

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).

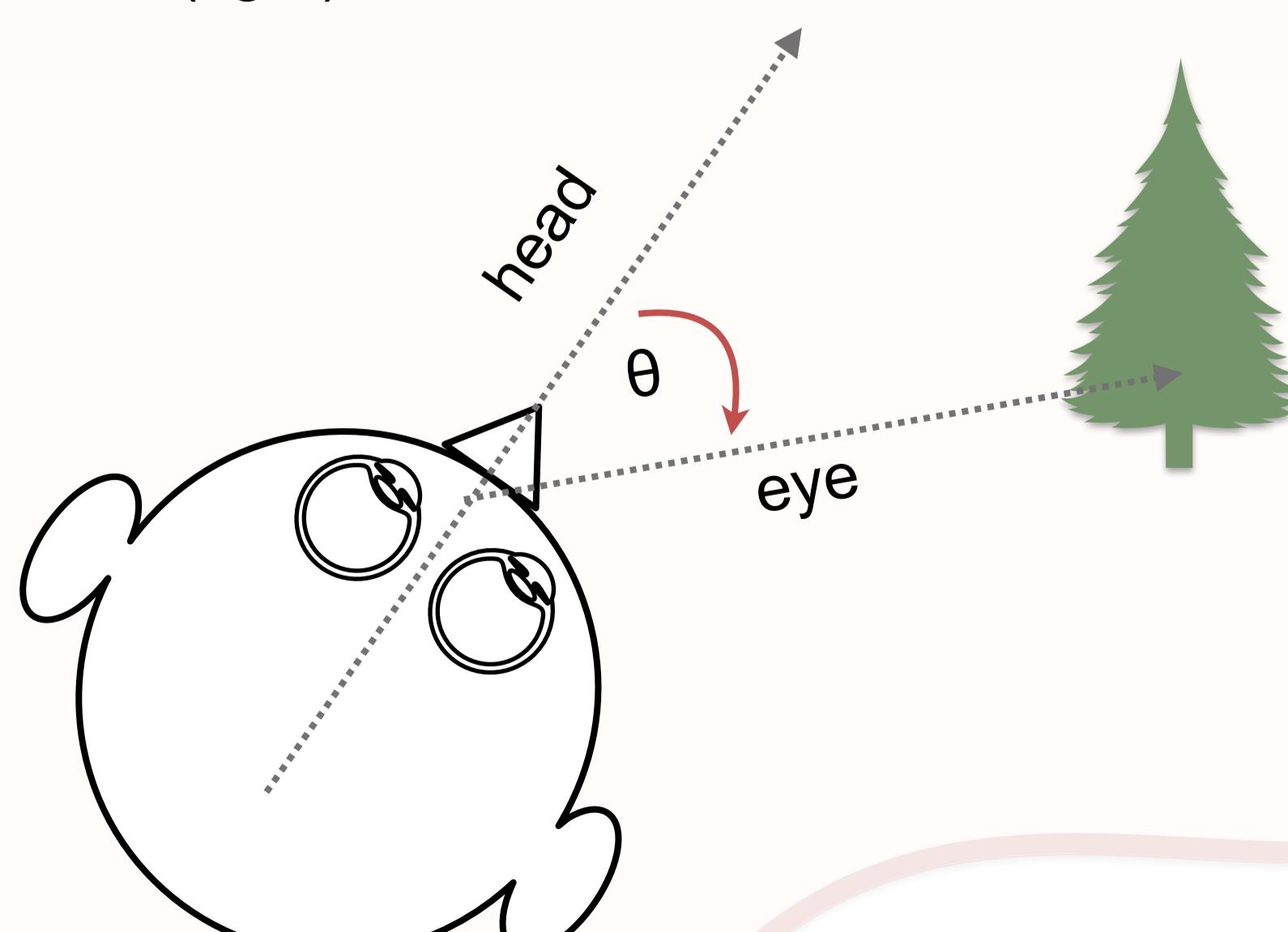


Fig. 1: Eye (θ) and head angles (θ)

