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# A Smart Video Magnifier Controlled by the Visibility Signal of a Low Vision User

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*Abstract*—**A smart video magnifier for the people with visual disabilities is now being developed to assist their stress-free reading. In a video magnifier, the users watch the monitor screen that is displaying the book page to be read. Eye movement is needed for reading a book. The difficulty of character recognition that is dependent on the environmental conditions is reflected to the eye movement. Accordingly, information on the visibility of the user is extracted as physiological signals accompanied by the gazing motion. These signals are basically used to control the video magnifier. The advantages and usefulness of the adaptive-type video magnifier are discussed in this paper.**

## I. INTRODUCTION

Conventional video magnifiers are well designed for low vision users in spite of the reasonable prices, but most of them do not exceed an electronically magnified glass from the view point of usability. We believe that more personalized assistance would be preferable for this kind of assisting tools. Since difficulty in character recognition, i.e., difficulty in book reading is highly dependent on individuals and their environment conditions, technical aids should also be personalized for the effective assistance by making use of information technology. This is the motive for our study. To incorporate more personalized assistance into the video magnifier, the action of viewing is utilized for controlling the reading camera and display through the gazing characteristics of the user. Figure 1 shows the experimental system developed for the basic studies. Gazing information is used to evaluate user's ability of viewing and to display the contents of a book with proper character sizes [1], [2]. Gazing point measuring system, Talk Eye-II (Takei-kiki Co. Ltd., Japan) is employed in this study, although the system with high accuracy [3]-[5] will be preferable in the future studies.

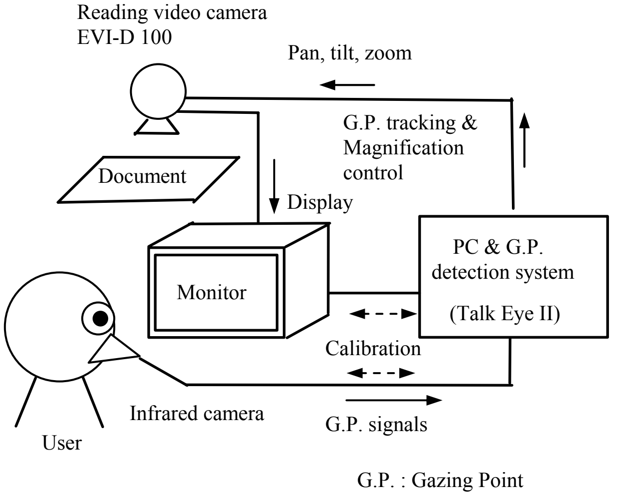

Fig. 1 Experimental set up of the adaptive viewer for low vision users

## II. VISIBILITY AND GAZING CHARACTERISTICS

### A. Substantial Eyesight

Firstly, relationships between the gazing characteristics and the degree of difficulty in reading were examined among the people with visual disabilities as well as the normal subjects.

Eyesight, in other word visual power is normally evaluated by the reciprocal of the minimum visual angle that is measured by Landolt rings displayed 5m in front of the subject. We define the "substantial eyesight" which is evaluated in the same way by using Landolt rings displayed on a monitor screen placed 80 cm in front of the subject. The substantial eyesight depends on the display, luminosity in the room, and some other parameters including mental- and physiological-conditions of the subject.

The substantial eyesight may be used to determine the initial magnifying power of the video magnifier although this is not implemented in the present system.

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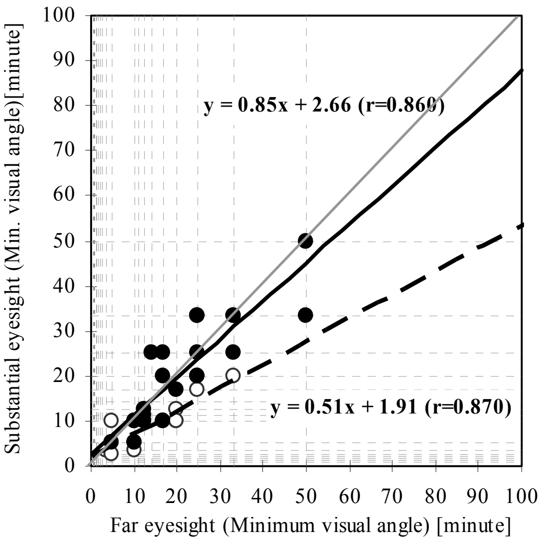

Fig. 2 Relationship between far point- and substantial-eyesight
Closed circle (●) represents the datum for low vision people and open circle (○) is for people with normal eyesight. Measurement was done with one eye by closing another one.

### B. *Stationary- and Transient-Characteristics of Gazing*

Since the measurement accuracy of Talk-Eye II is not sufficient for discussing absolute values of the gazing point coordinates, we used the standard deviation to indicate the amount of scatter in the measured values. This is called "fluctuation" in this paper and it shows the stationary characteristics of eye movements during gazing.

