Tracking Perceptual Depth Changes with Eye Vergence and Inter Pupillary Distance in a Virtual Reality Environment

Mohammed Safayet Arefin
Mississippi State University

J. Edward Swan II
Mississippi State University

Russell Cohen Hoffing
DEVCOM US Army Research Laboratory

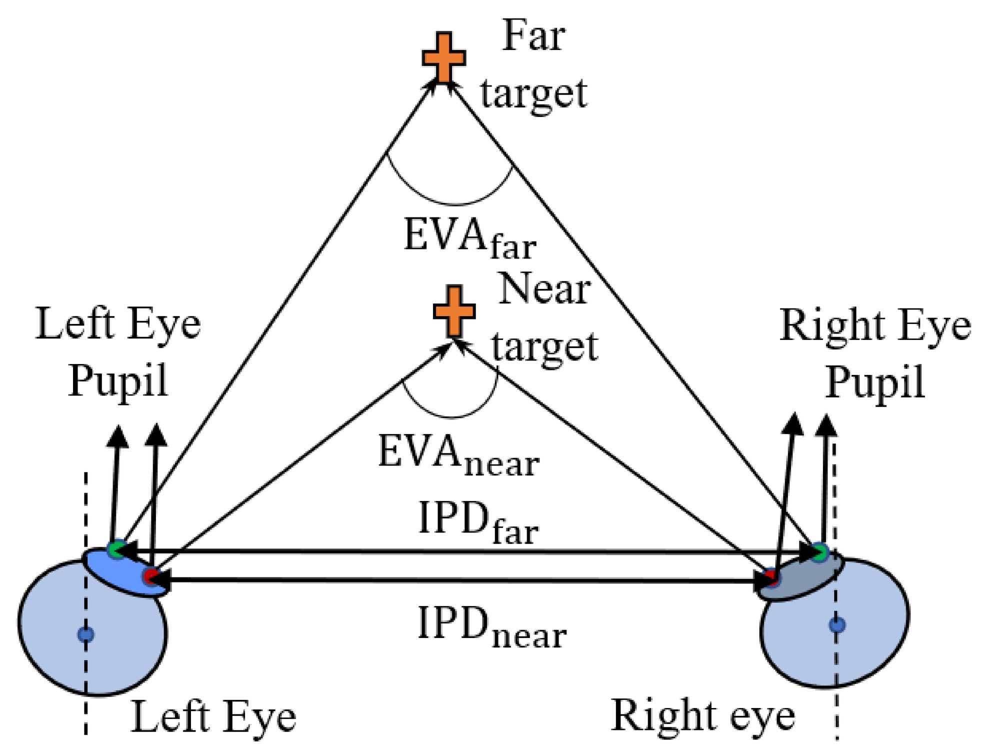
Steven M. Thurman
DEVCOM US Army Research Laboratory

