Eye and Head Movements in Virtual Reality: a Comparison of Gaze Events during Free-viewing Exploration

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Introduction

- Eye-tracking is a highly used method for research, and it is becoming increasingly used in combination with virtual reality (VR)
- The applications of eye tracking in virtual reality are highly diversified and span multiple disciplines [1].
- VR-based eye-tracking calibration and validation procedures are faulty and occasionally fail due to various reasons.
- Traditional eye-tracking research has measured and compared head and eye movements with mixed results [2][3] and suggesting head rotation guidance during batting [4]
- The relationship between head and eye movements in VR is poorly understood

Goal:

- **To investigate eye and head tracking differences during free-exploration of naturalistic environments.**
- **To understand eye and head behavioral differences during gaze events**
- **To explore the possible contributions of behavioral head data when considered in eye-tracking calibration/validation procedures and for identification of gaze events**

Methods

- We invited participants to the lab to explore a virtual city comprised of various buildings, objects and human-like avatars (fig. 1)

Fig. 1: Reconstructed view during virtual walk

- Gaze events were calculated in a previous study [5]
- We calculated the rotations (in degrees) and the Euclidean distance of the head with respect to the eyes during gaze events (fig 2).

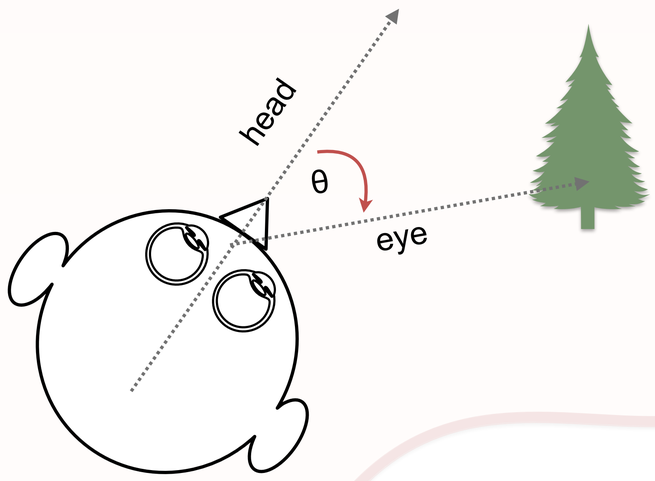

Fig. 1: Eye (θ) and head angles (θ)

Results

- Eye and head axes follow each other in a similar path (fig. 3), less so on the Y-axis

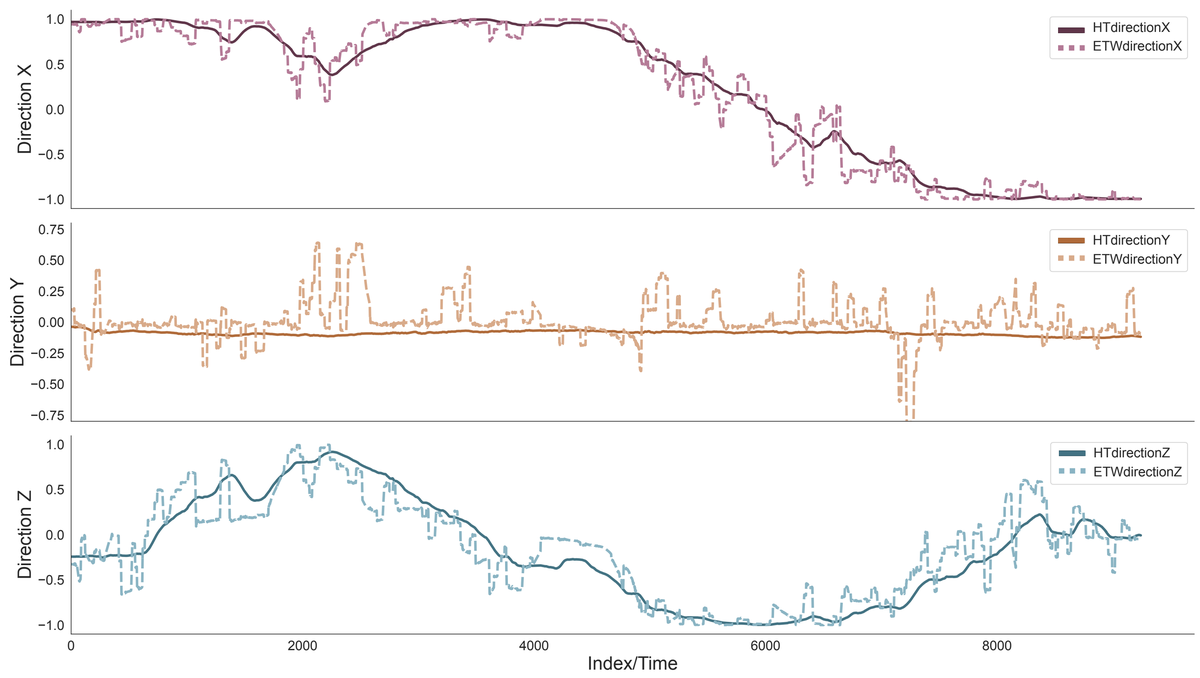

Fig. 3: Head and eye axes' directions

- X, Y, and Z axes have similar mean distributions (fig. 4) and are highly correlated (fig. 5)