We measured the eye fluctuation of ten subjects. Figure 3 was obtained by stimulating the eyes with the black solid circle 5 mm in diameter displayed on the monitor screen placed 80 cm in front of the subject. Each of ten subjects has 36 fluctuation data in Fig. 3. They were measured at 12 points obtained by repeating the measurement three times. Although the dotted line was drawn by inspection, the monotonically decreasing feature seems to be unquestionable. This is the stationary characteristics between the fluctuation and eyesight. People with poor eyesight show larger fluctuations. The reverse is considered to be true also.

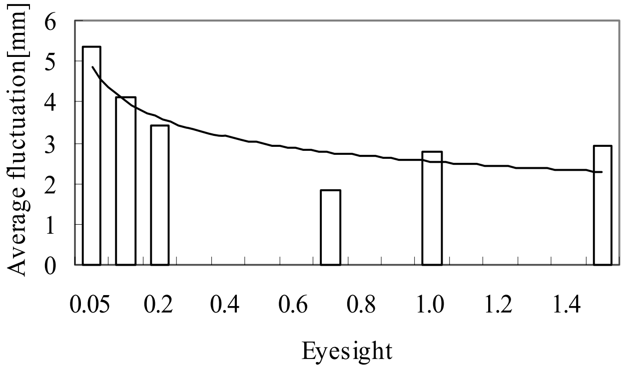

Fig. 3 The average fluctuation versus substantial-eyesight

Transient characteristics of the eye movement were examined next. By stimulating the eyes with the black circle 5 mm in diameter and randomly moving upward or downward, or rightward or leftward at 5 cm, 10 cm, and 15 cm intervals, the latency and transit time were measured as shown in Fig. 4. People with poor eyesight take longer time for the eye movement, although the latency does not show eyesight dependence. This was confirmed by the analysis of variance.

Ten subjects were intentionally classified into two groups enclosed with the circles, i.e., people with good or poor eyesight. Between these two groups, dependence on the eyesight of the transit time and non-dependence of the latency were confirmed by the significance test. This specific feature can be used also to control the video magnifier wisely.

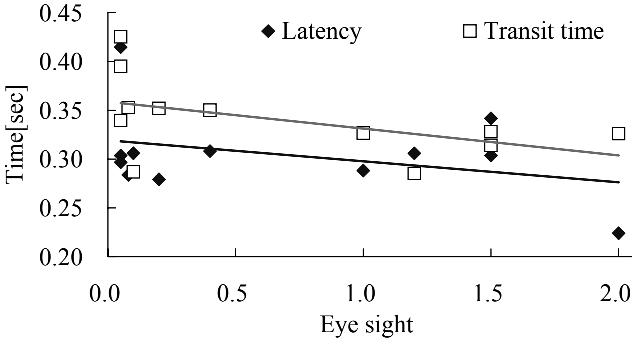

Fig. 4 Eyesight dependence of the transit time and latency in eye movement

Figure 5 shows the blinking probability evaluated in 10 subjects. Each subject was asked to follow with the eyes the black solid circle 5 mm in diameter and shown at the point jumped by 55 mm, 165 mm, or 275 mm from the origin. The frequency of blinking was examined to calculate the probability during the gazing point measurement. It was evaluated at 1.0 when blinking was observed, regardless of the frequency. In Fig. 5, eyesight dependence of the probability becomes clear according to the increase in the distance of eye movement. This suggests that the frequency of blinking is useful for evaluating the visual field angle of low vision users. Control parameters such as a scanning speed of the reading video camera will be adjusted by making use of this probability.

