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Master's Thesis
Academic Year 2016

Notify Me: Smart Glasses with a Peripheral Vision Display

Keio University Graduate School of Media Design

Takuro Nakao

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

Takuro Nakao

Thesis Committee:

Associate Professor Kai Kunze	(Supervisor)
Project Senior Assistant Professor Charith Fernando	(Co-supervisor)
Project Senior Assistant Professor Liwei Chan	(Co-supervisor)

Abstract of Master's Thesis of Academic Year 2016

Notify Me: Smart Glasses with a Peripheral Vision Display

Category: Science / Engineering

Summary

There are plenty of interesting application cases in virtual and argumented reality scenarios for technologies based on properties of human peripheral vision, from inducing the illusion of motion, over changing walking speeds/ walking trajectory to e client crowd control. Unfortunately, most research uses either stationary setups or relatively bulky experimental headsets (e.g. for Virtual Reality applications). I want explore the peripheral vision interfaces in everyday life. To this end I developed an unobtrusive smart eye wear device with an low resolution screen on one side. This paper focus on the question, if information displayed on the screen can be perceived by a users peripheral vision and in a second step what kind of animations are best for users to recognize. Contributions of this paper are as follows:

(1) I present a novel design for smart glasses with a low-resolution peripheral display implemented in a first prototype.

(2) Evaluating design in two experimental setups,

(3) validating its functionality and

(4) exploring different stimuli. After this, I also suggested to developed application scenario. It is a method to control peoples movement when the people is walking or doing exercises. I made a dual side display for that proposal and confirmed its effectiveness.

Keywords:

Peripheral Vision, Display, Eye-Wear Computing, Human Interaction

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Last but not the least, I would like to thank my family: my parents and to my brothers and sister for supporting me spiritually throughout writing this thesis and my my life in general.

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Chapter 1

Introduction

In recent years, Many smart devices capable of connecting to the Internet have become widespread. The distance between information and people has shrunk, that the people can get more information easily. However, many problems have also appeared.Users can connect to the net at any time and get the necessary information. When you need a map, you can quickly find a route to your destination on your smartphone. For examples, When the person is talking with someone, If a smartphone is ringing, usually people see it. Such things hinder smooth communication(1.1). Also, in Japan many people are watching smartphone, when the people are heading to their destination. Using a smartphone while walking is occasionally incurring a serious accident, that is one of social problems. However, the importance of information is increasing more and more from now on, and users will have to get it more properly. Under such circumstances, I have to fig out the above problem and sought out what kind of solution to realize a ubiquitous computing society. This is a background of this research. Among them, I focused on the cause of vision and tried to solve the problem. In many cases, Information has characters, shapes, colors exist and are interpreted by the user, so that they are communicated as knowledge. In this research, I proposed a basic method of presenting information in the form of new movement.

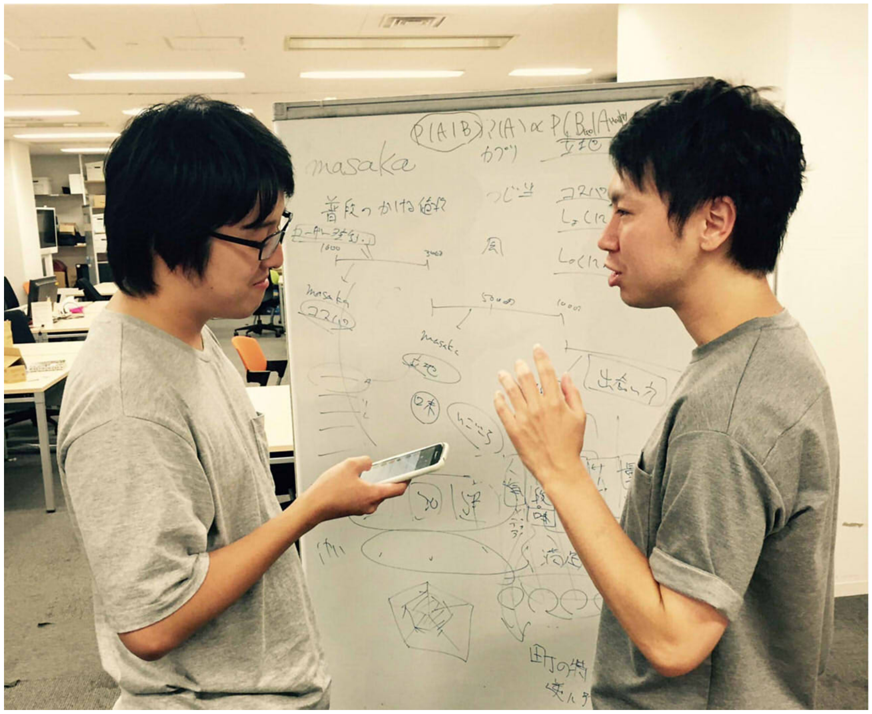

Figure 1.1: Problem of Smartphones

1.1. Purpose

People get a lot of information by sight in their lives. When viewing PC screens and mobile phones or walking outside they also get information on where they are going to their destination from shops and buildings. An interesting point of human sight is unconscious sight. For example, when walking in the town, People can walk so that they do not hit others. Because I acquire to the movement of other person in sight and avoid unconsciously. Unconsciousness of human sight can be related to features of peripheral vision. Even in the walking while to see a smartphone of the preceding paragraph, experiences of noticing and avoiding just before hitting people are those experienced by many Japanese people. I focused on the strength of cognition to movements, from such peripheral vision characteristic. And I thought, that there was no need to see if presentation information can use movement. Also, I aimed to control human behavior by presentation the motion information.

