Basic Study of Mammographic Image Magnification System with Eye-Detector and Simple EEG Scanner

A. Umemuro, M. Sato, M. Narita, S. Hori, S. Sakurai, T. Nakayama, A. Nakazawa, T. Ogura

***Abstract*—**Mammography requires the detection of very small calcifications, and physicians search for microcalcifications by magnifying the images as they read them. The mouse is necessary to zoom in on the images, but this can be tiring and distracting when many images are read in a single day. Therefore, an image magnification system combining an eye-detector and a simple electroencephalograph (EEG) scanner was devised, and its operability was evaluated. Two experiments were conducted in this study: the measurement of eye-detection error using an eye-detector and the measurement of the time required for image magnification using a simple EEG scanner. Eye-detector validation showed that the mean distance of eye-detection error ranged from 0.64 cm to 2.17 cm, with an overall mean of 1.24 ± 0.81 cm for the observers. The results showed that the eye detection error was small enough for the magnified area of the mammographic image. The average time required for point magnification in the verification of the simple EEG scanner ranged from 5.85 to 16.73 seconds, and individual differences were observed. The reason for this may be that the size of the simple EEG scanner used was not adjustable, so it did not fit well for some subjects. The use of a simple EEG scanner with size adjustment would solve this problem. Therefore, the image magnification system using the eye-detector and the simple EEG scanner is useful.

***Keywords*—**EEG scanner, eye-detector, mammography, observers.

I. Introduction

MAMMOGRAPHY is used for early detection of breast cancer. Early detection of breast cancer increases survival rates, but calcifications that are too small are difficult to detect [1]-[3]. For this reason, high-resolution, high-intensity monitors are used for reading mammograms to make it easier to detect microcalcifications. Because the images must be viewed in such detail, reading mammograms requires a high level of concentration. Physicians read mammograms by zooming in on the images and looking for microcalcifications (Fig. 1). When reading a large number of images, mouse operation fatigue accumulates and concentration is reduced. Decreased concentration is a potential cause of decreased ability to detect microcalcifications. To solve this problem, we devised an image magnification system using an eye-detector and a simple EEG scanner, and evaluated whether this system could be used.

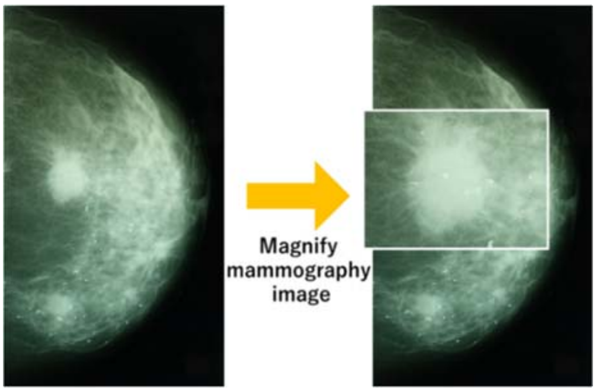

Fig. 1 Magnify mammography image

II. Methods

In previous research, we have used EEG scanner to create devices that can give various instructions by converting EEG signals into commands [4], [5]. However, the EEG scanner did not allow the observer to freely select the area of interest to be magnified. Therefore, we devised a system in which an eye-detector and an EEG scanner can be combined to magnify the region of interest centered on the gazing point when the observer is concentrating on the subject. In this study, we examine the usability of the eye-detector and the simple EEG scanner used in the developed system. The following are the details of the verification.

A. Eye Detection Error Verification between the Gazing Position Detected by Eye-detector and the Actual Gazing Position

Fig. 2 Image of the eye-detector (Tobii PCEey Mini (Tobii Ltd., Danderyd, Stockholm, Sweden))

An eye-detector was placed at the bottom of the PC monitor to detect the gaze position in real time at a sampling rate of 60

A. U. is in the Department of Radiological Technology, School of Radiological Technology, Gunma Prefectural College of Health Science, Gunma, Japan (corresponding author, phone: 090-9800-7715; e-mail: r192004@gchs.ac.jp).
M. S. is Assistant professor with Department of Radiological Technology, School of Health Sciences, Niigata University, Niigata, Japan (mitu-sato@clg.niigata-u.ac.jp)
M. N. and T. O. graduated School of Radiological Technology, Department of Radiological Technology, Gunma Prefectural College of Health Science, Gunma, Japan (e-mail: mr215103@gchs.ac.jp, togura@gchs.ac.jp).
S. H., S. S., T. N., and A. N. are in the Department of Radiological Technology, School of Radiological Technology, Gunma Prefectural College of Health Science, Gunma, Japan (e-mail: r192027@gchs.ac.jp, r192013@gchs.ac.jp, r202023@gchs.ac.jp, r202023@gchs.ac.jp).

Hz. Fig. 2 shows the eye-detectors used in this verification [6]. Fig. 3 shows a photograph of this eye-detector installed.

