Developments of a peripheral vision system using immersive virtual environment

Y Tabata[1], M Suga[2], K Minato[3], O Oshiro[4], K Chihara[5] and S Nagata[6]

[1-5] Graduate School of Information Science, Nara Institute of Science and Technology,
8916-5 Takayama, Ikoma, Nara, 630-0101, Japan

[3-5] Nara Research Center Telecommunications Advancement Organization of Japan,
8916-19 Takayma, Ikoma, Nara, 630-0101, Japan

[6] Department of Medical Informatics and Biomedical Engineering, Shiga University of Medical Science,
Seta Tsukinowa-cho, Otsu City, 520-2192, Shiga, Japan

[1-5]*{yoshi-t, suga kotaro, oshiro, chihara}@is.aist-nara.ac.jp*, [6]*nagata@belle.shiga-med.ac.jp*

[1-3]*http://kotaro.aist-nara.ac.jp/index.html*, [4,5]*http://chihara.aist-nara.ac.jp/index.html,*
[6]*http://www.shiga-med.ac.jp/~hqkikaku/SUMSGUIDE-e.html*

ABSTRACT

Peripheral vision is one of the important vision that human eye has. To measure the peripheral vision is necessary because there is disease process that can affect the peripheral vision such glaucoma. However, the infant or the aged cannot have a peripheral test. They cannot utilize the conventional perimeter system. The authors proposed a newly perimeter system by utilizing Immersive display. This proposed system enables them to have a peripheral test easily.

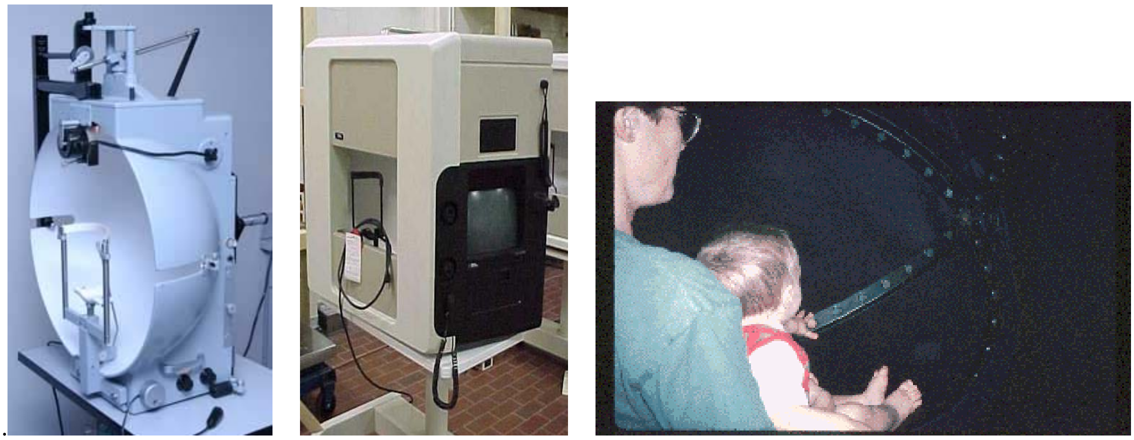
1. INTRODUCTION

Peripheral vision is one of the important visions that the human eye has. Peripheral vision is located in a retina that contains rod cells. The peripheral retina is sensitive to relatively low light and to movement. The primary job of peripheral vision is to make human aware of the location of objects in the visual space and to direct central vision toward a particular object. To measure the function of the peripheral vision is necessary, because the disease process exists that can affect vision field such as glaucoma. As a means of measuring the vision field, eye doctor utilizes a perimeter system, which is an instrument to measure the peripheral vision.

The perimeter systems have been developed (H.Goldman 1945; Zeiss; V Dobson et al 1998) and are divided into two types. One is the perimeter system based on kinetic perimetry such as Goldman Perimeter (Fig.1 (a)). The other is the perimeter system based on static perimetry (Fig.1 (b)). The kinetic perimetry based system is to see if a patient looks at the moving target that appeared in front of the patient with the patient looking toward a centered fixation point. The static perimetry based system is to see if a patient looks at the static target that projected on a screen.

However, these conventional perimeter systems cannot automatically judge whether the patient looks at the targets. When the patient saw the targets, the patient makes the eye specialist know what he/she saw by pushing a button. Thus, the diagnosis result depends on the patient. In addition, as the patient has been made to fix his/her chin on a board in a peripheral test, the patient is much tired. These problems have caused an infant or the aged not to have the peripheral test. In order to overcome the problem, a perimeter system for infant was developed (Fig.1 (c)). However, it is reported that this system couldn't give the doctors information enough to diagnose the disease of visual field. Therefore, the infant and the aged do not have any means to test the vision field. This is critical problem in the ophthalmology.