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Chapter 2

Related Works

In this section, I discuss the related research on smart devices and devices that use peripheral vision. Glasses have been used for medical purposes for centuries. They revolutionized till their modern form of spectacles with two lenses placed in front of both eyes and with supports on the nose and ears with a fixed frame. Under such circumstances, the glasses have undergone significant evolution, and their form has become more complicated. From monocular designs supported only by eyelids to complicated frames suitable even for sports. Miniaturization of sensors and microcomputers in recent years, allows us to create and use systems that can be placed inside eyeglasses frame. In the field of smart eyewear there are already some devices that can keep the user connected to any web service imaginable, like Google Glass. Researchers have been working on information presentation techniques for quite a long time. However, in many cases, most of the available products directly display information in a direct manner, as it is normally done on a PC or smartphone display. It is mostly motivated by convenience, but I believe I need a different approach to information representation to some extent. I focused on unconscious information acquisition, so the user would not have to pay any attention to get useful information from the device. Considering this, I have made a device that is using the benefits of peripheral vision to achieve my goals. The information representation for the peripheral vision has been studied by Flank et al. [9] In their study they show that it is possible to affect the movement direction using the optical flow. Their research is used as the base to affect the navigation using while driving a car and their method is mostly relying on peripheral vision. Through their experiments, they have proved that it is possible to distinguish between more than 10 patterns of information using only the intensity and direction of the optical flow.

2.1. Eye Wear Devices

In recent years, Head Mounted Displays (HMD) has increased in variety, along with that, multiple devices are also being developed in various forms factors and application areas. All united by the concept of smart eyewear.

-Transmissive HMD for visually presenting virtual information to real world such as MR and AR

-Displayless eyewear device with built-in sensor for life log.

-Immersive HMD for reproducing the VR environment

2.2. Optical HMD

2.2.1 Google Glass

Glasses is the most popular device, and the development of wearable Eye wear devices applying it is diverse. Among them Google Glass is a famous devices. (2.1) It is possible to present images to the transmission display. It attached to the right eye part, thereby enabling a hands-free internet connection. It attracted attention as a multifunction device created by Google. However, the problem of privacy due to the camera function and not general orientation due to multifunctionality, It is not currently produced.

2.2.2 Hololens

Horolens is an HMD specialized for holographic reproduction manufactured by Microsoft Corporation. Hololenses equipped with a transmissive display have built-in GPU and CPU, and can operate independently. As shown in the figure, Hololens takes the form of covering the front of the eye as a whole. However, the image to be displayed does not dominate the whole visual sense, and the user can freely select the target and view. In the Hololens, I acquire surrounding environments with multiple sensors, and I am building a VR environment accordingly. These methods are called Mixed Reality (MR). The operation of Hololens also includes acquiring and manipulating the movement of the hand with a sensor, a gesture manipulation, and a method of manipulating with eye movements such as gaze. These are devised to move them intuitively.

Figure 2.1: Google Glass

Figure 2.2: Microsoft Hololens

2.3. Smart Eye Wear Device

2.3.1 JINS MEME

Jins MEME is a widely available off-the-shelf smart glasses equipped with 3 Electrodes for Electrooculography (EOG), a 3-axis accelerometer and gyroscope. EOG electrodes allow reading the movement of the user's eyes, but do not provide an estimation of the absolute position of the eyes, only relative motion for each eye along vertical and horizontal axes.

Using Jins MEME user can collect data on his or her attention and fatigue levels throughout the day, as well as track activity head and body posture. Thus Jins MEME can be also used as a basic fitness tracker.

It is equipped with Bluetooth Low Energy (BLE) module, which assures low power consumption and makes it usable all day long.[1]

Figure 2.3: JINS MEME

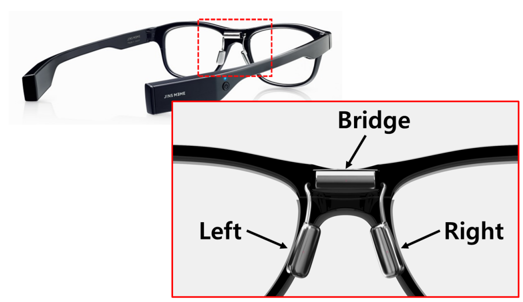

Figure 2.4: JINS MEME Electrodes

According to National Eye Institute, 64% of adult population of the US are wearing eyeglasses. [10] Which is significantly more than 41% of watch users. [**?**] This data strongly supports my vision and shows great perspectives for the concept of Smart Eyewear.

2.3.2 Vue

Vue is the pair of smart glasses that are designed for everyday use. It was developed by students at the University of Peninsular, this product is including the accelerometer, gyroscope and touchpad etc. Vue implements many things that smart eyewear devices can do, such as logging the user's daily life, playing music, notifying information, etc. In addition, they are actively responding to problems that arise in smart eyewear devices, and they are developing smart devices with higher quality.

