Gaze-Based Moving Target Acquisition using Pseudo Stopping for the Time predicted via Fitts' Law

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ABSTRACT

This paper describes a technique of gaze-based moving target acquisition achieved by pseudo stopping the target for the time predicted via Fitts' Law, after saccades have been detected. This technique only requires eye-movements for the acquisition of moving targets. The results indicate that participants were able to acquire targets moving at various speeds and with different widths.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction**

KEYWORDS

gaze interaction, moving target acquisition, Fitts' Law

1 INTRODUCTION

In this paper, a method of acquiring moving targets by stopping the target for the time predicted via Fitts' Law is proposed. Recently, several types of eye-tracking devices, such as attaching to the bottom of the display [1] or head-mounted displays with eye tracking function [2], have been developed. Moreover, gaze-based target acquisition techniques have received significant attention in this field. There are mainly two types of target acquisition techniques employing eye movements. In the first type, eye movements are combined with another input method such as mouse clicks or hand gestures. The second type only employs eye movements. Although the former type of technique has disadvantages that deteriorate the rate of target acquisition, the latter technique is also limited by the Midas-touch problem [3] which occurs target acquisition without user's intention.

This research presents a technique of gaze-based moving target acquisition that only employs eye movements. When a long time setting is required for gaze-based techniques, users may find it difficult trace the moving target with the gaze cursor, owing to the micro-saccade or limited precision of the eye tracking device. If a short time setting is required for gaze-based target acquisition, the occurring ratio of Midas-touch increases. The proposed technique involves pseudo stopping the target only for the time predicted by Fitts' Law after saccades have been detected. This technique enables users to easily acquire moving targets.

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2 METHOD

In this study, we attempted to acquire moving targets by only using eye movement; for this purpose, the targets were pseudo stopped only for the duration determined using Fitts' Law. Figure1 presents schematic views of the proposed technique. In this technique, smoothening of the gaze-coordinates and saccade detection were achieved by employing the technique proposed by Kumar et al [4]; in their technique, the eye-coordinate is smoothed via calculations using a weighted mean of a few gaze-coordinates, and saccades were detected when the Euclidean distance between two gaze coordinates exceeds a given saccade threshold. The time required for moving the gaze cursor to the target is acquired using Fitts' Law [5], after saccades have been detected. Subsequently, the moving target is pseudo stopped for the time determined using Fitts' Law. The original moving target is also displayed to make it inconspicuous while the target is stopped. Thus, users can acquire the target via pointing tasks, using by moving their gaze towards the stopped target. The dwell time for acquiring the target should be as short as possible, because the user must acquire the target within the time predicted using Fitts' Law. In the proposed technique, targets are acquired by employing a dwell time reduction technique proposed by Isomoto et al [6]; in this technique, when the difference between the eye movement time predicted using Fitts' Law and the actual eye movement time is small, the target is acquired. Schuetz et al [7] proposed that Fitts' Law apply to gaze interaction when the Index of difficulty (ID) value of pointing task should exceed a certain value (i.e., 1.4). In our technique, when the ID value of the target exceeds 1.4, the target is acquired by employing the dwell time reduction technique proposed by Isomoto et al. When the ID is less than 1.4, the target is acquired by gazing at the target for 400 ms, which is the appropriate time for gaze-based target acquisition, considering Midas-touch [8].

