method, and maximum 50 % of vibration motors work because of limitation of current of electricity.

Figure 1: “Touch Light through the Leaves” with a Camera Version

3.2 System of “Touch Light through the Leaves” with light sensors

“Touch Light through the Leaves” with light sensors uses light sensors for sensing light and shadow and uses vibration motors for a tactile display. We put 16 light diode sensors on the top of the device with 19 mm pitch. We also put 16 vibration units with 19 mm pitch. One unit consists of a vibration motor with a plastic polyvinyl chloride cap in the same way with a camera version. We use two Arduino Nano for controlling vibration units. We also put 8 dry cell batteries in the device. The device is a stand-alone and you can bring anywhere on your hand. The size of the device is a

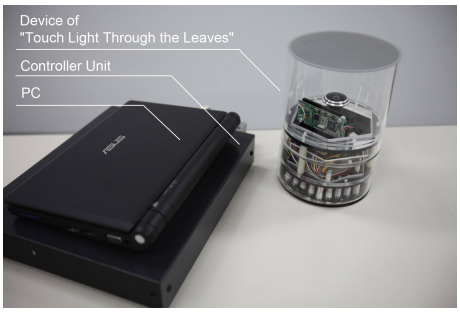

Figure 2: System “Touch Light through the Leaves” with a Camera Version

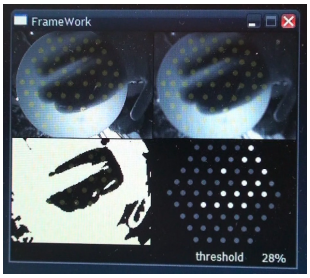

Figure 3: Display of “Touch Light through the Leaves” with a Camera Version

cylindrical form. The height of it is 130 mm and the diameter is 100 mm. Fig. 4 shows a picture of “Touch Light through the Leaves” with light sensors uses light sensors and Fig. 5 shows the backside of it.

We set the threshold of light sensors. When the light level is less than the threshold, the vibration units will vibrate for detecting shadow. It can change an opposite way to detect light. When the device starts up, calibration of light sensors is conducted. The threshold is determined automatically based on the calibration level.

4 Exhibition of “Touch Light through the Leaves”

We exhibit two system of “Touch Light through the Leaves” at an international academic conference (SIGGRAPH 2010 Emerging Technologies) [10]. We demonstrated more than one thousand persons from various countries in 5 days. The picture of exhibition is shown in Fig. 6.

At first, audiences saw the exhibition place curiously and did not know what is going on. When they experienced “Touch Light through the Leaves” on their palms, they began to express smile.

Figure 4: “Touch Light through the Leaves” with light sensors version

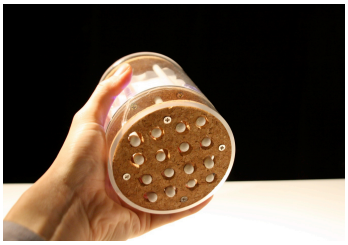

Figure 5: Back view of “Touch Light through the Leaves” with light sensors version

They could understand the meaning of “Touch Light through the Leaves”. We could observe many people enjoyed it. We put a small tree under the spotlight at the exhibition booth, thus audiences experienced light and shadow under the tree by moving the device under the leaves. They can feel light and shadow on their palm. We could observe many children enjoyed it (Fig. 7).

At the exhibition, we asked audiences to experience both two devices. They can enjoy both with a camera version that is higher resolution and with light sensors version that can be brought everywhere because of stand-alone system. The strength of vibration motors with light sensors version is stronger than that with a camera version. Some people like with light sensors version and other people likes with a camera version.

Figure 6: Exhibition of “Touch Light through the Leaves”

Figure 7: Picture of a child playing with “Touch Light through the Leaves”

5 Evaluation

5.1 Method of Questionnaire

At the exhibition of “Touch Light through the Leaves”, we conduct a quick survey in the form of a questionnaire to evaluate it. We prepared three questions and asked audiences in five levels. Audiences were asked to put dot-form mark to answer each questions. A view of the questionnaire is shown in Fig. 8. Audiences were asked to answer three questions and asked to put one mark for one question. They could know the situation of answer of others because answers were visualized by dot-form marks. We changed questions during the exhibition days and got several questions.

Figure 8: Picture of the questionnaire

5.2 Results of Questionnaire

Method of questionnaire was very simple and analog, and it could see easily from outside, thus many people cooperated this survey. We could get answers from 400 audiences.

We asked the question about concept of “Touch Light through the Leaves”; Q1: “Were you touched by the light/shadow?”. The result is shown in Fig. 9. We got 400 answers in 5 days and 89 % of respondents answered “Very good” score and “Good” scores. It indicates “Touch Light through the Leaves” was accepted as a device to feel fluctuation of light and shadow.

We also asked the question about a tactile display; Q2: “Did you feel movement of light / shadow? (changing position of vibrated vibration units) “. The result is shown in Fig. 10. We got 166 answers in 2 days and more than half respondents answered “Very good” score. 86 % of respondents answered “Very good” score and “Good” score. It means that the device generates tactile feedback to show changing and transition of light and shadow. From these results, we could say that we could archive our first concept “touch light and shadow”.