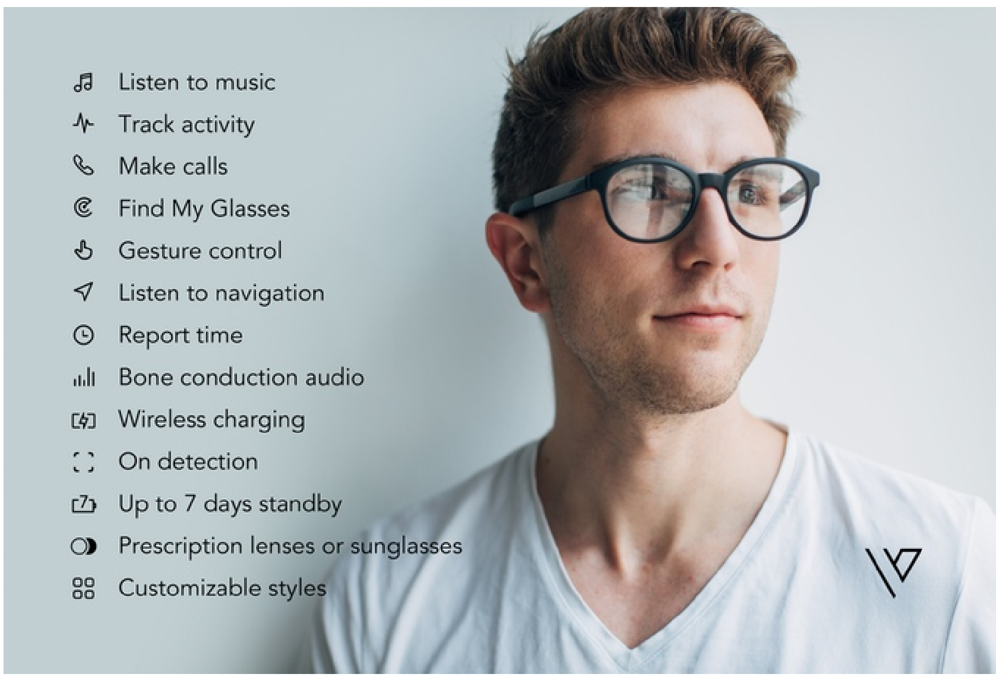

Figure 2.5: Vue

2.4. Head Mounted Displays (HMD)

2.4.1 Oculus Rift

Figure 2.6: Oculus Rift CV1

Oculus Rift is a pioneering HMD device. It is a head-mounted display(HMD) specialized for immersive VR with acceleration sensor(2.9) for head movement and orientation tracking. The system is using two LCD displays with the extremely high number of dots per inch (DPI) together with optical systems for left and right eyes. It is astonishing how a user can be immersed into the VR worlds using a simple setup with liquid crystal displays and a couple of fisheye lens. The display resolution of the latest Oculus Rift's (CV 1) organic liquid crystal displays (OLED) is 2160 * 1200, 233 million pixels, and refresh rate of 90Hz. The provided viewing angle is about 110 degrees. The viewing angle of HMDs is narrower than natural, which can be one of the causes of VR sickness which is also a reported problem of the Oculus Rift.

Early versions were released for developers only, and used with Unity, a popular

3D development engine. Thus a lot of contents were created before the official release. This product played a huge role very early in the recent VR boom, many advanced devices such as Gear VR, HTC Vive, PlayStation VR, etc were developed later.

2.4.2 HTC Vive

HTC Vive HMD is technically very similar to the Oculus Rift, but it was the first HMD that introduced room-scale tracking of the user, thus allowing to map user's motion and position in the room to his/her avatar in VR. Player tracking within a room, allows designing many new different interactions and experiences that were impossible with inertial sensors.

Figure 2.7: HTC Vive

2.4.3 Google Cardboard

Google Cardboard is an open source project trying to make VR accessible to everyone. The setup is made of cardboard and fish-eye lenses. Users are supposed to use their smartphones as the display. Assembly instructions and specifications are open-sourced and available to anyone. Any person with a smartphone equipped with a accelerometer and gyroscope is suitable can be used in this system.

2.4.4 StarVR by Acer and Starbreeze

Figure 2.8: StarVR

This headset features ultra wide field of view of 210 degrees horizontally and 130 degrees vertically, which is more than any other available HMD. Display quality is also unprecedented, this HMD uses two 5.5 inch displays 2560x1440, achieving 5K panoramic image when two displays are combined. This device is mostly oriented to panoramic video consumption, because the computational power required by two 2560x1440 displays with different points of view is unlikely to be affordable and available in consumer segment within next few years. And such an image quality is absolutely necessary for video contents.

2.5. Peripheral Vision Display

Development of peripheral vision devices can be roughly divided into two groups: first is enhancing or affecting the user's movement, and second group is the information presentation. Okano's [11] research is a good example of changing the sense of movement. Their aim is to improve the feeling of immersion while exercising on running machines. In this paper, the researches focus on the fact that the changing the sense of motion is easily done by changing the optical flow of the peripheral vision. Figure 2 shows the device elaborated by the researchers at that time. In this device, a 32 * 16 dot matrix of 8 cm length is placed at a distance of 4 cm from the left and right eyes, and used to generate or change the optical flow in the peripheral field. Experiments show that it is possible to affect the sense of speed using the peripheral vision. Another important point of this research is that it does not provide any stimulus in the central visual field when presenting information to peripheral vision. However, as the definition of this range may seem to be ambiguous, Okano et al. show that the effect upon the kinesthetic sensation decreases when the angle is exceeding 10 degrees. Moreover, when assuming the described system is a prototype, I am urging the development of a simpler and lighter system.

Figure 2.9: Peripheral Display([11]

2.6. Veciton Illusion

2.6.1 Vection Field: the Visual Navigation Method for Pedestrian

Vection illusion is a phenomenon that The person feel to moving. More specifically, If the person on a stop train. People see other trains that started to move, The person feel like their train is moving. Such a phenomenon is called a vection illusion. Vacation can be considered as one of causes of sickness in virtual space [?]. Control of human behavior using the vection illusion has been shown to be possible by Yoshikawa et al [8].

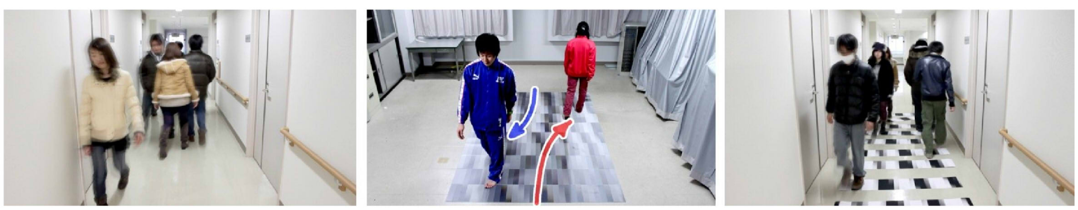

Figure 2.10: "Vection field" for pedestrian traffic control [8]

This research is using the lenticular lens to present the right motion on the floor.If the users walk on this floor. The users is unconsciously walking right.I think I can reproduce this system by my device then control the human motion more simply.