To overcome the problem, the authors proposed a newly perimeter system by utilizing an Immersive display. In this proposed system, the user does not need to fix his/her chins while doing the peripheral test. This proposed system is an instrument to judge automatically whether the user looks at the targets that appeared on the screen by processing the obtained images from a camera. This system enables the patient to have a test easily with the patient sit.



(a) (b) (c)

Figure 1. *Perimeter systems (a): Goldman Perimeter, (b): Static Perimeter, (c): a perimeter for infant.*

2. PROPOSED PERIMETER SYSTEM

2.1 Conceptual design

Fig.2 shows the block diagram of the proposed system. The proposed system consists of five computers, one camera and an immersive display. One computer captures user's face images from the camera that is put in front of the user. The others render the targets and the images of a centered fixation point constantly. The rendering images are projected on the four screens of the immersive display. The immersive display is CAVE-like system, which has four-faced screen: sides, face and bottom. The procedure in this system is as follows.

0 An operator determines the configuration concerning a perimeter test condition.

1. A server computer sends the configuration data to four client computers. The configuration data contains the colour of target and background, a timing to appear the target and vanish it, and so on.
2. Four client computers render the targets under the obtained configuration. One of client computers also renders the scene of the centred fixation point in a same time.
3. When clients finish rendering the targets and scene, they send a signal to the server.
4. When the server receives the signal from all clients, the server makes the operator know that the system was ready.
5. When the operator pushes the "start" button, the server calculates the positions and orders to render targets.
6. Finishing calculating them, the server sends a signal to clients.
7. One client received the signal renders the scene of fixation point. The others render nothing.
8. Some minutes later, the server sends the target's position to clients at intervals of the defined time. The server captures images from the camera and begins to detect the direction of user's eye in the same time.
9. When clients receive the data from the server, they render the targets in a fixed time.
10. When the fixed time passes, all clients send a signal to the server.
11. When the server receives the signal from all clients, the server stops capturing images and finishes detecting the eye direction. The server also sends the new target's position to clients.
12. Go to 9. The process from 9 to 11 runs for the fixed times.
13. When the process finishes for the fixed times, the peripheral test is finish and the test result is outputted.

Proc. 4th Intl Conf. Disability, Virtual Reality & Assoc. Tech., Veszprém, Hungary, 2002

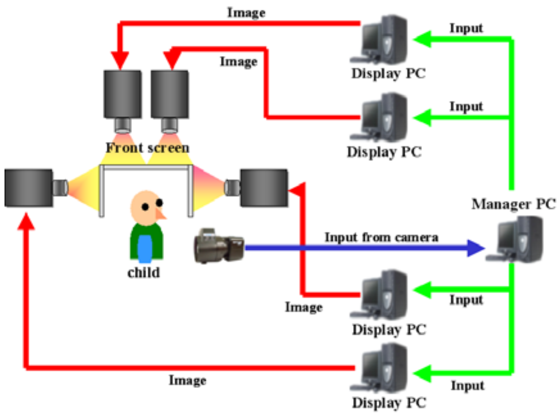


Figure 2. *Block diagram of proposed system.*

2.2 Eyes detection

One of the features in the system is to judge whether the user reacts against the target. The proposed system runs the following process and judges that. First, in the proposed system, the server computer detects the eye's direction and the head movement of the users. Second, the sever computer compares the direction of user's eye with the position of a target and judge whether these directions are the same direction.

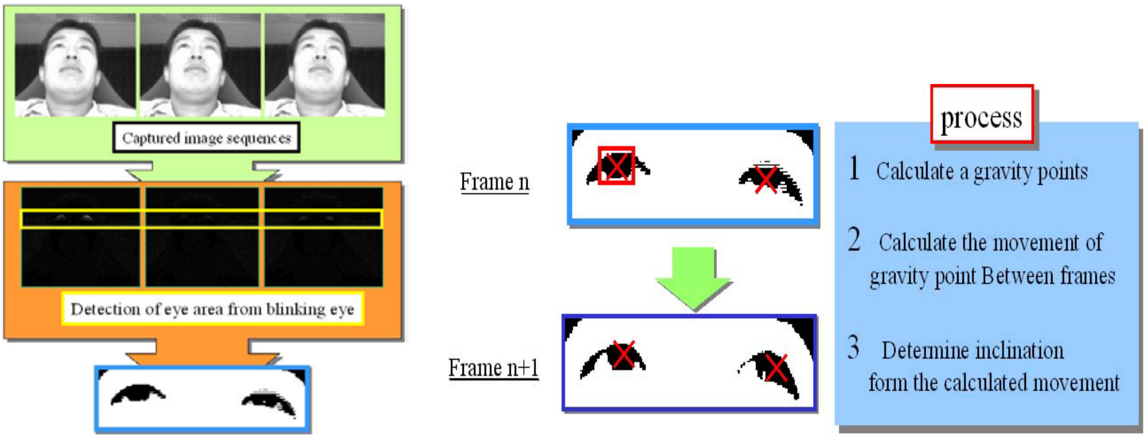
This explains about the eye detection procedure. The server computer ("Managed PC") captures user's face images from a CCD camera. The captured image is monochrome images. The camera is situated on the front poison of the user in order to shoot the face area (Fig.3).