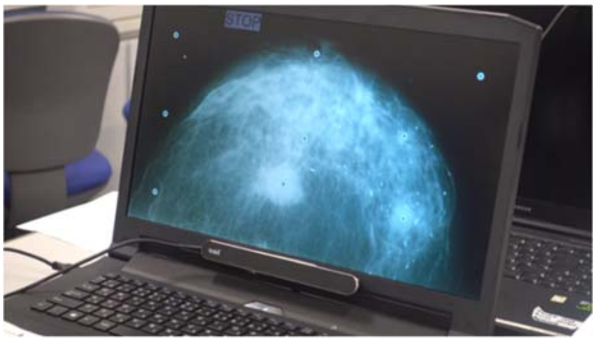

Fig. 3 Installation of an eye-detector

The device is compact and lightweight, with a width of 170 mm, height of 18 mm, thickness of 13 mm, and weight of 59 g, making it easy to set up. The computer (Windows 10, Intel (R) Core (TM) i7-6700HQ CPU, NDIVA GeForce GTX 960M) and eye-detector can be connected by USB. The recommended usable distance is 45 cm to 85 cm from the eye-detector and the recommended screen size is 19 inches. The screen size was 17 inches, which is within the recommended size for this eye-detector. The eye-detector is equipped with an infrared camera and infrared LEDs. Fig. 4 shows the summary of tracking gaze points.

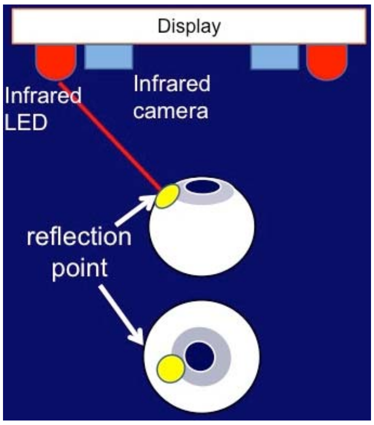

Fig. 4 Summary of tracking gaze points

Calibration is required when using this eye-detector. Calibration is performed by gazing at a point displayed on the screen. The eye center is calibrated by detecting the position of the pupil center point and the point where the infrared light emitted from the infrared LEDs reflects off the cornea. The eye-detector detects the position of the gazing point from the corneal reflection point and the pupil center point based on the calibrated eye center. In the experiment, calibration was performed first, and then the participants gazed at each of the nine points in the mammographic image displayed on the monitor one by one (Fig. 5).

The coordinates of the mouse cursor when gazing at a point (the gazing position detected by the eye-detector) were recorded and the eye detection error with the actual gazing position was calculated. The experiment was performed five times per point. The nine points in the mammogram image are circled in light blue to make the black dots easier to see. The observer was told to gaze at the black point in the center of the image during the experiment.

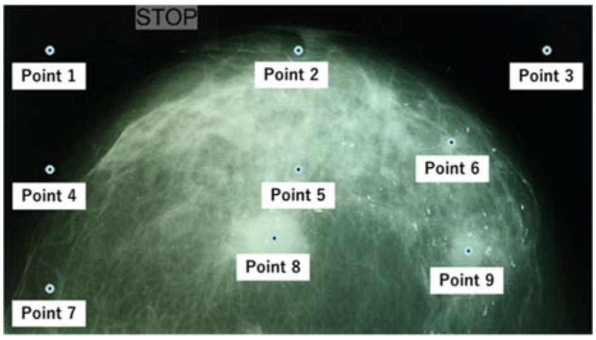

Fig. 5 Mammographic images used in the experiment A

B. Verification of Image Magnification Time with a Simple EEG

Our brain is composed of neurons. When the brain is active (speaking, listening, moving, etc.), information is transmitted between neurons, and the electrical signals generated at this time are measured by an EEG scanner. Fig. 6 shows the simple EEG scanner used in this verification [7].

Fig. 6 Image of the simple EEG scanner (Mindwave MOBILE (Neurosky Ltd., CA, US))

The simple EEG scanner was able to transmit data by Bluetooth connection to a computer, with a sampling rate of 512 Hz. In this simple EEG scanner, electrodes are attached to the forehead and earlobes, and the electrical signals near the frontal lobe are detected by setting the potential of the electrode attached to the earlobe to relatively zero. The experiment was performed using a system in which the cursor on the screen expanded when the subject, wearing a simple EEG scanner, concentrated. Whether the subject was concentrating or not was determined by using an index of concentration called "Attention". This index is provided by NeuroSky Co., Ltd. which is the manufacturer of the simple EEG scanner, and can express the degree of concentration as a numerical value in the range of 0 to 100 every 1 second. In this experiment, the subject was judged to be in a state of concentration when "Attention" was 65 or higher. Fig. 9 shows the mammography image displayed on the monitor. Subjects were asked to magnify each of the 12 points in this mammographic image one by one. The time taken to magnify after cueing a subject in a relaxed state was measured five times per point.