Notes

1 https://jinsmeme.com/en/products/compare/

Chapter 3

Notify Me

As mentioned before, I want to evaluate effects related to the peripheral vision for interactions in virtual and augmented reality. Complimentary to other research using peripheral vision I implement my display in an unobtrusive eye glasses design. Most of my senses including the dominant vision are on the head, making the human skull a perfect location for interaction devices. Eyeglasses are publicly accepted accessories, often worn continuously throughout the day, rendering them an ideal platform for unobtrusive information delivery. My initial goal is controlling the human motion without consciousness. Eyeglasses are publicly accepted accessories, often worn continuously throughout the day, rendering them an ideal platform for unobtrusive information delivery.

3.1. Problem of Information Presentation

Most of visual information until now was mostly picked from the central area of the field of vision. Most of information that human receive from smartphone displays and PC monitors, comes through the visual channels. However, in recent years, problems such as accidents caused by operating smart phones while walking or driving are becoming a major concern in Japan and worldwide. Another disadvantage of constantly having to keep your eyes on the device is that it becomes difficult to focus on other information. The benefit of information representation using the peripheral vision consists in the fact that it does not require the user to concentrate on it and does not affect the central visual field.

In addition, the human brain processes the information in the peripheral vision has been shown to be 800 times faster than the in central vision, according to the study of Win Wenger [18]. Summing up all the above, in this research I propose a simpler information representation system and some concepts and use-cases for its application.

3.1.1 Principle

Human's vision is considered to be around 180 degrees wide. And from this field, only about 30 degrees are called the central visual field, and only objects in this field can be distinguished by color or shape. I am focusing on the area outside the central visual field and developing Notify Me project using dynamic images, because moving objects are naturally easy to detect in the peripheral vision. (3.1) To use this feature of human vision in Notify Me, I mount a LED dot matrix with a number of LEDs in both vertical and horizontal axes, because I want to explore how well the human eye can perceive various and directions and kinds of "movement" animations.

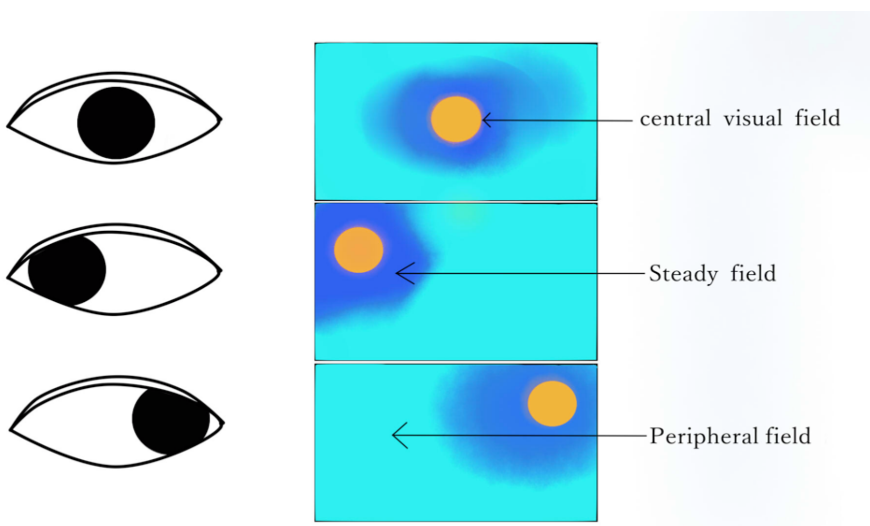

Figure 3.1: Human sight image

3.1.2 Principle of One Side Prototype

As mentioned above, one side prototype was developed for basic cognitive experiments. Cognitive methods present multiple patterns of lights moving in the user's peripheral vision. I tried to make the user able to obtain information without looking at the display. As a good form-factor example I took JINS MEME, which weights only 45 grams. I believe that similar size and form-factor would be suitable for my Notify Me prototype. So a comparable eyeglass rim was designed using with 3D CAD software, with additional space to house the LED matrix.

Figure 3.2: Notify Me: uses image

3.1.3 Principle of Dual Side Prototype

Dual Side Display Glasses are aimed to control or change human behavior to demonstrate another application scenario for peripheral vision displays. There are plenty of interesting application cases in virtual and augmented reality scenarios for technologies based on properties of human peripheral vision, from inducing the illusion of motion, over changing walking speeds/ walking trajectory to e client crowd control [5] [11]. Unfortunately, most research uses either stationary setups or relatively bulky experimental headsets (e.g. for Virtual Reality applications). Introduce application example. Okano's research [11] suggests that it is possible to enhance human sense of self-movement by changing the optical flow using low resolution LEDs. In second prototype, I made glasses with displays on both sides, to be able to affect and change the optical flow for both eyes. Although Okano's research focused on only enhancing the sense of self-motion, this device aims to control behavior with a simpler method Using by 128 * 64 OLEDs for more accurate control and multiple patterns. The Final goal of this project is higher level and simpler human behavior control. To make it possible to navigate unconsciously without using any navigation devices nor paying attention to navigational cues. Using my setup I can unobtrusively adjust the walking speed to the optimal or change the walking movements and direction.

Figure 3.3: Notify Me: uses image (walking)

Chapter 4

Implementation

4.1. One Side Prototype

One side prototype consists of a small Arduino NANO board embedded in a glasses and a small 8*8 dot matrix module (OSL641501 - ARA) on the left side of the glasses (see 4.1).