Managed PC detects a blinking eye of the user utilizing the inter-frame differential method from the obtained images. The eye area is defined the area covered with the area moved by blinking and the edge area of the user's face Managed PC extracts the image in the eye area and makes the binary images from the extracted image by utilizing the threshold process (Fig.4 (a)).

Managed PC puts the label on the black parts concerning the pupil of the eye. Managed PC calculates gravity points in the black area from the binary image of eye area. It calculates the gravity points of black area every frame. Managed PC calculates the movement of the gravity points between the gravity point of a frame (n) and one of a frame (n+1). After calculating the movement, it calculates the inclination of user's eye in some frames by utilizing the movement. The direction of user's eye is calculated from the inclination (Fig.4 (b)). As the base point of the gravity point in first frame, Managed PC calculates the inclination of angle and determines the eye's direction from the inclination of angle.

Managed PC compares the eye direction with the target poison. If the target appeared in the eye direction, it judges that the user reacted correctly. If not so, Managed PC judges that the user did not react.

Figure 3. *Camera position.*



(a) (b)

Figure 4. *Eye detection process (a) extraction of eye area, (b) detection of eye detection.*

2.3 Operation of the proposed perimeter system

When the eye specialist makes use of the proposed system and tries a peripheral test, they does the peripheral test by using Graphical User Interface (GUI) of this system (Fig.5). This GUI enables the eye specialist to set up the condition needed in the peripheral test. The setting items are as follows: the patient's sex and age, target's color, background color, interval till the target appears, vanishes and appears again and so on. The right area in this GUI determines the area that the targets appear by controlling the mouse. The left one determines the detail information such as the stated items. The reason that this GUI has the item to set the color is that the eye specialist tries the perimeter test, which is used the information of color difference.

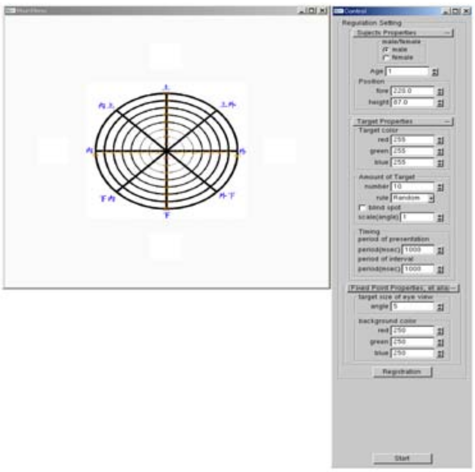


Figure 5. *GUI to control the proposed system.*

3. EXPERIMENTS

3.1Experimental purpose

As mentioned above, this research aims to develop the newly perimeter system, because the conventional perimeter system cannot measure the visual field of the infant or the aged. To overcome the problem, the authors propose the perimeter system, which can measure the visual field of the infant and does not make the infant feel tired. If the proposed concept has advantage in a peripheral test of the infant, the peripheral vision of the infant can be measured by the proposed system. Therefore, the authors developed the prototype perimeter system and experimented about the effectiveness of the prototype perimeter system. In addition, an eye specialist evaluates the prototype perimeter system.

3.2 Prototyping

Table 1 shows the main spec of the prototype perimeter system and Fig.6 shows the snapshot of the proposed perimeter system.

Table 1. *Main spec of the prototype perimeter system.*

server computer	Dell PC OS: WinNT CPU:Pentium4 1.8GHz, Memory: 1.0GB, Graphics card: Geforce3 Ti500
client computer	Dell PC OS: Win2k CPU:Pentium4 1.8GHz, Memory: 512MB, Graphics card: Geforce3 Ti500
camera	CCD camera :WAT-100N (produced by watec co. ltd) Minimum object illminance : 0.001 lux
network	Protocol: TCP/IP, 100Mbps connection
capture board	IP5005 image processing Board (produced by Hitachi)

The prototype utilizes the CCD camera that can use as the astronomical observation. During the peripheral test, it is so dark in the prototype that it's impossible to shoot the subject's face image by a normal CCD camera. As the capture board, the prototype uses the special board "IP5005", which is the instrument capable of image-process on the board, because the prototype needs to process the captured images in real time in order to detect the subject's eye direction.

