

## Research Article

# Mouse Cursor Control System using Gaze and Eye Opening and Closing

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## ARTICLE INFO

### Article History

Received 25 November 2021

Accepted 24 April 2022

### Keywords

Mouse cursor control system

Eye gaze

Eye opening and closing

## ABSTRACT

It is necessary to support of computer operation for a physically disabled person. One of the possible physical movements of the physically disabled person is Eye movement. Eye gaze and detection of eye opening and closing of a person makes it possible to operate a computer. In our system, a web camera, Gaze pointer, Dlib C++ library and OpenCV library are used to recognize eye gaze and detect eye opening and closing. Changing the eye gaze, we can move a mouse cursor. Recognizing closed eye, we can carry out an operation of mouse click. In this paper, we evaluated the effect on operability due to the eye gaze and detection of eye opening and closing.

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## 1. Introduction

In recent years, a computer input system without the mouse and keyboard has been developed as a support system of computer operation for a physically disabled person. However, many of them are contact type systems that must be attached to the body which imposes a physical burden on the user. In addition, many non-contact type system are special sensors and expensive.

Therefore, in the previous study [1], we proposed a non-contact system which operates the mouse cursor using an inexpensive web camera. The system recognizes the direction of the face and the opening and closing of the mouth and eyes so that the mouse

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pointer moves to the face direction and the system clicks the mouth in the case of the opening mouth and the closing eye. However in the previous study we assume that the user can turn his face and open and close his mouth and eyes so that the system cannot be used by severe amyotrophic lateral sclerosis (ALS) patients.

So, it is necessary to develop a mouse cursor control system that can be used by patients with severe ALS. In this research, we developed a mouse cursor control system only by eye movements, and evaluated its performance.

## 2. The communication means

In ALS, it is important to consider communication means as the symptoms progress. If a patient can move his arms and fingers, he can talk in writing, and if he

can move his mouth, he can communicate using shape recognition of mouth. If he can move his eyes, he can communicate using a transparent letter board. However, communication means using shape recognition of mouth and a transparent letter board always require the help of a helper. On the other hand, if he can move his body or eyes, it is possible to communicate by selecting an appropriate computer input system. This study targets people with advanced symptoms who have residual eye movements.

### 3. Comparison with the previous study

In the previous study [1], we assumed that the user could turn his face and open and close his mouth and eyes. In this study, it is assumed that the user cannot change the direction of his face, cannot move his mouth but he can move his eyes. The movement of the mouse cursor depends on the direction of his eyes and click process is performed by gazing. In addition, we make it possible to change click to double-click by changing the input mode by closing his eye.

### 4. The proposed system

The movement of the mouse cursor depends on his eye gaze and click process is performed by gazing for 2 seconds or longer. To prevent unintended click processing, the click function will be stopped if both eyes are closed for 4 seconds or longer. The proposed system can be divided into three elements: "movement of mouse cursor", "mouse click processing", and "controlling mouse click function". Figure 1 shows a flowchart of the outline of the system.

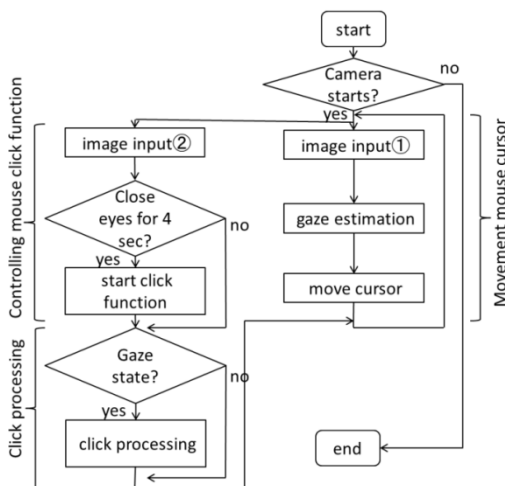


Fig 1. Flowchart of the outline of the system.

### 5. Movement of the mouse cursor

In this research, we use a web camera and GazePointer software [2] to estimate the eye gaze and move the mouse cursor based on the eye gaze. Before using the system, the user calibrates eye gaze.