Figure 4.1: One Side Prototype

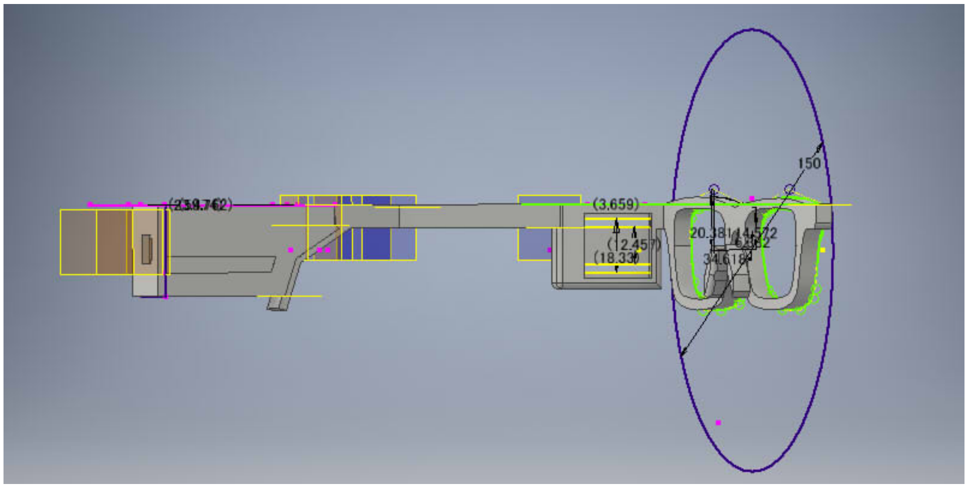

Figure 4.2: 3D design

The LED module is inclined by around 20 degrees an optimal position for the peripheral vision. The glasses design by 3DCAD software and printed by a 3D printer. In order to improve the wearability the frame made rubber and digital ABS at a ratio of 30:70. Also, due to weight reduction and durability, the thickness of the device housing part was limited to 0.8 cm at the maximum. Based on these, the weight of the frame is 42 g. My final goal is to implement a display around the frame of the glasses, yet for the beginning to explore I focus on the side. The main reason is that the peripheral vision region on the side of the eyes is larger and not occluded by eyebrows or cheeks.

4.1.1 Operation verification

The user does not need a specific operation after wearing, and the operation pattern of the LED is directly performed by the control of the microcomputer. In the 1st prototype, for the experiment, a pattern was transmitted from a PC connected by a third party with micro USB.

Figure 4.3: Wearing the 1st prototype

4.2. Dual Side Prototype

In Dual side prototype, I created the device for the purpose of transmitting information. Dual side prototype has developed a device for more advanced research. My goal is to unconsciously control people's behavior and I have created devices for both side displays as a more practical means for that. I focus on the part unconsciously in this device, and control the OLED with lower luminosity than LED by I2C (controller: SSD 1306 Z). The average cd / m 2 of OLED is about 150 on average, which is less than 250 cd / m 2 which is generally visible outside in the outdoors. These are very appropriate in that it presents motions only unconsciously and presents only motion.

The glasses redesign by 3DCAD software and printed by a 3d printer. The two OLEDs are controlled by Arduino Nano and the code goes inside to optimize for mounting. The OLED operates by connecting at 3.3 V. It is possible to operate with an independent battery because the register has already passed.

Figure 4.4: The 2nd prototype

4.2.1 Operation Verification

It is an experimental device for controlling user's behavior, and it can perform a single operation like the one side prototype. Since this prototype adopts OLED, there is no problem such as dazzling when LED is used. There was absolutely no opinion that it was dazzled when actually used by more than 10 users. Also, although it is limited to indoor, there was an opinion that most users can recognized of basic motions of up and down, left and right

Figure 4.5: Operation Verification

Chapter 5

Evaluation

In this chapter.I conducted an experiment using my device. Experiments divided into three parts. First of all, I investigated to ability of getting the information using peripheral vision. Next, I investigated whether are they possible to reproducible in other working situations. Then, as an application experiment, I conducted experiments that an influence of human behavior using the characteristics of peripheral vision.

5.1. Notification Experiment

5.1.1 Experiment Setup

My notification application case focuses on explicit output: signaling to the user. I want to answer the questions "Can a user recognize patterns displayed on my glasses?", "How many different patterns can a user recognize or differentiate?" and finally "Can the glasses be used to give the users information in an unobtrusive way while they are working or engaged in other tasks?". For these questions, I designed so far 2 notification experiments. The notification is using a 8 pattern animations. Pattern 1 and 2 are horizontal movements (left to right, right to left respectively). Pattern 3 and 4 are vertical (up to down, down to up). Pattern 5 is a "ripple" movement originating in the middle of the LED matrix (2x2 LEDs) towards the outside. Pattern 6 is a movement from both sides to the center. Pattern 7 is similar to Pattern 1, yet includes waves (not straight lines). Pattern

8 is a radial movement. light motion was shown 0.7 seconds, this is approximately double of the mean time an average human can recognize movement using his peripheral vision [15]. addressing part of the 2 different questions. I had the subjects tell me the patterns that they could see, and based on that information, I created a confusion matrix in order to examine light movements that are easily recognized by users. For this experimental setup I connected the glasses to a laptop to make coordination etc. easier. This is however not necessary. The system works stand alone.

Figure 5.1: Image of Notification Experiment

5.1.2 Experiment Procedure

I show 8 patterns(5.2) of light motion. I recruited 7 participants 6mans and 1 female. and the users reactions were observed.