We prepared the question about accuracy of sensors on the top of the device and vibration units on the bottom of the device. The question is Q3: “Did you feel position of shadow is corresponding to position of vibration?”. The result of this questionnaire is shown in Fig. 11. We got 212 answers in 3 days. 35 % of respondents answered “Very good” score and 41 % of respondents answered “Good” score. It indicates that they could feel association between position of shadow and position of tactile points. The reason that number of respondents who answered “Very good” score is less than that of “Good” scores is the situation that some vibration units vibrate even if the device with a camera version is at bright place. At the exhibition booth, we used strong spotlight, it cause to make brighter part and darker part in the camera image. It leads that some vibration units vibrated even if they are not expected to vibrate. When there is light and shadow part in a camera image, it worked very well.

In addition, we asked the preference question; Q4: “Which do you prefer? Bigger One or Smaller One?”. Bigger one indicates with a camera version and smaller one indicates with light sensors version. We could get 247 answers in three days. The preference of audience is almost divided. The result is shown in Fig. 12. We could talk with some audiences. They indicated that standalone, resolution of a tactile display, strength of vibration units are parameters of the preferences. Some audiences like both and answered “so-so” score. Other audiences advised us that to develop standalone version with high resolution.

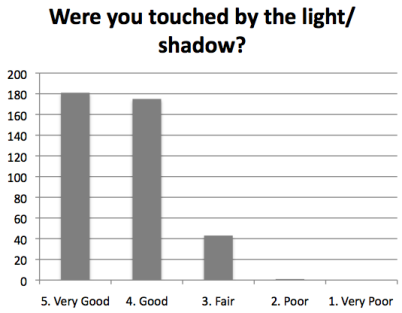

Figure 9: Q1: Were you touched by the light/shadow? (n=400 persons)

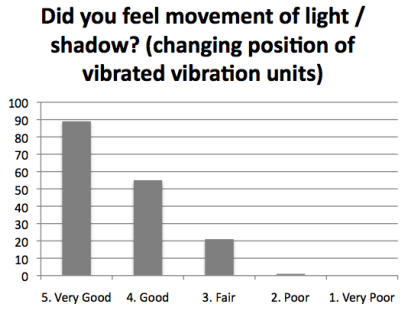

Figure 10: Q2: Did you feel movement of light / shadow? (changing position of vibrated vibration units (n=166 persons)

6 Summary

In this paper, we proposed “Touch Light though the Leaves” that is a tactile display for light and shadow. We have developed two systems of it with a camera and with light sensors for detecting light and shadow. We used vibration motors to generate tactile display. We demonstrated “Touch Light though the Leaves” at the international conference. At the exhibition, more than one thousand persons experienced it and enjoyed it. We took a questionnaire survey from 400 audiences. The result indicates that many people could feel fluctuation and movement of light and shadow and feel touched by the light and shadow. We can say that even if there is only 16 tactile points, people can feel the movement of tactile. People who experienced this display had weird and new feeling because they can feel light or shadow directly. In their daily life, light and shadow are perfectly ordinary. When they feel light and shadow directly on their palms, it becomes a tactile sensor, which reminds them of light and shadow. We could say that we can archive our concept of “Touch Light though the Leaves”.

We did not show this device for visually impaired persons. Thus we want them to experience this display and want to get feedback from them.

For our future work, we want to develop more lightweight and wireless system for experiencing ”Touch Light Through the Leaves” everywhere. We want to think about forms of the device in order to fit our palm. We also think about changing strength of vibration motors based on light and shadow level. It can generate tactile graduation based on light level. We think it leads enhancement of it’s powers of expression. We also have an idea to use different sensors instead of light sensors. When we use distance sensors on the top, we can feel form of object at remote place. Then we can make some application of it.

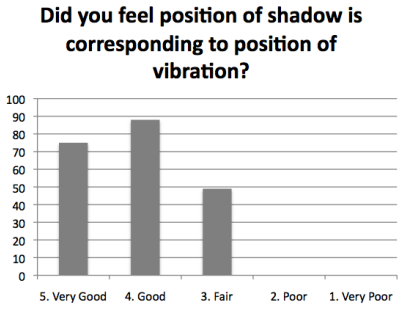

Figure 11: Q3: Did you feel position of shadow is corresponding to position of vibration? (n=212 persons)

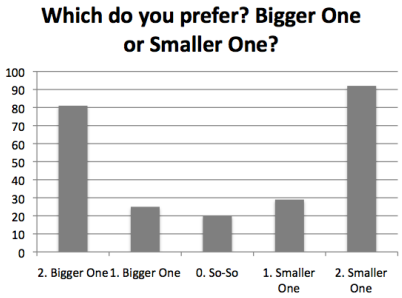

Figure 12: Q4: Which do you prefer? Bigger One or Smaller One? (n=247)

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