### 6. Mouse click

#### 6.1. Judgment of gaze state

The system gets the coordinate  $M_0$  of the mouse cursor at time  $t = 0$  and sets this coordinate to the point  $G_0$ . If the coordinates  $M_1$  of the mouse cursor gets by the system at the next time  $t = 1$  are within the rectangular area  $R_0$  of  $114 \times 106$  centered on  $G_0$ , the system sets  $R_1$  with the midpoint of the coordinates  $M_1$  and  $G_0$  as the point  $G_1$ . When the coordinate  $M_t$  of the mouse cursor at time  $t$  is in the rectangular area  $R_{t-1}$  (Fig. 2) for about 2 seconds, it is judged as "gaze state" and the coordinates of  $G_t$  are determined to be the gaze coordinates. If  $M_t$  is not in the rectangular area  $R_{t-1}$ , initialize the time and continue the calculation (Fig. 3).

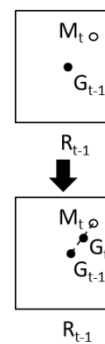


Fig.2 The coordinate  $M_t$  is in the region  $R_{t-1}$

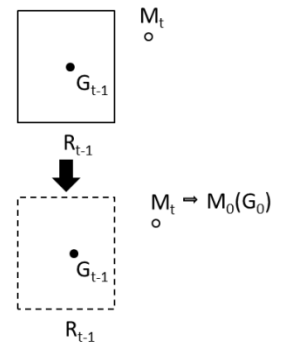


Fig.3 The coordinate  $M_t$  is out the region  $R_{t-1}$

#### 6.2. Process of Mouse click

If the state is the "gaze state", the coordinate of the point  $G_t$  is the coordinate of the gaze and the system Moves the mouse cursor to the point  $G_t$  to perform click processing.

#### 6.3. Judgment of eye opening and closing

The judgment of opening and closing eyes is used by the method described in [1]. First, an open source C++ library Dlib [3] is used to detect facial feature points (68 points in total).

The eye area is determined by the coordinates of the feature points of both eyes, as shown in Fig. 4. The

range of x-axis is the difference of x-coordinate between the left and right, and the range of y-axis is the difference of y-coordinate between the top and bottom. The RGB image of the eye area is extracted from a captured image and converted from the RGB image to a grayscale image. Next, we determine a threshold value is obtained by the discriminant analysis method [4], and binarization is performed for the eye area image. From the binarized image, we make the histogram of black pixels. The vertical length  $h_e$  of the eye is the maximum on the histogram, and the horizontal length  $w_e$  of the eye is the range of x-coordinate in the eye area, as shown in Fig. 5. The ratio  $R_e$  is obtained from  $h_e$  and  $w_e$  by equation (1). If  $R_e$  is above the threshold value, it is determined that the eyes are open, and if  $R_e$  is below the threshold value, it is determined that the eyes are closed. From the previous study [1], the threshold is set to 0.3.

$$R_e = \frac{h_e}{w_e} \quad (1)$$

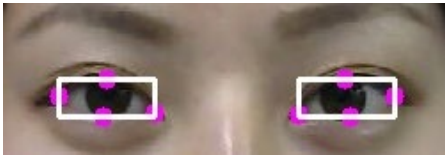


Fig. 4. Feature points of eye extracted using Dlib.

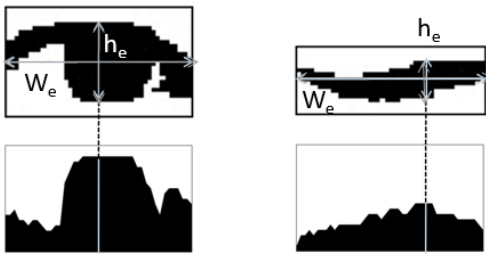


Fig. 5. The vertical and horizontal length and histogram of opened eye (left) and closed eye (right).

#### 6.4. Controlling the mouse click

When the mouse click function is activated and one eye is closed for about 1 second, the double click and single click functions are switched. Also, if both eyes are closed for about 4 seconds, the mouse click function will be stopped. On the contrary, when the mouse click function is stopped and both eyes are closed for about 4 seconds, the mouse click function is activated. Figure 6 shows a flowchart for controlling the mouse click function.