1. Participant wearing notify me and sitting, face forward.
2. Explanation of the eight patterns to present. Show each pattern.
3. Patterns are randomly presented to Participant (10 times 8 patterns)
4. Participant answer the number of the pattern that they could see.

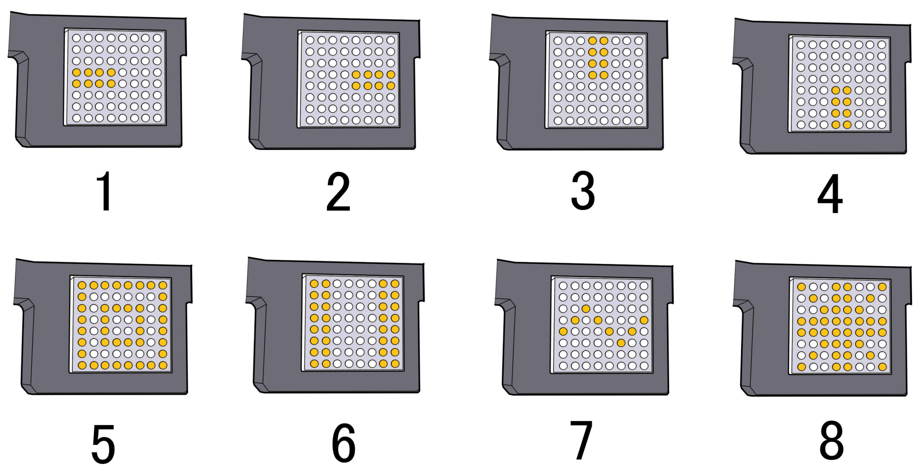

Figure 5.2: Giving Patterns

5.1.3 Result and Discussion

(5.3) summarizes the results of the notification experiments, downwards you see the number of patterns and towards the right are the stimuli the users reported. This shows the usefulness of my smart glasses. The vertical movements seem to perform best (pattern 3 and 4). One possible explanation is that most of my visual stimulation I receive from peripheral vision is horizontal. Therefore, vertical movements might be more noticeable as they dont occur so often in ordinary life. The Exploration Experiment showed that my glasses can present information to the users and gave some evidence about effective presentation patterns.

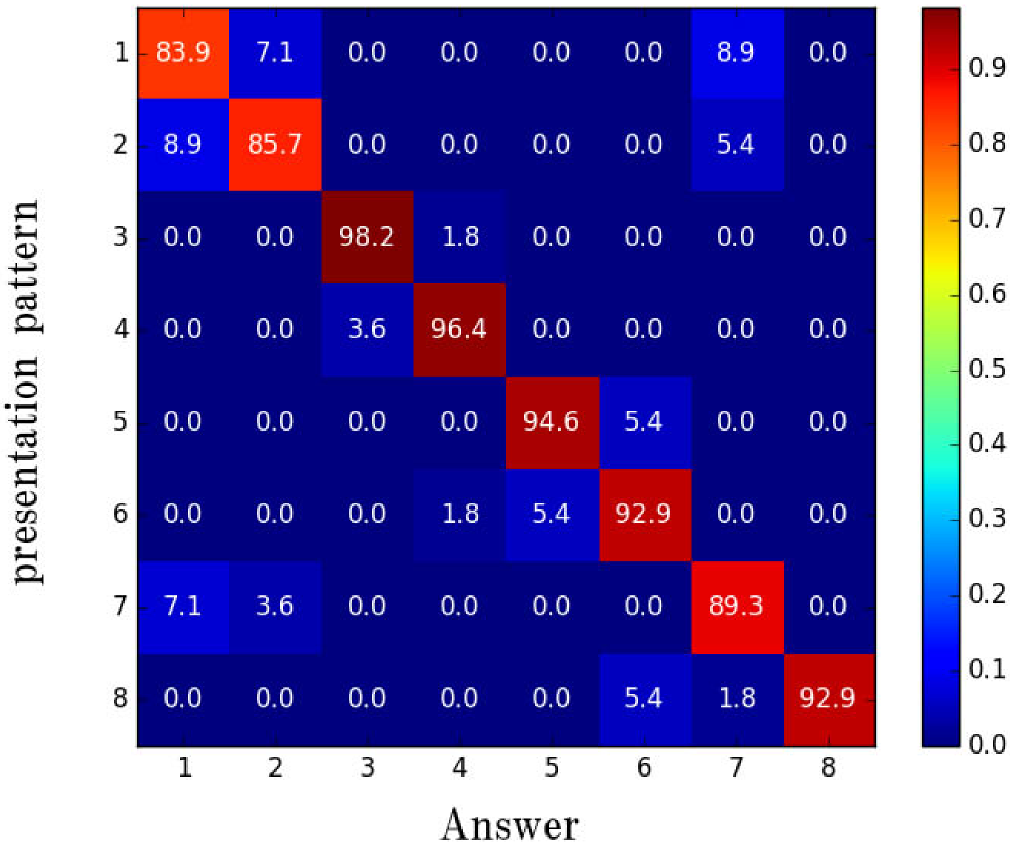

Figure 5.3: Result of Notification Experience

5.2. Distraction Experiment

5.2.1 Setup

For the distraction experimental setup I wondered if the information display will work also if the user is occupied by another task. I selected "watching a video" as task, the users watch a Youtube video[1] 1. From experiences from the notification experiment I limited the stimuli to patterns 1, 3, 4, 5 and 6. The rest of the experimental setup is the same as above: the same user participated and the same random occurrences of the patterns and animation duration.