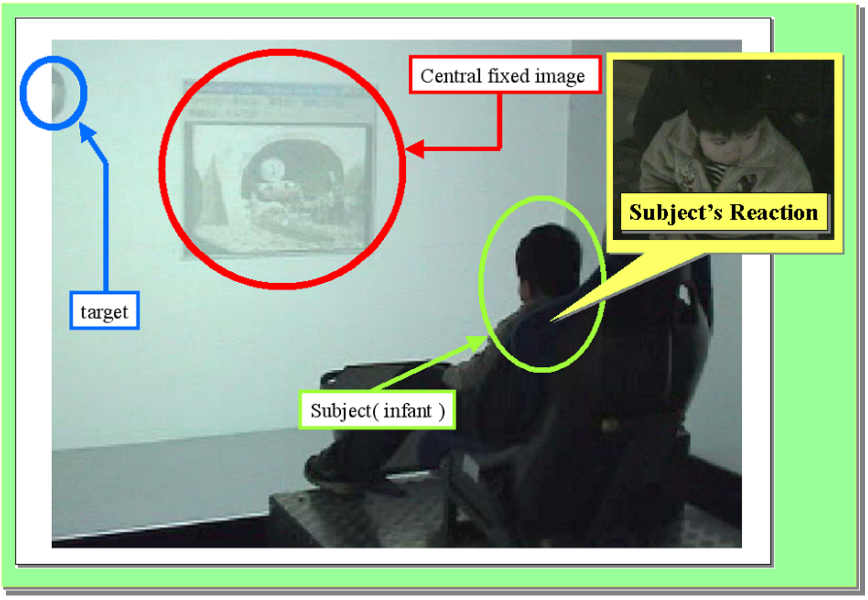


Figure 6. *Snapshot of the prototype perimeter system.*

3.3 Experimental procedure

To have the subject look toward the center fixation point, the proposed perimeter system displays the images that the infant has interested in (Fig.6). After one minute, the proposed system displays the targets every 9 minutes. The targets are displayed on the positions instructed by the eye doctor (Fig.7).

The total number of displayed targets is 23. Target color is white and background color is black in order to enhance contrast between a target and background. The authors made the experiments under these conditions. The subjects are tested three times under the same condition by the proposed perimeter system. The subjects are two infants. One is a boy whose age is 2 years old. The other is a girl whose age is 4 years old.

4. EXPERIMENTAL RESULTS AND DISCUSSION

Fig.7 shows the result of peripheral test against a boy. Circle area in Fig.7 shows the poison of displayed target. The circle area of white color means that the subject looked at the target in all peripheral tests and one of black color means that the subject did not look at the target. Gray color means that he could look at it in one or two times.

This experimental result states that the proposed perimeter system has a possibility that utilizing the proposed system tests the infant's peripheral vision. The reasons are two, which the proposed system has the possibility. One is to be able to make the result chart of a peripheral test from this experiment. It is difficult to make the chart by utilizing the conventional perimeter system. The other is the result that the subject wasn't tired of this perimeter till the test is finished. In this experiment, the subjects sit on the knee of their father. Thus, the condition may make the subject feel relieved and it seems that the subjects are absorbed in the situation of peripheral test. However, the proposed system measured the infant vision filed by using such a condition. Therefore, it seems that the proposed system is the effective system as to a peripheral test for infant.

Also, the eye doctor utilizes this prototype and is evaluated about it. The eye doctor reported that it would be possible to test a child's peripheral vision by the proposed system.

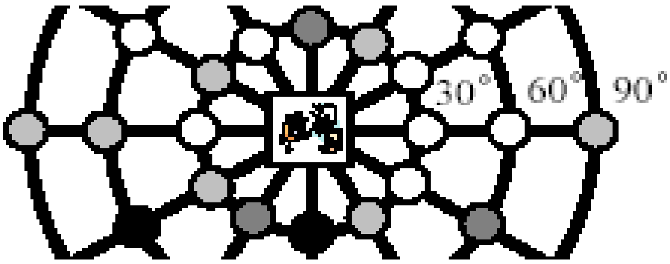


Figure 7. *Peripheral test result of a subject.*

5. CONCLUSIONS

This paper proposed the newly perimeter system by utilizing an immersive display. The proposed system displayed the scene of the center fixation point and targets. The scene utilized the images where the subject is interested to have the subject look toward center fixation point. The proposed system could judge whether the subject notices the target by making use of image processing. The prototype system was experimented and the result proved the effectiveness of the prototype system.

Acknowledgements: This research is partly supported by Telecommunication Advancement Organization and International Communication Foundation.

6. REFERENCES

H.Goldman (1945), An automatically registering Spherical Projection Perimeter, *Ophthalmologica,* **109**,*2-3*.

Zeiss Humphrey systems, http://www.humphrey.com/Company/company.html.

V Dobson, AM Brown, EM Harvey, DB Narter(1998), Visual field extent in children 3.5 to 30 months of age tested with a double-arc LED perimeter, *Vision Res,* **38**,*pp.2743-2760*