Introduction

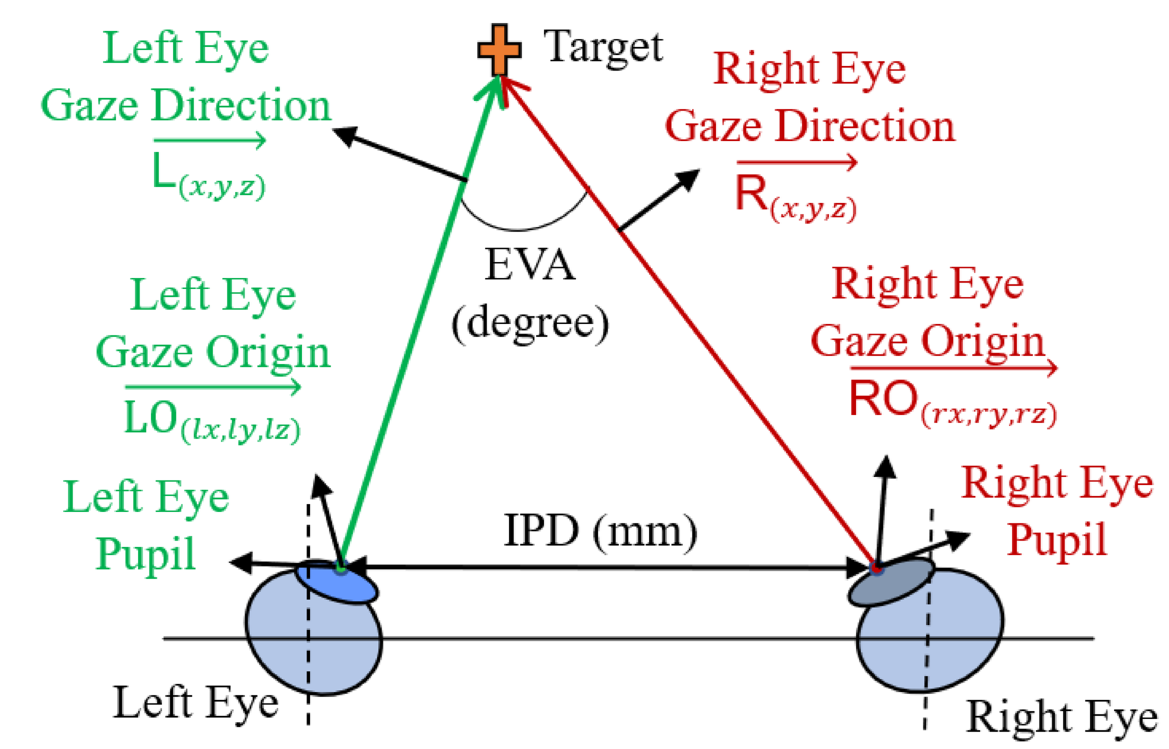
- Recent commercial technology developments have allowed the combination of VR and eye-tracking.
- This technological advancement allows for the investigation of novel research questions.

- **Research Question:** How does our visual system behave in response to depth changes in VR?
- **Research Goal:** *To investigate whether perceptual depth can be tracked using eye-tracking data in VR by considering eye vergence angle and inter pupillary distance (IPD).*