Figure 5.4: Images of Distraction Experiment

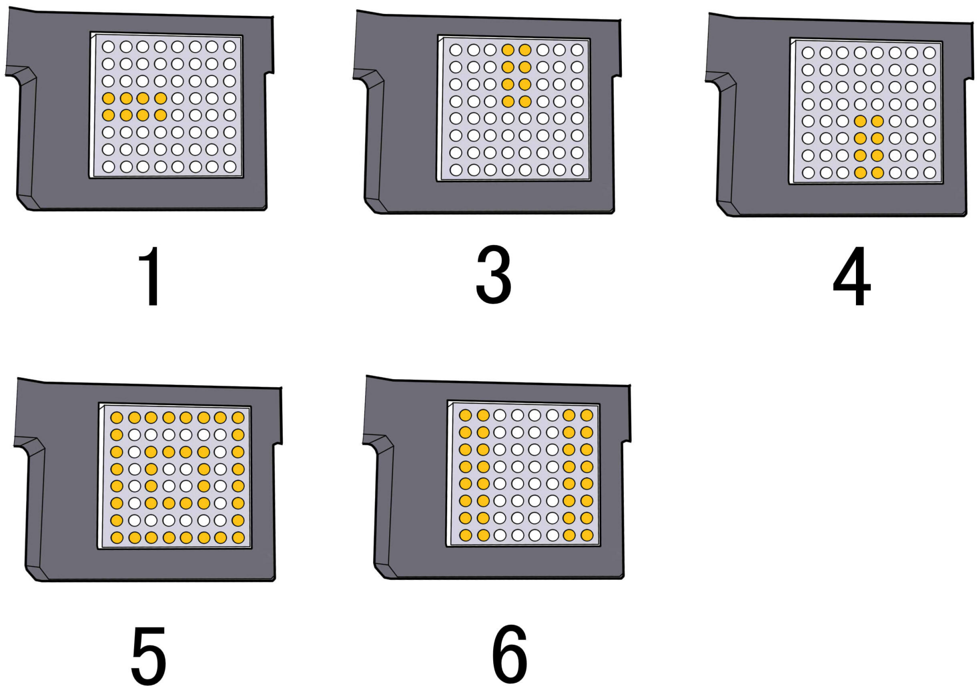

Figure 5.5: Images of Distraction Experiment

5.2.2 Distraction Experiment Procedure

I show 5 patterns(5.2) of light motion. Other conditions are same as notification experiment.

1. Participant seated with the device wearing and watched the youtube video on the front screen
2. Explanation of the eight patterns to present. Show each pattern.
3. Patterns are randomly presented to Participant (10 times 5 patterns)
4. Participant answer the number of the pattern that they could see.

5.2.3 Result

The Distraction Experiment demonstrate the presentation ability of the glasses in situations with a more dynamic stimulus. As for the notification experiment, the results are depicted in (5.6). The vertical axis shows the randomly presented movement of light, and the horizontal axis shows the answer of the subjects. There are slight confusions between up and down movements and the two full screen animations (5 and 6 ripple and moving to the middle).

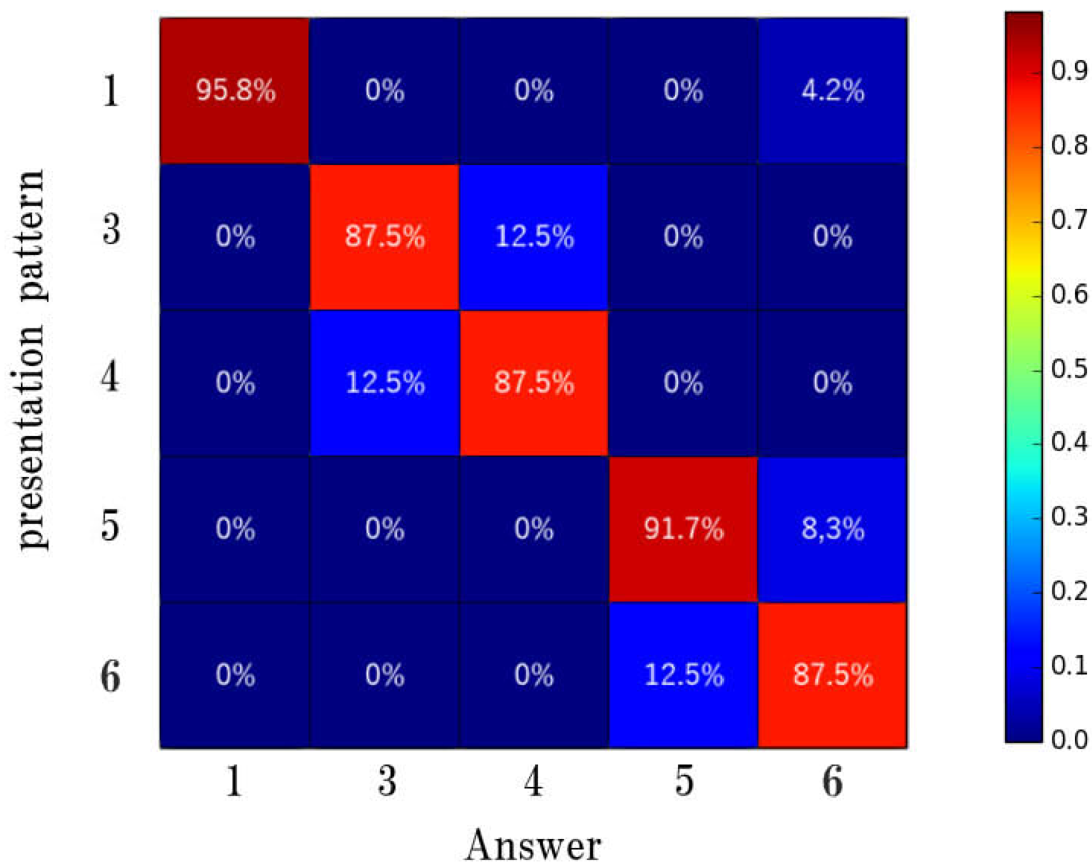

Figure 5.6: Result of Experience

5.3. Enhancing Human Motion Experience

5.3.1 Experiment Setup

From two experiments, I found that I can get the information using by peripheral vision. In the related research it is obvious that the influence of information on people is large. This mean, I can control human behavior with information of movement [17] [16]. In this experiment. I presented the optical flow to the user's visual field, and measured to change the speed accordingly. The users walk straight the same condition of 15 m distance with wearing Dual side prototype. At that time, users walk with a pattern that present optical flow and a pattern that not present. Presented light motion a flows from the top left to the bottom right. Experiments were repeated 5 times in each of the patterns, and each light movement was shown in the same seconds of other experiments. Power is supplied from the battery module, and a system is work alone. Experiments were conducted for seven males and female (male:6 female:1).

