

Does Eye Position Alter Depth Perception? An Evaluation of Perceptual Effects Deriving from Pupil Swim Distortions in HMDs



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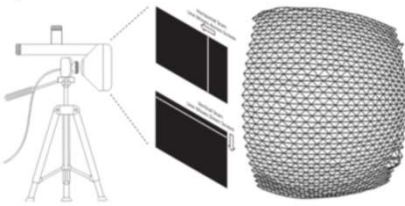


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Aim 1: Distortion

- Use computer vision and image processing to measure lens distortion from camera-lens misalignment simulating IPD mismatch.
- Predistortion is based on the lens's optical center, but distortion varies with eye position and gaze. Previous work_[1] shows distortion from misalignment up to 3° of displacement.



Measurement Method

- Contrast images between the ideal viewing location and when displacing the camera position.

Current HMDs:

(a) Meta Quest Pro, (b) HTC Vive Pro 2, (c) Pimax 8k, and (d) FakeSpace Wide 5



Aim 2: Perception

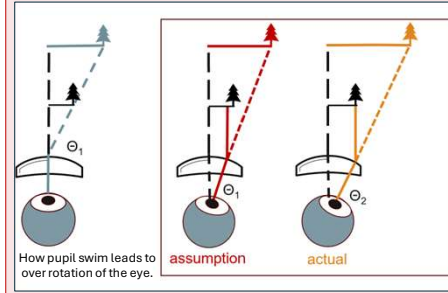
- Through eye tracking, show lens distortion from misalignment causes perceivable error.
- Pupil swim: perceived change of image quality as the eye moves or rotates within the system pupil or eyebox_[2].

Eye Tracking Task

- Participants (N = 10) were asked to monocularly (right-eye) fixate on targets sized 1° visual angle in a Varjo XR-3.



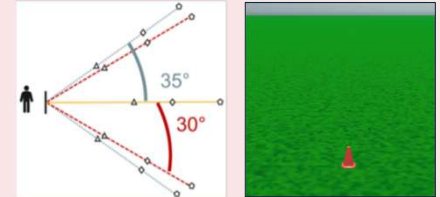
Varjo XR-3
200Hz Eye-tracker
Aspherical Lenses



Aim 3: Action

- Assess whether these perceptual errors affect depth perception in action space (blind walking) or personal space (blind reaching).
- Previous work shows mixed results of distortions from pupil swim leading to errors in depth perception_[3].

Blind Walking Task

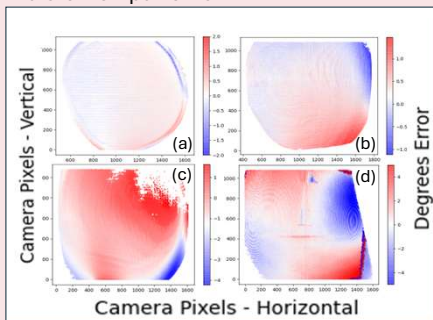


- Participants (N=46) assess target placement and then walk without vision to the target location.
- To induce pupil swim, participants could not rotate their head and used their eyes to find targets in the periphery.
- Using the HTC Vive Pro (N=22) or Varjo XR-3 (N=24), subjects completed the task with a matched IPD and a mismatched setting (max possible IPD displacement).

3 Preliminary Results

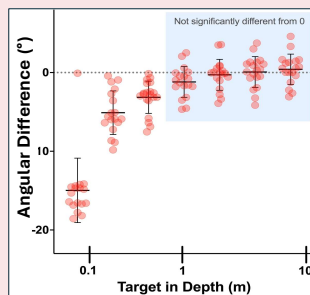
HMD Measurement Results

- The more saturated the color the stronger the distortion from misalignment.
- Different HMDs manifest different distortion patterns.



Eye Tracking Results

- Fixation location skewed in the direction of eye rotation when converging on targets 0.5m or closer causing the eye to over-rotate.



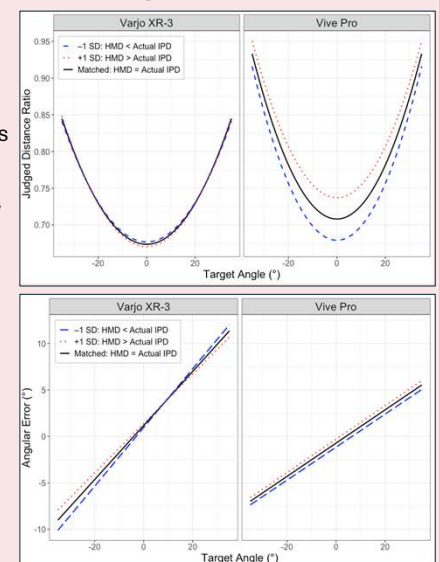
Blind Walking Results

- Distances to the periphery yielded greater distance estimates, replicating previous results_[4].

- IPD mismatch only affected depth judgments for the HTC Vive Pro.



Demo showcasing IPD mismatch!



4 Future Work & Discussion

- Preliminary results suggest distortion from eye rotation or IPD mismatch can alter depth perception in HMDs. Furthermore, particular HMDs may be more susceptible to these distortions.
- Women and children are disproportionately affected by the accommodation of IPDs in HMDs typically forcing an IPD mismatch and its distortions_[5,6].
- Ongoing work explores pupil swim's influence on depth perception in personal space.
- Open questions remain on minimizing these distortions through software predistortions_[7] or hardware exit pupil steering_[8].

ACKNOWLEDGEMENTS

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