MVA '96 IAPR Workshop on Machine Vision Applications, November. 12-14, 1996, Tokyo, Japan

A wide-view VR system with multi-level description and rendering of 3D scenes

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Abstract - It is known that a wide-view of an image increases a true sense of reality in VR. The amount of the displaying data, however, becomes enormous, and displaying speed will become much slower. In order to solve these problems, we have focused on the characteristic of human vision, of which the resolution falls from the center to the periphery. If we emulate such a VR system using non-uniform 3D scene description and rendering, it will be necessary to detect subject's eye movements in order to display the high resolution image always to his/her central vision. In this study, we propose eye tracking system using EOG (Electro-OculoGram) for that purpose, and explain how it works in an actuator control system. Then, we show a rudimental result of EEG (Electro-EncephaloGram) during eye movements, which would be a useful tool to predict eye movements.

I. INTRODUCTION

Some statistics show that our humans gain more than 90% of all external information through a visual system. This is the reason why most researchers pay attention to visual VR. Although many products are developed, a true sense of reality has remained at the low level [1,2,3].

It is known that a wide-view of an image is effective to increase a true sense of reality [Kishino, et. al., 1985]. The data size of such images, however, becomes tremendously large. This causes slow data-transferring and time-consuming drawing in computer graphics. Although some hardware (i.e. graphic accelerators) or software (i.e. level-of-detail processing) is developed to increase the speed, the present VR systems do not satisfy people's need.

Here, an interesting characteristic can be found in a human visual system [4,5]. Only the small central area of human vision has the highest acuity, and no detail visual information can be obtained from the peripheral vision. If the high resolution image is displayed at the central area only, the data size will get smaller. Moreover, the displaying speed will be increased without decreasing a true sense of reality. Based on such a basic idea, we are planning to construct a following VR system (Fig.1).

In this system, 3D data of the scene is obtained in several levels of the spatial resolution and the color resolution from camera-taken or computationally-generated 2D images. (We call this process as "description phase".) Before displaying an image, the region which a subject looks at is rendered with the high resolution data, and the rest with the lower. (i.e. rendering phase.) This rendering method could be effective to display an image in a wide-view VR. Such a computationally rendered image is displayed with a liquid crystal projector onto a lenticular screen (2 to 3 m of its diameter) through a fish-eye lens.

The subject's eye movements, however, must be detected in order to display the detail image to his/her central vision. Otherwise, the subject will see the low resolution image and

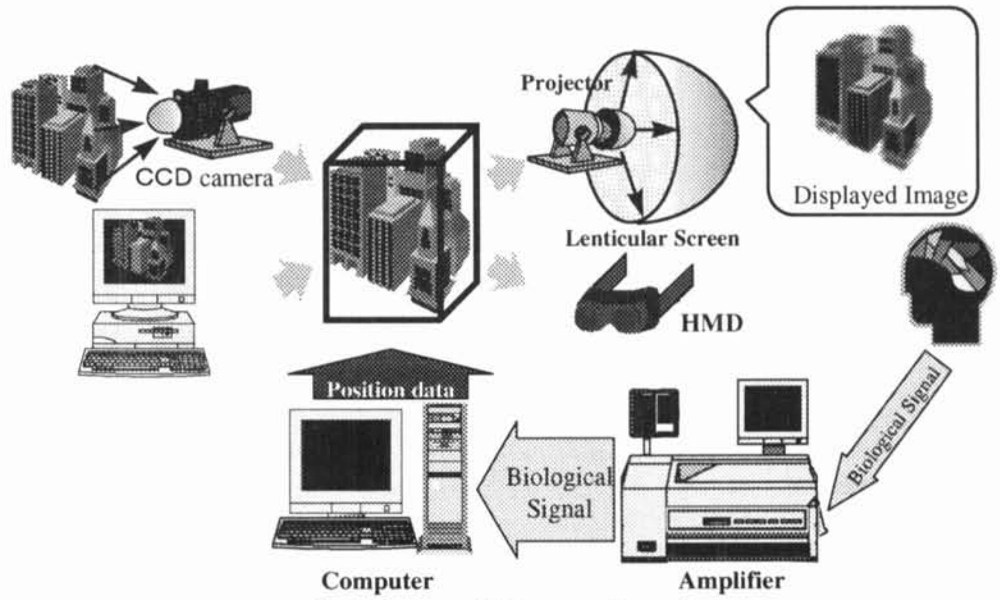


Fig.1 Proposed VR system (image).

this will cause to decrease a true sense of reality. Among a number of procedures to measure eye movements, we use EOG (Electro-OculoGram), which is widely used in eye movement studies. In the following section, we will show the experimental setting and the method using EOG. Then, we evaluate how EOG method works in the system. In addition, we tested EEG (Electro-EncephaloGram) for our future application, which is the attempt to predict eye movements. Finally, we discuss the feasibility of our method and future work [6,7,8].