Eye Vergence Angle and IPD



Changes in Eye Vergence Angle (EVA) and IPD at a near and far target

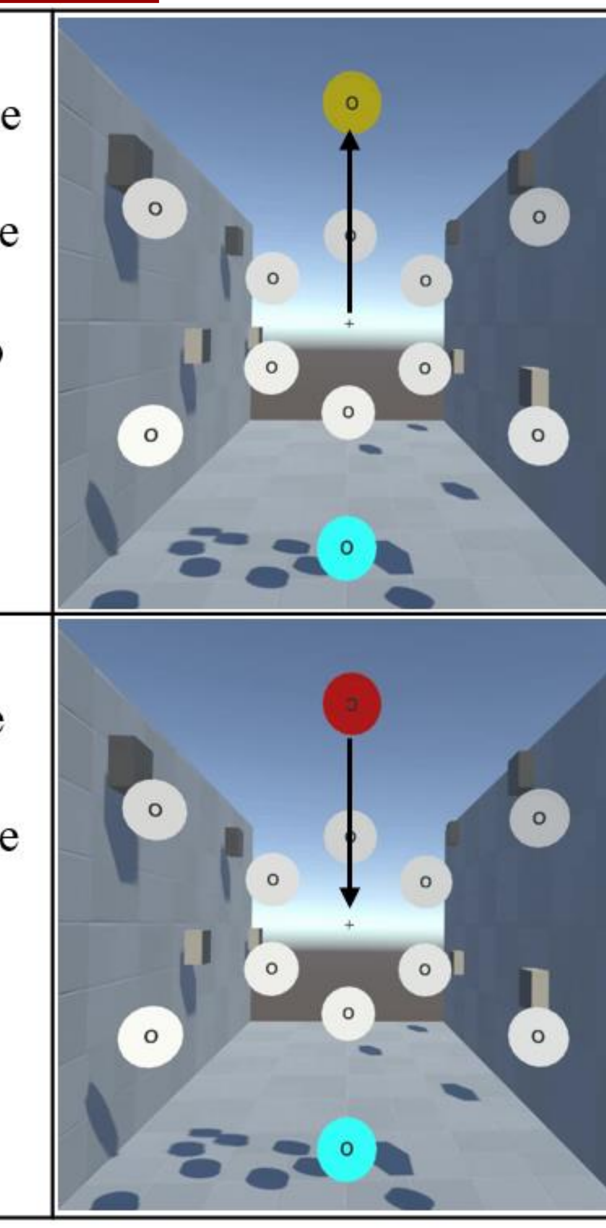


Calculating Eye Vergence Angle (EVA) and IPD from eye tracker data

Methods

Convergence (Shifting eye gaze from the cross to the virtual disk)

Divergence (Shifting eye gaze from the virtual disk to the cross)