Results

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

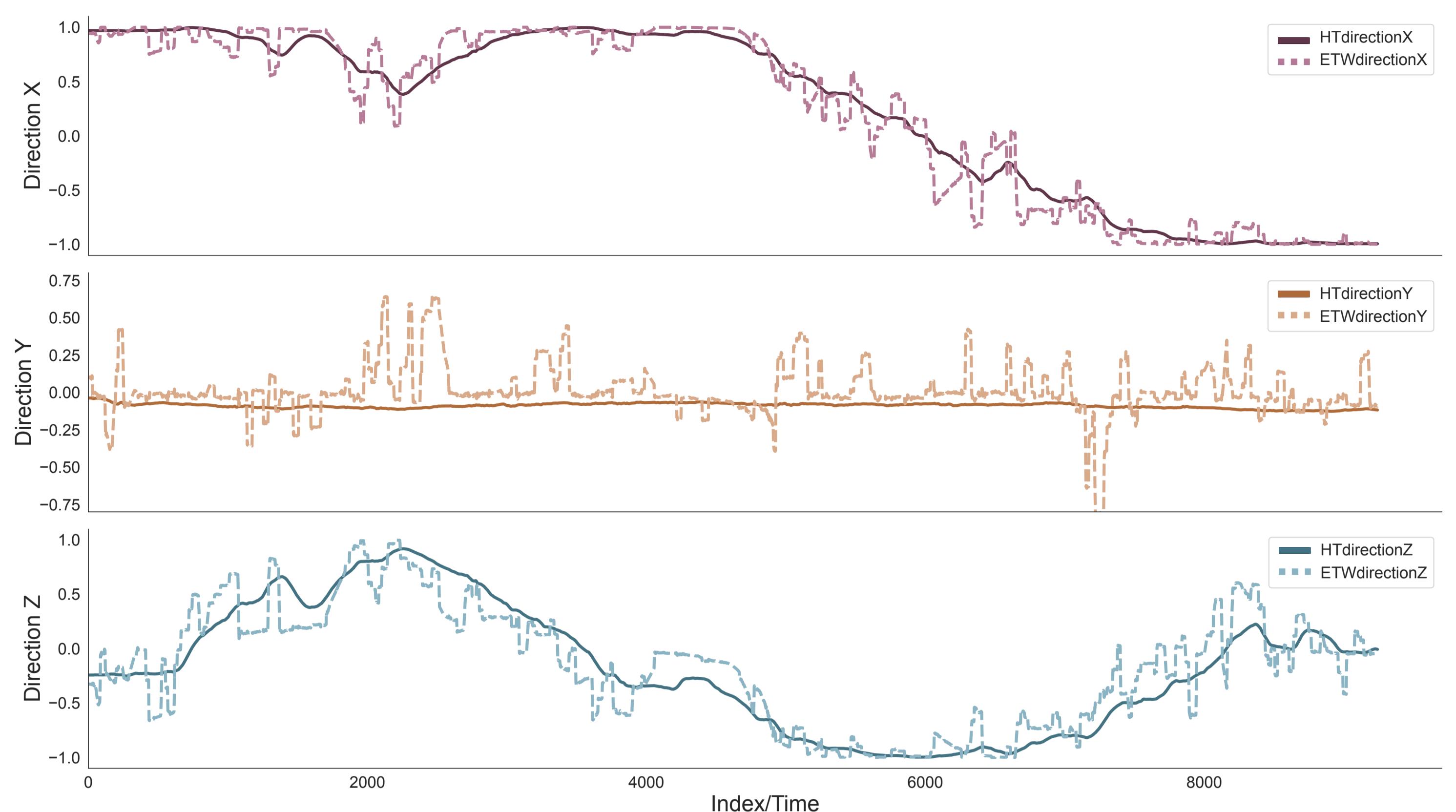


Fig. 3: Head and eye axes' directions

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

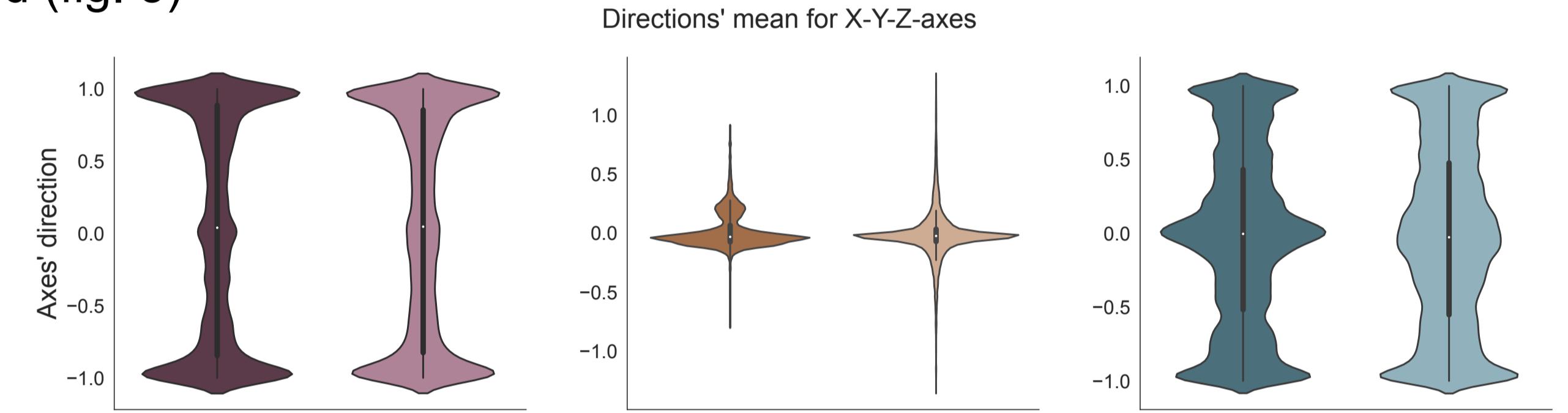


Fig. 4: Head and eye distributions

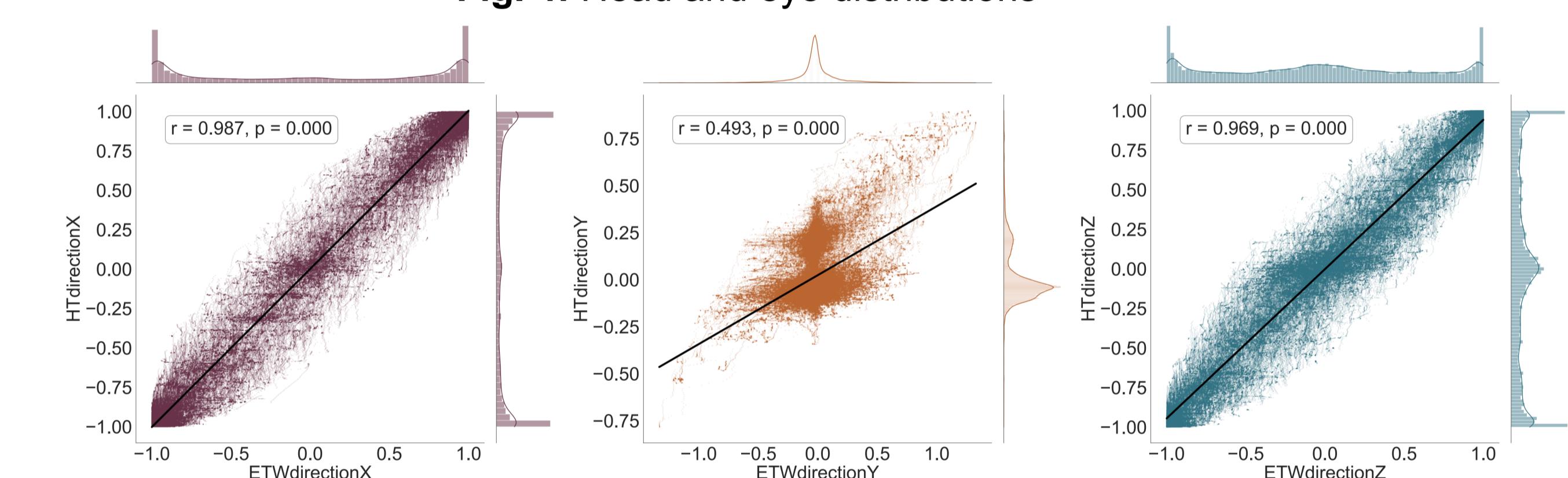


Fig. 5: Axes' correlations

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

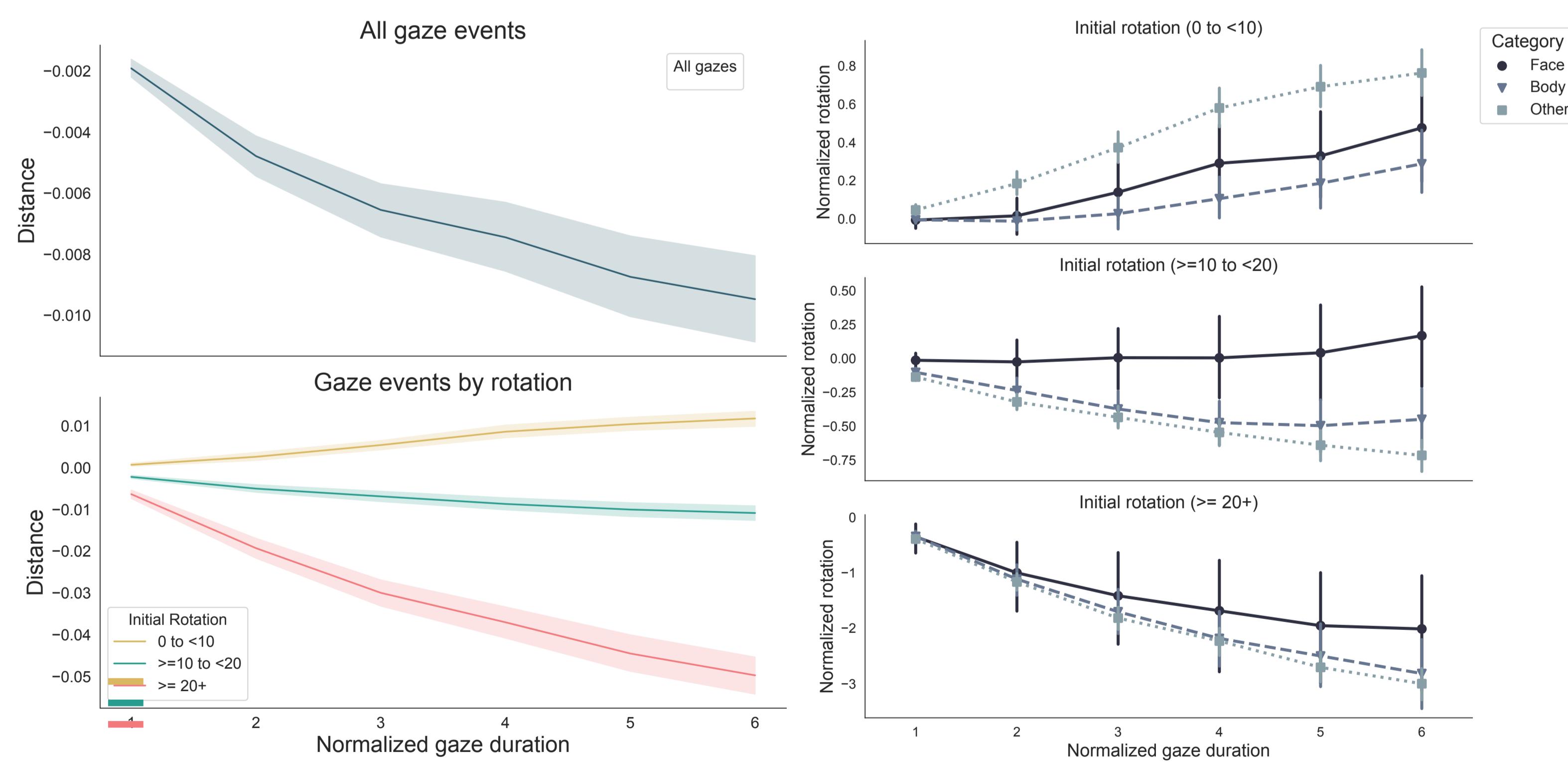


Fig. 6: Angles' distances during gaze events

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:

- [1] I. B. Adhanom, P. MacNeilage, and E. Folmer, "Eye Tracking in Virtual Reality: a Broad Review of Applications and Challenges," *Virtual Reality*, Jan. 2023, doi: 10.1007/s10055-022-00738-z.
- [2] N. Fogt and T. W. Person, "A Pilot Study of Horizontal Head and Eye Rotations in Baseball Batting," *Optometry and vision science : official publication of the American Academy of Optometry*, vol. 94, no. 8, p. 789, Aug. 2017, doi: 10.1097/OPX.0000000000001100.
- [3] N. Fogt and T. W. Person, "Vertical head and eye movements in baseball batting," *Optom Vis Perform*, vol. 8, no. 3, pp. 129–134, Sep. 2020.
- [4] Y. Kishita, H. Ueda, and M. Kashino, "Eye and Head Movements of Elite Baseball Players in Real Batting," *Frontiers in Sports and Active Living*, vol. 2, 2020, Accessed: Oct. 21, 2022. [Online]. Available: <https://www.frontiersin.org/articles/10.3389/fspor.2020.00003>
- [5] D. Nolte, M. Vidal De Palol, A. Keshava, J. Madrid-Carvajal, A. Gert, E.-M. von Butler, P. Komurluoglu, and P. Konig, "Combining EEG and Eye-Tracking in Virtual Reality - Obtaining Fixation-Onset ERPs and ERSPs. Attention, Perception, Psychophysics, submitted."