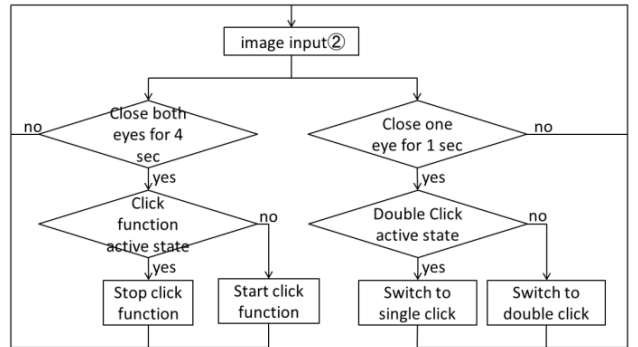


Fig. 6 Flowchart of controlling the mouse click

### 7. Experiments

#### 7.1. Operation screen

Figure 7 shows the operation screen when using the system. The user's face is displayed in the upper left and upper right of the screen. The upper left screen displays the eyes gaze detection, and the upper right displays the eye opening and closing judgment.

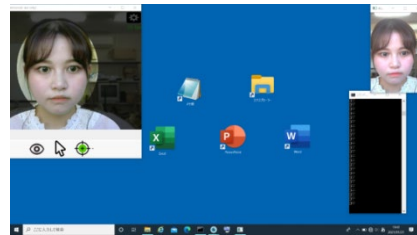


Fig. 7 Operation screen

#### 7.2. Experiment contents

We conducted the following two evaluation experiments comparing the proposed system with the previously reported system [1] for 10 subjects in their 20s (male: A to F, female: G to J).

- Evaluation experiment on mouse cursor movement and mouse click
- Evaluation experiment on character input

Before the experiment, the subjects explained the operation method of each system and the contents of the experiment, and then practiced for 2 minutes. When using the proposed system, calibration was performed for each experiment. After the experiment, a questionnaire was conducted.

### 7.3. Evaluation of mouse cursor movement and mouse click

The subjects use each system to double-click the icon (Notepad) installed on the desktop, and measured the required time (Experiment 1). Also, for the operation of double-clicking five icons installed on the desktop, the required time was measured for each system (Experiment 2), and the difference in the required time between single operation and continuous operation was investigated.

### 7.4. Evaluation of character input

Using the Windows screen keyboard (Fig. 8), we measured the time it took to enter "kyoto" in Notepad, and evaluated the difference in operability in character input of each system (Experiment 3).

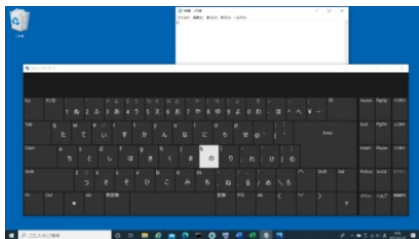


Fig. 8 Character input

## 8. Results

### 8.1. Evaluation of mouse cursor movement and mouse click

Figure 9 shows the time required for each subject under experiment 1 and the average value of 10 subjects, and Figure 10 shows the time required for each subject under experiment 2 and the average value of 10 subjects. Under experiment 1, the time required

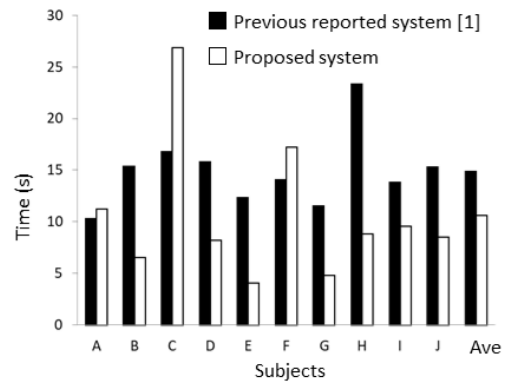


Fig. 9 Time required for Experiment 1

was shorter when the proposed system was used except for 3 subjects. Under experiment 2, the time required was shorter when the proposed system was used for all subjects. The time required for the three subjects who used the proposed system under the experiment 1 was longer than that when the proposed system was used under the experiment 2. This is because the proposed system, which is accustomed to moving the mouse cursor with the eye gaze while performing continuous operations, gradually shortens the time required to move the mouse cursor, and as a result, the mouse cursor moves faster.