II. EXPERIMENTAL SETTING

Fig.2 shows an experimental setting. Biological signals (EOG or EEG) are measured and amplified by an electroencephalograph (EEG-5532,NIHON KODEN). Next, the signal is sent to a personal computer (Gateway2000 P5-120,Gateway) thorough an AD converter (IBX-3507, Interface). In the computer, the signal is converted to the angle of an eye movement. Then, the angle data is sent to a motor controller (IBX-7204,Interface) . Finally, the controller generates pulses to manipulate an actuator.

A. Control experiment with EOG

In the first experiment, we tried to control an actuator with EOG. We tested 8 adult human subjects who have no eye movement disorders. Each subject was instructed to move his/her eyes toward 30 degree right or left several times. Then, EOG was measured during the eye movements. Fig.3 is a typical example of the result. Fig.3a shows movements of a human subject's eye and the ones of the actuator. Fig.3b~d is the diagram of a given instruction, EOG, and an actuator movement respectively. It is obvious that the actuator actually followed the eye movements. The movement of the actuator was slightly influenced by blinking, which is shown as small spiky waves on a EOG diagram. Although it is not clear from the diagram, the time delay (about 500 msec) exists between EOG and the actuator movement.

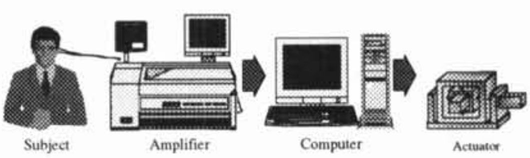
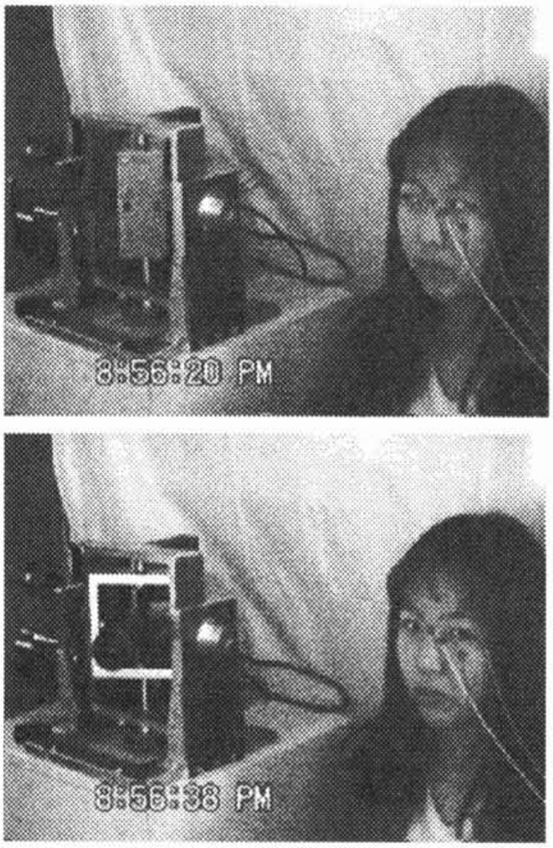
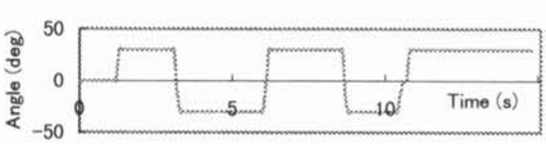


Fig.2 Experimental setting.

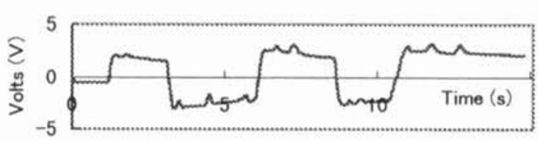
a



b



c



d

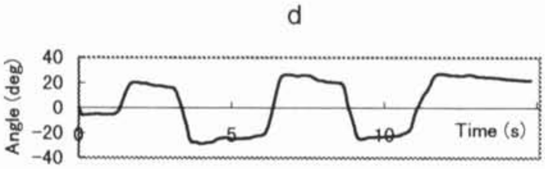


Fig.3 EOG experimental result
a: The movement of a human subject and the actuator, b: Instruction, c: EOG, d: Actuator

B. Experiment with EEG

In the second experiment, we measured EEG during eye movements. Because EEG is the signal of the diverse neural activity in the brain, it might be possible to detect a precursor signal for eye movements, which could be useful to compensate EOG control. At this moment, we only show the experimental procedure and its result in this section.