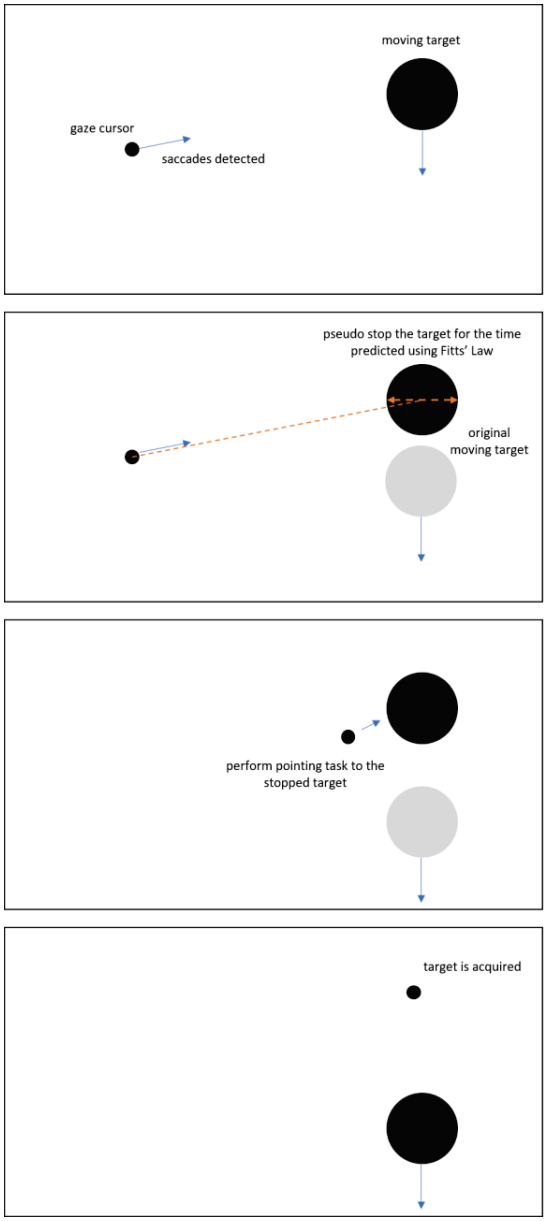

Figure 1. schematic views of our technique

We conducted an experiment to evaluate the performance of our technique. The proposed technique was compared with the technique that involves the acquisition of moving targets by gazing at the targets for 400 ms. Eight subjects participated in this experiment. We selected Tobii Eye Tracker 4C [1] as the eye tracking device. The participants were required to acquire all 96 types of moving target (4 target width conditions × 6 target velocities ×4 target movement patterns) with each technique once. In this task, when the participants judge the target to be impossible to acquire, they can skip the pointing task of the target by pushing key 'a'. The movement patterns of the targets used in the experiment are illustrated in Figure2.

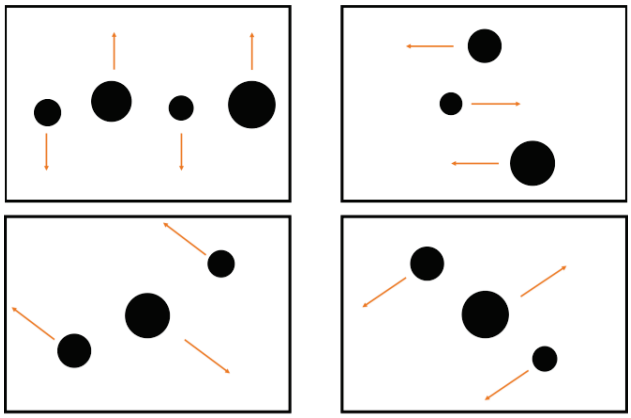

Figure2. Movement pattern of targets

3 DISCUSSION

We acquired each ratio of which all participants skipped the task by judging the target to be impossible to acquire. (Table1, Table2) The results indicate that the acquisition of moving targets by using the technique that involves gazing at the target for a certain period of time is difficult, particularly when the width of the target is small or the movement velocity of the target is high. Contrarily, we observed that the proposed technique increases the ease of gaze-based moving target acquisition.

Table1. Skip rate for gazing at targets for 400ms

		speed [inch/ms]					
		0.025	0.050	0.075	0.100	0.125	0.150
width [inch]	0.75	21.9	87.5	93.8	93.8	100	100
	1.00	12.5	40.6	75	96.9	100	90.6
	1.25	6.3	31.3	78.1	100	93.8	100
	1.50	3.1	15.6	31.3	90.6	100	100

Tarble2. Skip rate of proposed technique

		speed [inch/ms]					
		0.025	0.050	0.075	0.100	0.125	0.150
width [inch]	0.75	3.1	3.1	6.3	0	0	0
	1.00	0	0	0	3.1	0	3.1
	1.25	0	0	0	6.3	0	0
	1.50	0	0	0	0	0	3.1

4 CONCLUDING REMARKS

We propose a technique for the gaze-based acquisition of moving targets by pseudo stopping the target for the time predicted by Fitts' Law, after saccades have been detected. Therefore, this technique enables the acquisition of targets moving at various speed and with different widths. Moreover, we are currently attempting to develop a system for the acquisition of targets in virtual reality (VR) and augmented reality (AR), using the proposed technique.

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