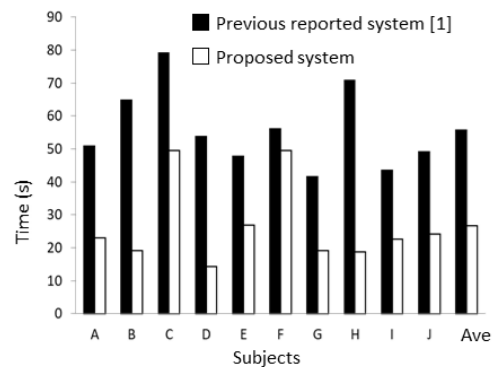


Fig. 10 Time required for Experiment 2

### 8.2. Evaluation on character input

Figure 11 shows the time required for 10 subjects to enter "kyoto" in each system and the average value of

10 subjects. The time required was shorter when the proposed system was used for all subjects. It is considered that this is because, as in the above experiment, the user became accustomed to moving the mouse cursor with the eye gaze while performing continuous operations, and as a result, the required time was shortened.

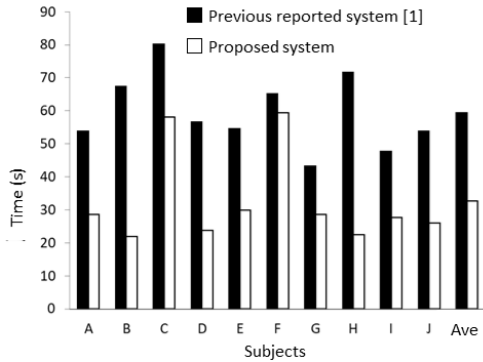


Fig. 11 Time required for Experiment 3

### 8.3. Experimental questionnaire

Table 1 shows the contents of the 5-step evaluation questionnaire conducted after the experiment, where System ① is the previous reported system and System ② is the proposed system, and Table 2 shows the evaluation results and averages of each question item of all subjects. In Q1 and 3, the average value of the proposed system was 0.5 higher than that in the previously reported system [1], and in Q2 and 4, the average value of the proposed system was 0.6 higher than that of the previously reported system [1]. In the free description field,

- It was difficult to fix my face, so that I thought it would be nice to have something like a chin rest.
- Since system ② can input characters faster, I felt that the operability was good after some practice.
- I thought that the operability of System ① would not change even if I got used to it. It took time to get used to system ②, but I think that the accuracy will improve once you get used to it.

Table 1 Questionnaire

Q1. Did you think the operability of System ① is good?
Q2. Did you want to use System ① again?
Q3. Did you think the operability of System ② is good?
Q4. Did you want to use System ② again?

Table 2 Evaluation results of all subjects

	A	B	C	D	E	F	G	H	I	J	Ave
Q1	4	4	3	3	5	4	3	3	5	4	3.8
Q2	3	3	3	3	5	4	4	2	4	4	3.5
Q3	5	5	4	4	4	5	3	3	5	5	4.3
Q4	4	5	4	3	5	4	3	3	5	5	4.1

## 9. Conclusion

In this research, we developed a system that detects the eye gaze and the eye opening and closing, moves the mouse cursor, and clicks the mouse, and evaluated its performance. Comparing the time required for the operation, the time was shorter overall when the proposed system was used than the previous reported system [1]. It can be said that it is particularly useful to require continuous mouse operations such as character input.

A future task is to reduce the error in the non-contact state with respect to the problem that the position of the mouse pointer is inaccurate due to the displacement of the head.

In addition, in order to further improve usability, we will add a function that allows the user to freely change the gaze time at the time of clicking, and develop easier character input system with the eye gaze.

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### Authors Introduction

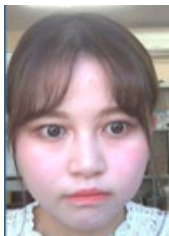
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