

Expanding the Freedom of Eye-gaze Input Interface using Round-Trip Eye Movement under HMD Environment

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Abstract

In this paper, we propose a specific gaze movement detection algorithm, which is necessary for implementing a gaze movement input interface using an HMD built-in eye tracking system. Most input devices used in current virtual reality and augmented reality are hand-held devices, hand gestures, head tracking and voice input, despite the HMD attachment type. Therefore, in order to use the eye expression as a hands-free input modality, we consider a gaze input interface that does not depend on the measurement accuracy of the measurement device. The proposed method generally assumes eye movement input different from eye gaze position input which is implemented using an eye tracking system. Specifically, by using reciprocation eye movement in an oblique direction as an input channel, it aims to realize an input method that does not block the view by a screen display and does not hinder the acquisition of other lines of sight meta information. Moreover, the proposed algorithm is actually implemented in HMD, and the detection accuracy of the roundtrip eye movement is evaluated by experiments. As a result, the detection results of 5 subjects were averaged to obtain 90% detection accuracy. The results show that it has enough accuracy to develop an input inter-face using eye movement.

CCS Concepts

• **Human-centered computing** → Mixed / augmented reality; Gestural input; User studies;

1. Introduction

With the rapid development of virtual reality (VR) technology, immersive 3D content using the head-mounted display (HMD) is widely available. The realization of truly immersive VR is necessary to enable physical sense virtualization and natural two-way communication [EJM13]. The operation of current VR and augmentation reality (AR) devices rely on hand-held devices, hand gestures, head tracking, and voice input. Therefore, recent research has been actively conducted to add the gaze as a modality of hands-free input [MAH13] or [SMGM17]. Above all, a gaze-based input interface, which uses eye tracking to sense where the user is looking, is compatible with the nature of the HMD, and commercialization aimed at practical application is also in progress [KRV*18] or [SCG19]. However, Gaze inputting that applies such Eye Tracking technology is limited by the lack of input vocabulary, cognitive and physio-logical difficulties, and ambiguous targeting areas. Traditional gaze input is intuitive and has many accurate prior methods, but there are still many limitations when it is used in HMD. Therefore, in this research, we propose a method to solve the problem of classical gaze input by using the movement of the gaze itself as input. In this paper, as a rudimentary approach, we propose an Eye-Glance input method using diagonal reciprocation of eye gaze as an input trigger as an input interface at the time of

HMD wearing, and confirm the accuracy of its operation by experiments.

2. Proposed method

The Eye-Glance method is a moving direction input that uses diagonal reciprocation eye movement. This is a motion of "flicking" such that the line of sight moves out of the field of vision for a moment and then returns to the original position again. Considering the selection type UI, one Eye Glance input allows one input from four options. If this is repeated twice, 16 options can be input, and if it is repeated 3 times, 64 options can be input. The merit of this is that although the required accuracy of the measuring device does not increase even if the number of options is increased by this method Can be mentioned. In the case of gaze position inputting, the required accuracy of the measuring device is proportional to the increase in the number of input options. The Eye-Glance input identifies four directions based on the combination of the amounts of respective eye movement of the round-trip. In this research, eye-glance input by an optical measurement method is realized by measuring eye movement by image processing from the image around eyeball photographed by an infrared camera. Next, the judgment algorithm of Eye Glance input is described. Fig. 1 shows an ideal average velocity field waveform at the time of Eye Glance input in

the upper right direction. Here, in the horizontal direction, a positive value means the left direction, and in the vertical direction, a positive value means the upper direction. The Eye Glance waveform has the following features: 1) Reverse waveforms occur in succession. 2) Horizontal and vertical waveforms occur simultaneously. We constructed a simple discrimination algorithm based on these features. The detection of the Eye-Glance waveform is an Eye-Glance input when the waveform exceeding the detection threshold is continuously measured and the above feature 1) and 2) are satisfied. The threshold value is set in advance from the waveform obtained by calibration. And as a numerical value with few erroneous discriminations, and 55% of the maximum value and the minimum value of the obtained waveform are used. According to feature 2), the location where the horizontal peak and the vertical peak occur simultaneously is detected. Next, based on the feature 1), it is determined whether or not the subsequent peak detection points are opposite in both horizontal and vertical directions. And when these are satisfied, it is determined as Eye-Glance input.