5.3.2 Experiment Procedure

Participants were 6 males and 1 female.

1. Participant stands with his toes on the start line.
2. Start walking at free speed according to the signal.
3. The optical flow presentation operates the power supply of the device according to the instruction. Then Start walking at free speed according to the signal.
4. Measure 5 times to record their time. Then calculate the average.

5.3.3 Result

(5.7) is a result of this experiment. As a result of total 70 measurements, 6 out of 7 users were able to confirm the decrease in walking speed. The average of the whole was 0.256 seconds, walking with no optical flow presented was faster. In many cases, Users did not feel any discomfort to information presentation to the peripheral vision. These results show that the downward optical flow may reduce the users walking speed.

	With Effect Average	Without Effect Average
Subject 1	11.524 sec	11.442 sec
Subject 2	11.704 sec	11.512 sec
Subject 3	12.064 sec	12.104 sec
Subject 4	11.540 sec	11.338 sec
Subject 5	11.322 sec	11.300 sec
Subject 6	12.124 sec	11.702 sec
Subject 7	12.064 sec	11.152 sec

Faster data

Figure 5.7: Result of Walking Experiment

5.4. Discussion

In Notification and distraction experiments, I used a one side of the information presentation as basic research. As a result I could get a 83.9% collect answer at least. The lowest numbers Optical flow from left to right that yielded was 8.9% as misunderstanding with wave type optical flow number:7. From these results, the possibility of miss recognition occurring with the probability of about 9% is shown in the movement of light with similar movement. As a solution to this problem, it can be thought that it can be solved by differentiating the stimulus with the change of luminous intensity done in the previous research. Then the highest figure was 98.2% from bottom to top. reason why, because I think vertical movements might be more noticeable as they dont occur so often in ordinary life. From the above results, It can be said that the effectiveness of Notify Me was confirmed.

Also, an interesting observation was made in walking experiments. When the walking experiments using dual side display presented downward optical flow, Decrease in speed was observed. The error confirmed at the present time is extremely small, and I believe it is desirable to verify at long distances and in various situations from now on. However, since it has been verified that human behavior control is possible from the previous research. Then I think this experiment data shows the possibility of controlling behavior with notify me. Moreover, in the experiment of the present stage, it was driving with a battery via USB. However, there are still many possibilities to miniaturize the device, such as the control portion being incorporated and introducing a lithium battery. By doing so, I can expect more complex information presentation via the network and application to exercise effect etc. accompanying behavior control.

Notes

1 `https://www.youtube.com/watch?v=vV5NEDfhy4Q`

Chapter 6

Conclusion

In 1st chapter, I discussed the previous works that I rely on, recent developments of smart eyewear devices and human visual characteristics. Among them, I noted the high importance of peripheral vision, how it can affect my consciousness and explained that there can be many applications scenarios that are using those properties of my perception. And as an example, I propose feasible practical application scenario that uses peripheral vision display.

In 2nd chapter I introduce examples of various eyewear devices for different application scenarios. And then I introduce several peripheral vision display designs which were prior to this research.

In 3rd chapter I mainly describe the main concept of this research, the process leading up to the development of my first prototypes, the principles and direction of the whole project. In many cases, a major issue with information representation, was the necessity to pay attention to devices presenting this information. As a solution, I describe information representation approach that does not require direct attention as it is using peripheral vision. In addition, I believe that using this approach it is possible to affect human behavior, then I give an application scenario, as an example.

In 4th chapter I describe the development of the prototypes. One side display is a smarter and simpler device that is designed to check whether the information presentation is possible without looking at the display directly. The Dual display glasses are a simpler eyewear device with OLED matrices on both sides of the glasses. I developed it to test and measure how I can affect the human motion and behavior. I created two prototypes for each use case, and I was able to create smart glasses, in form-factor of normal glasses.

In 5th chapter. I conducted three experiments in total. In the notification experiment, I found out that it was possible for the user to recognize the information by the movement of multiple lights on the screen built in the rim of the glasses worn by the user. I shown an initial design and a prototype for peripheral vision glasses using an 8*8 dot matrix. I provide evidence that information can be visible to users even if they are not focusing on the display. I gave an initial evaluation and recommendation for useful animation patterns. As an initial result, I have proven that my device can deliver information to the user without requiring to look at the screen. Next, in walking experiments, I tested the hypothesis that there is a possibility that walking speed may be affected by presentation of optical flow patterns in the peripheral vision.

Although the effectiveness of information presentation using the peripheral vision is, as I demonstrated, entirely possible, I can not claim 100% recognizability for arbitrary pair of patterns. From the results of the experiments, I can confirm that there are some mistakes for similar light movement patterns.

The information will have more influence for humans by development a lot of devices. In such society, it is required that the device function more correctly and have a meaningful influence on people. In this research, the method of information presentation and its influence were considered. Because the magnitude of the influence will change in a fluid manner with further development in the future, we can expect to improve the quality of life and behavior better than using it. Among them, it is expected that "Notify Me" will be used as one of the method and technology.

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