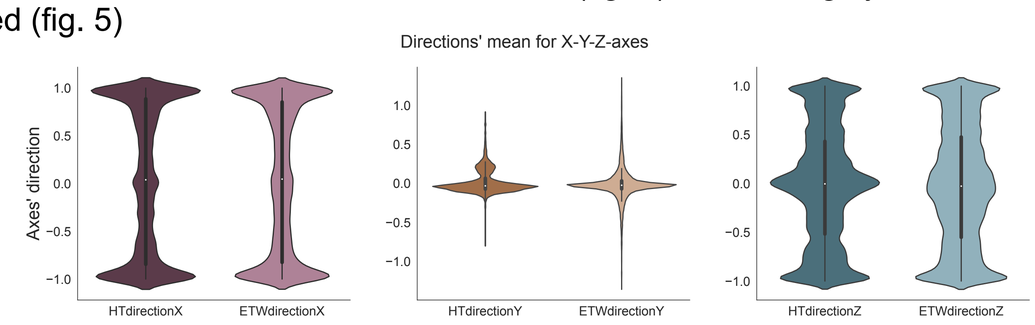

Fig. 4: Head and eye distributions

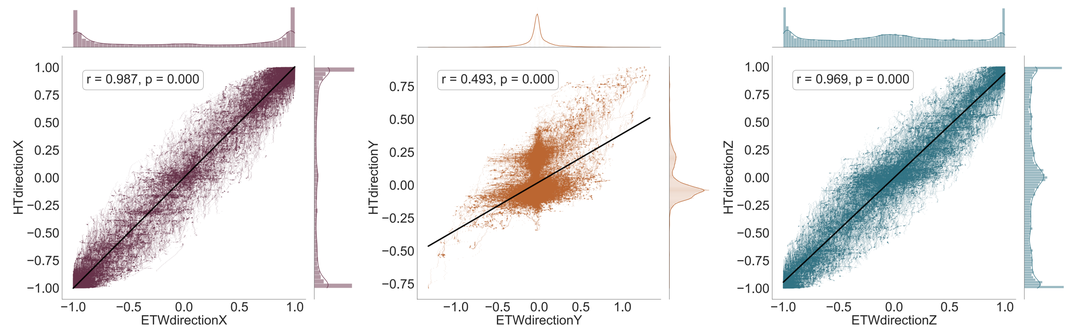

Fig. 5: Axes' correlations

- Head-to-eye distance decreases during gaze events when initial rotations > 10° (fig. 6), specially for large objects

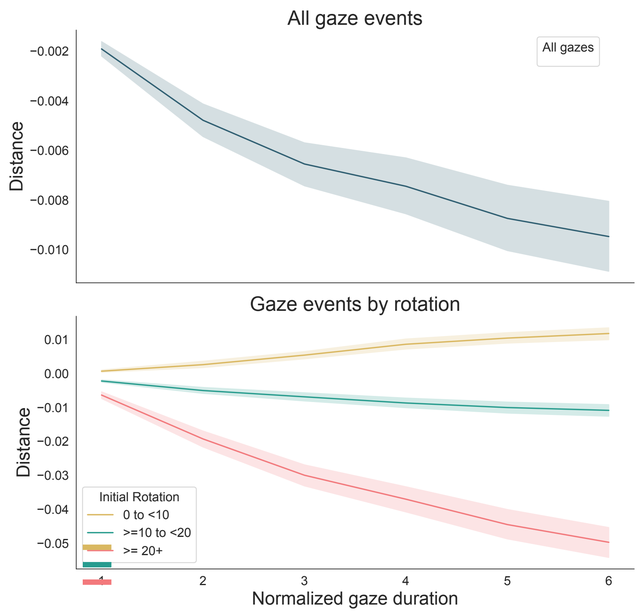

Fig. 6: Angles' distances during gaze events

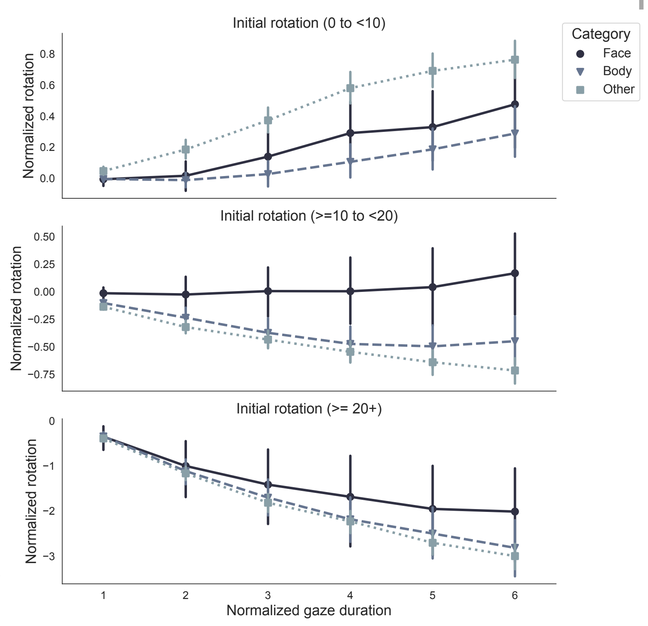

Fig. 7: Rotations per gaze category

Conclusion & Discussion

- We have compared head and eye movement differences during a free exploration task in a virtual city.
- We found similar distributions of eye and head directional axes, showing that eye and head are highly correlated in the X and Z axis and less so in the Y axis during gaze events.
- Eye and head angles' distances decrease when initial rotations > 10° and slightly increase when initial rotation < 10°.
- This analysis reveals the possibility of using head tracking to detect gaze events around specific areas of interest.

References:

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