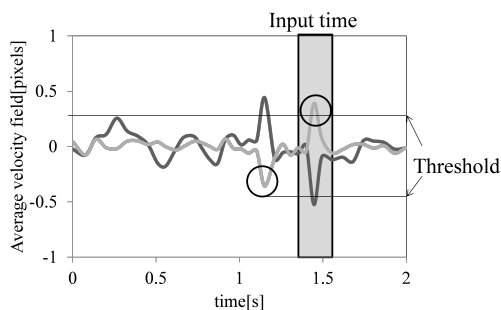


Figure 1: Threshold for Eye Glance input detection.

3. Experiment

An experiment was conducted to evaluate the accuracy with which the Eye-Glance input. The subjects were four males in their twenties and one male in their thirties. The hardware of the experimental system consists of HMD FOVE 0 incorporating an infrared eye tracking system, and a personal computer that performs graphics output to the display and analysis of acquired data. The subject was asked to wear the HMD while sitting in a chair and to follow the instructions on the input screen for the experiment and the voice output on the display. The eye movement amount measured by the infrared eye tracking system built into the HMD is measured at 120 fps. After that, detection of Eye Glance input was performed offline to the recorded eye movement data. In the experiment, the subject was instructed to find the UI presented at the center of the screen. In the experimental UI, the index for guiding the eye movement in the oblique direction is arranged at five points in four directions and at the center. At this time, the distance between the index centers is set to 5 degrees horizontally and 5 degrees vertically. After receiving an instruction to start the measurement, the subject was asked to carry out a diagonal round-trip eye movement in one direction in each direction clockwise from the upper right at an arbitrary timing. Taking this operation as one set, a total of three sets were measured for each subject. For the acquired eye movement

Subject	Left		Right		Total
	Up	Down	Up	Down	
A	2/2	2/2	2/2	2/2	8/8
B	1/2	1/2	2/2	1/2	5/8
C	2/2	2/2	2/2	1/2	7/8
D	2/2	2/2	2/2	2/2	8/8
E	2/2	2/2	2/2	2/2	8/8
Average	1.8/2	1.8/2	2.0/2	1.6/2	7.2/8

Table 1: Results of detection experiment.

data, the detection accuracy of the oblique eye movement is verified based on pro-posed algorithm. The data calculation first uses the first set of acquired data as calibration data to determine the detection threshold. In this experiment, 55% of the maximum value and the minimum value in the interval empirically set by the previous experiment was set as the standard. The measurement data is used to calculate the difference value and detect the peak value exceeding the threshold. In addition, if two consecutive peaks have vector components in opposite directions, it is detected as a reciprocating movement. The detection processing is basically performed with reference to the measurement data of the right eye, and the measurement data of the left eye is used when the measurement of the eye movement amount fails due to the calibration failure of the HMD device. Table 1 shows the detection results.

4. Conclusions

In this paper, we evaluate a special gaze movement detection algorithm that is needed to use eye movement as an input interface to operate VR/AR devices. As a result, it was possible to obtain about 90% detection accuracy on average in the experiment with 5 subjects in the diagonal reciprocation. The results of this paper provide a simple method for using eye-gaze input in HMD devices. If eye movement input becomes possible, it becomes a clue to solve the problems of measurement accuracy of the device, speed of input, and UI that largely occupies the screen, which has been a bottleneck in introducing gaze position input. As a future plan, the input interface using the reciprocal eye movement is actually mounted on the HMD. Then we want to verify the effectiveness of multimodal input with gaze movement input and other input channel.

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