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Discrete Rotation during Eye-Blink

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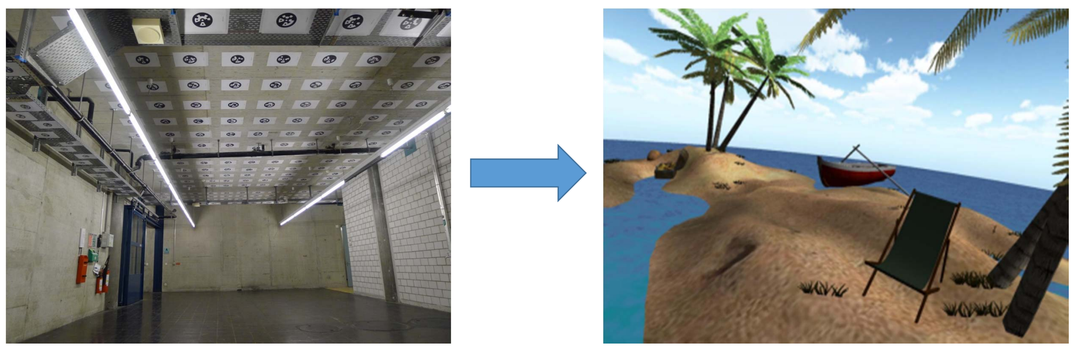
Introduction

Compared to other methods of walking in a virtual environment (VE) such as using controllers or walking-in-place, real walking has been shown to have better integrity and provide better immersion. However, the challenge arises when **the VE is much larger than the physical space**.



Redirection techniques (RDTs) are a solution to this problem. These techniques could be categorized into continuous vs. discrete and subtle vs. overt [1]. It is generally desirable that subtle techniques are used in order to maintain immersion. While continuous techniques have been extensively researched, discrete techniques have received less attention.

	Continuous	**Discrete**
Subtle	Curvature gain Translational gain Rotational Gain	Change blindness
Overt	Seven-league boots Gradual translation	Teleportation

With the development of new HMDs with affordable integrated eye trackers such as HTC Vive or FOVE, it is promising that research on subtle discrete RDTs using eye tracker information could be widely applicable in the future. Here we propose the application of **subtle discrete RDTs**, more specifically rotation, in real walking **during blinking**.

Methodology

During blinking the eye tracker loses track of the eyes and the pupil sizes become zero. However, it is worth to notice that the left and right eyes do not open or close at the same time and there is occasionally spurious noise like in Figure 1.

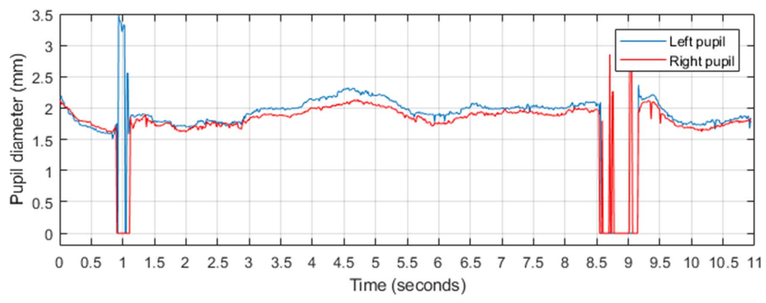


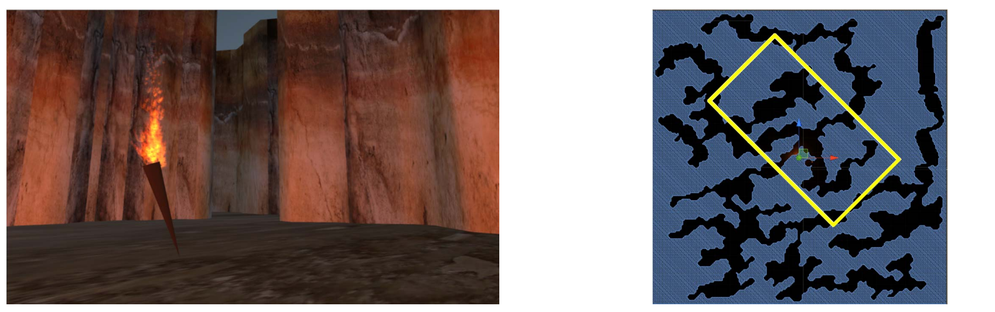
Figure 1: Typical signal obtained from the eyetracker.

Since redirection should only be applied during blinking, it is important that blinks are detected reliably and there can not be any false positive. Therefore, in our blink detection algorithm, the following two conditions need to be satisfied for an event to be considered a blink:

(i) Both eyes' pupil diameters should change from nonzero to zero and remain zero for a certain amount of time
(ii) The subsequent step from nonzero to zero will only be considered after a predefined amount of time to eliminate irregular blinks or noise like in Figure 1.

Experiment Design and Setup

To identify the detection threshold for scene rotation during blinking without disclosing the real aim of the study, a cover story is given to the participants that they are "… *testing a new system which may contain some technical bugs and are encouraged to inform the experimenter whenever such bug occurs*…". The environment for the experiment can be found in Figure 2.



(a) User view of the VR scene (b) Top view with real space overlay

Figure 2: Scene used in the study

Pilot Study and Preliminary Results

Five naive subjects (3 males and 2 females, age range: 20-29) participated in the study. The first pilot subject remembered to mention to the experimenter every time he noticed a technical "bug" such as: *"the colour is weird"*, some things *"seem a bit blur"*, or *"the scene just glitches"*. However, the next two subjects were too immersed in the VE that they forgot to say anything. We then changed the experiment protocol for the last two pilot subjects and added a training session where scene rotation was always 15 degrees. Keywords such as "jump", "blur", etc. were also used when they detect a "bug" and do not have to stop and explain. This adjusted protocol worked well and will be adopted for the final study. In general, it was observed that scene rotations **below 5 degrees** were on average not detected.

Conclusion

The performed study showed that the cover story was effective and resulted in an estimation of the detection threshold. Further studies with large sample size are required.

Reference

[1] E. A. Suma, G. Bruder, F. Steinicke, D. M. Krum, and M. Bolas. 2012. A taxonomy for deploying redirection techniques in immersive virtual environments" IEEE Virtual Reality Workshops (VRW), pp. 43-46.