Fig. 7 Fitting of the simple EEG scanner

III. Results

The results of the eye-detector validation are shown in Fig. 10. 37 subjects were tested in this experiment. The mean distance of eye-detection error ranged from 0.64 cm to 2.17 cm. The mean eye-detection error for all observers was 1.24 ± 0.81 cm.

The results of the validation of the simple EEG scanner are shown in Fig. 11. 20 subjects were tested in this experiment. The average time for point magnification ranged from 5.85 to 16.73 seconds. The average response time for all observers was 9.72 ± 2.37 seconds.

Fig. 8 A demonstration of the time it takes to magnify an image using a simple EEG scanner

Fig. 9 Mammographic images used in the experiment B

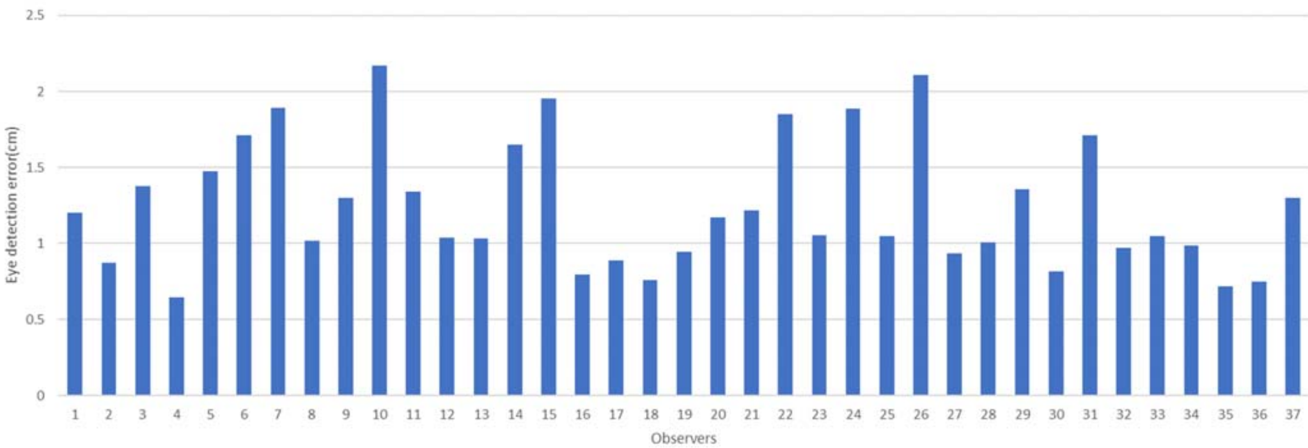

Fig. 10 Results for average distance of eye detection error per observer

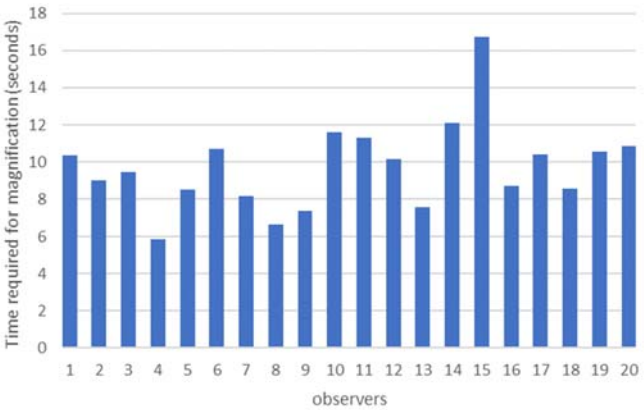

Fig. 11 Results of the average time taken to enlarge the image using a simple EEG scanner for each observer

IV. Discussion

Verification of the eye-detector showed an average eye-detection error of 1.24 ± 0.81 cm, which is small relative to the image magnification area and therefore unlikely to lead to false operation.

Verification of the simple EEG scanner showed that the average time required for point expansion ranged from 5.85 to 16.73 seconds, indicating individual differences. One reason for this may be that the simple EEG scanner used did not allow for size adjustment, so it did not fit well for some subjects. If it did not fit well, it is possible that the electrodes did not adhere to the forehead and sufficient signal could not be obtained. The use of a simple EEG scanner that can be adjusted in size may solve this problem. In addition, the fit of the simple EEG scanner is important to avoid stress when the subject continues to use it for a long time.

It is possible that the operation with the eye-detector and simple EEG scanner used in this study can be improved with more practice by the observer. Future work will focus on changes in the accuracy of the operation due to observer habituation.

V. Conclusion

It was demonstrated that the eye-detector can detect the position of gazing and the EEG can magnify the region of interest. Finally, we conclude that it is possible that eye-detection and EEG scanner can be utilized for image magnification system.

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