The experiment was performed in a soundproof darkroom, where a small light (LED) was set at the right-front and left-front of a human subject. The subject was instructed to look at either of a turned light, while his/her EEG was measured. Fig.4 is a diagram of EEG with 2D topography mapping during an eye movement. The frontal lobe seems to become active before an eye movement. We speculate that this could be caused by the activity of the frontal lobe for the preparation of eye muscle movement. Fig.5a shows a trigger signal of the light, EOG, and EEG at a frontal head after 50 time ensemble averaging. It is, however, ambiguous that the brain activity for the preparation actually occurs. Therefore, the EEG data was transformed with a wavelet function. Fig.5b shows a typical example of the result for farther analysis. It is obvious that there is some specific activity at a high frequency part, prior to an eye movement. Although we believe this is caused by the precursor of the brain activity for an eye movement, it must be studied more in future.

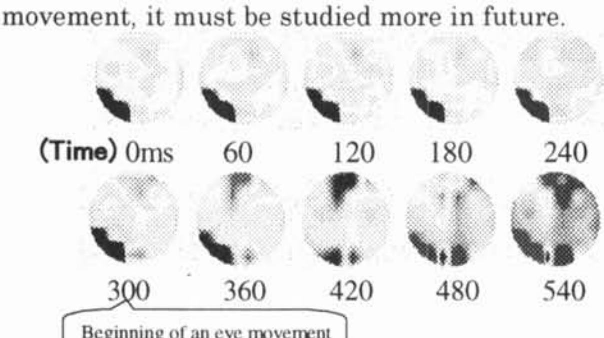


Fig.4 2D topography mapping of EEG during eye movements.

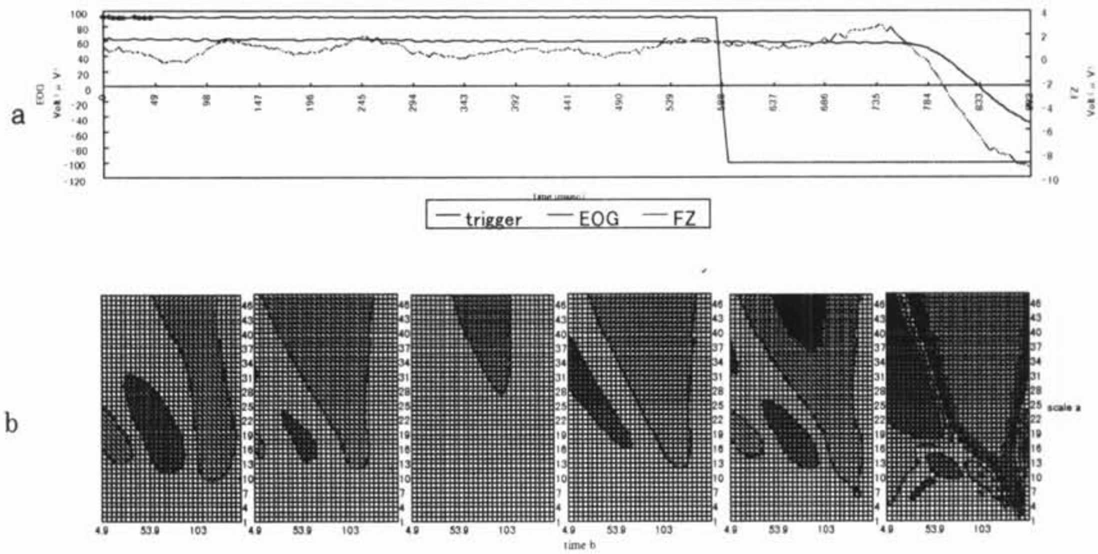


Fig.5 The activity at a frontal area.
a: Trigger, EOG, FZ b Continuous wavelet transform.

III. CONCLUTION AND FUTURE WORK

In this paper, we proposed a wide-view VR system, and introduced the basic idea of multi-level description and rendering. Because this system requires the eye direction, we examined EOG method for the purpose. Moreover, we evaluated EEG during eye movements for the future study. According to the experimental result, we could reveal the feasibility of EOG method. Moving average process is, however, the main cause of time delay. In our future study, we will test linear filters to improve the system's quality. In the case of EEG, it is far behind to apply EEG towards certain applications. We must analyze the characteristics of EEG, and evaluate our present result in future.

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