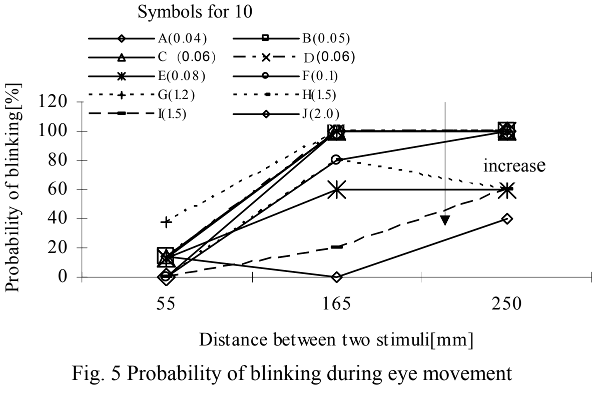

Fig. 5 Probability of blinking during eye movement

## III. ADAPTIVE VIEWER DESIGN

### A. Available Information and System Control

As described in the preceding chapter, we found some relationships among the gazing characteristics and control parameters of the viewer. However, at the present stage of the study, we do not come to a lucid conclusion how the adaptive viewer should be controlled by utilizing those physiological signals extracted from the gazing process. The tentative scheme we built from the experimental results that relating the gazing characteristics to control parameters of the vieweris given in Fig. 6. Characters displayed on the viewer are magnified by increasing in the fluctuation of the gazing points of the subject. This is achieved by computing the moving average of the gazing point. When the moving average exceeds the threshold, characters on the display are magnified by a certain extent that is predetermined. In principle, the magnification control will also be done by the transit time of a subject. However, this function is not installed since we have not yet developed an appropriate way of acquiring the transit data. The scan speed of the reading video camera will easily be controlled by the frequency of blinking so that the book contents are displayed on the monitor screen with an appropriate speed.

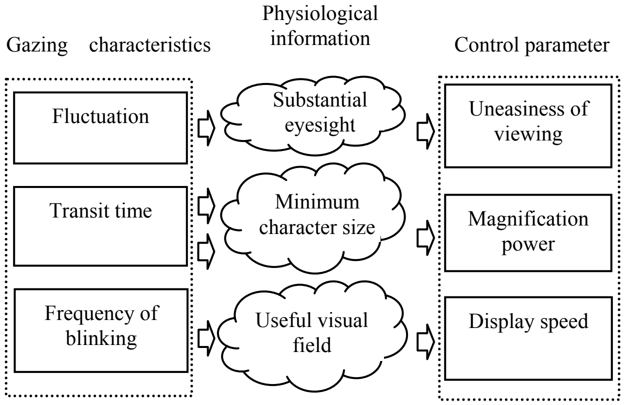

Fig. 6 Gazing characteristics and control signals of the adaptive viewer

### B. Software Configuration

We developed a prototype model of the adaptive video magnifier for low vision users by integrating various kinds of hardware and software as shown in Fig. 7. The video magnifier works in the following way according to the movement of the gazing point, i.e., the demand of the user. Principal algorithms for the camera control are summarized as follows:

(1) The software system consists of six phases, i.e., determination of the basic magnifying power, buffering, gazing point survey, camera motion, modification survey of the camera motion from gazing point, and initialization.

(2) In the beginning of use, initial magnifying power of the viewer is determined for each user interactively. User is asked to close his eyes when the character size becomes large enough to read during the character size is gradually increasing. This is referred to as the basic magnifying power.

(3) The reading camera scans the document from left to right and from top to bottom according to the gazing point movement for reading.

(4) When the moving average of the gazing points exceeds the threshold value, the character size is increased in some degree and the modified magnifying power is kept for this reading.

(5) If the gazing point remains within a certain area for a certain period, character size is gradually increased until the user closes his eyes intentionally for a certain period longer than the fixed time (presently, for 0.5 seconds).

(6) During the eye movement back to the leftmost position for line spacing, magnifying power is decreased to exhibit the wider area of the document to the user.

In addition to the above software, many other application- and system-software were developed for the viewer. It is hard to evaluate quantitatively the system performance, usability and so on. In this study, the average time for reading some sentences were measured ten times for ten users. It does not show a big difference among those users. Furthermore, the system works as the user wants without having a big problem.

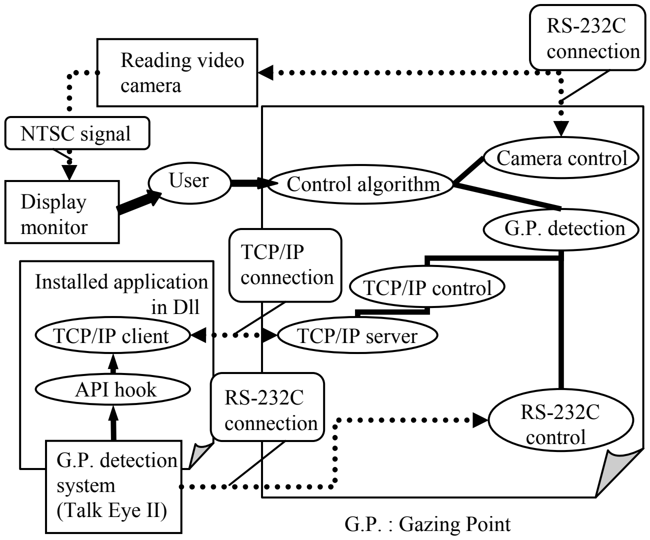

Fig. 7 Software configuration in the prototype model of the adaptive viewer

## IV. CONCLUSION

The adaptive video magnifier using gazing point information to control the reading camera and display was developed. The system still remains the prototype model and not all signals extracted from the gazing process are incorporated for controlling the system. However, it works properly as we designed in advance. The adaptive video magnifier will be useful for many people with visual disabilities.

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