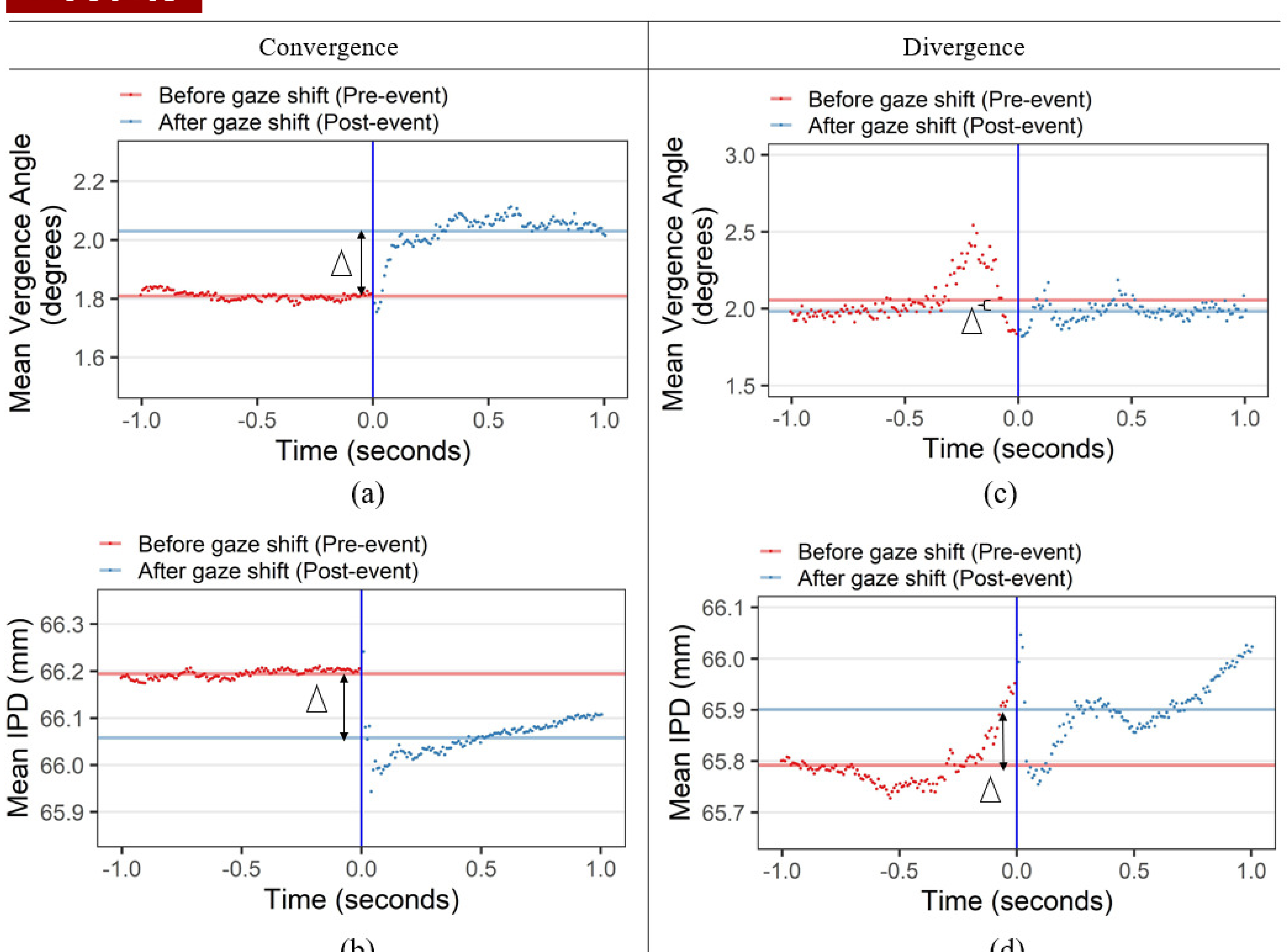


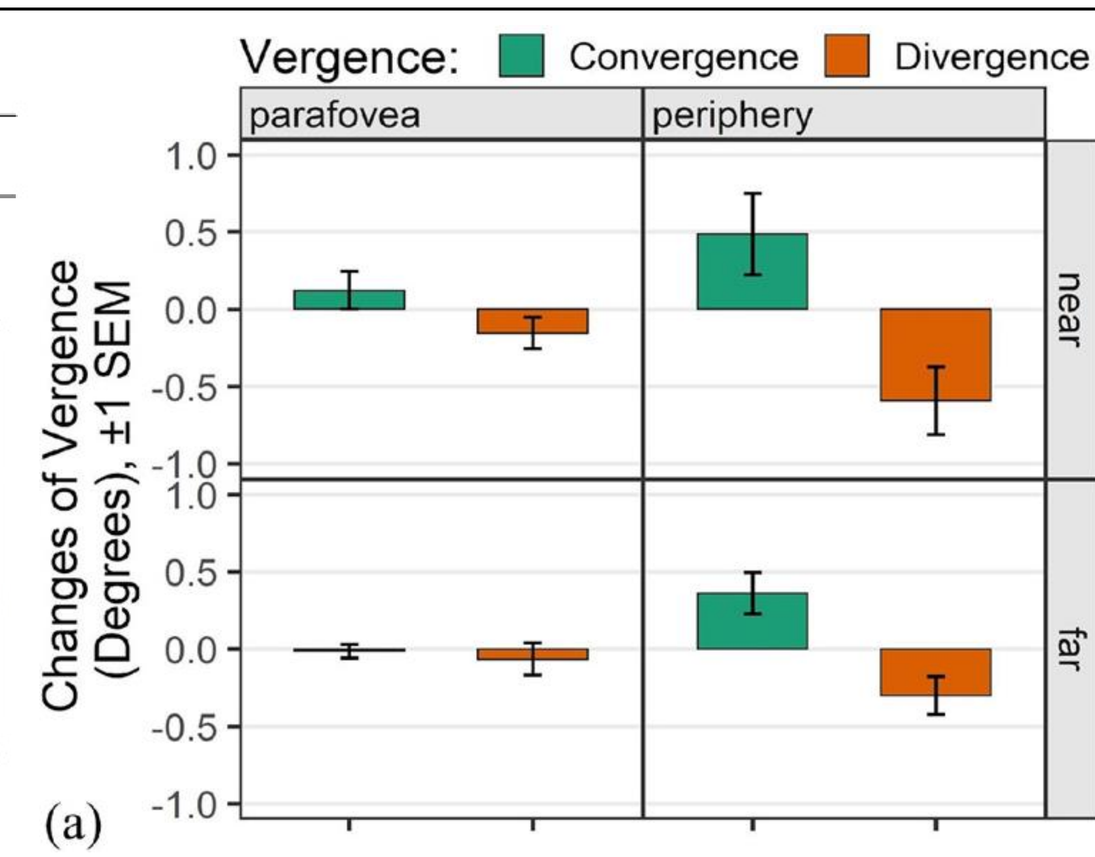
- 2 AFC Visual discrimination task
- HTC Vive VR headset
- Eye-tracking from Tobii Technologies
- 24 subjects

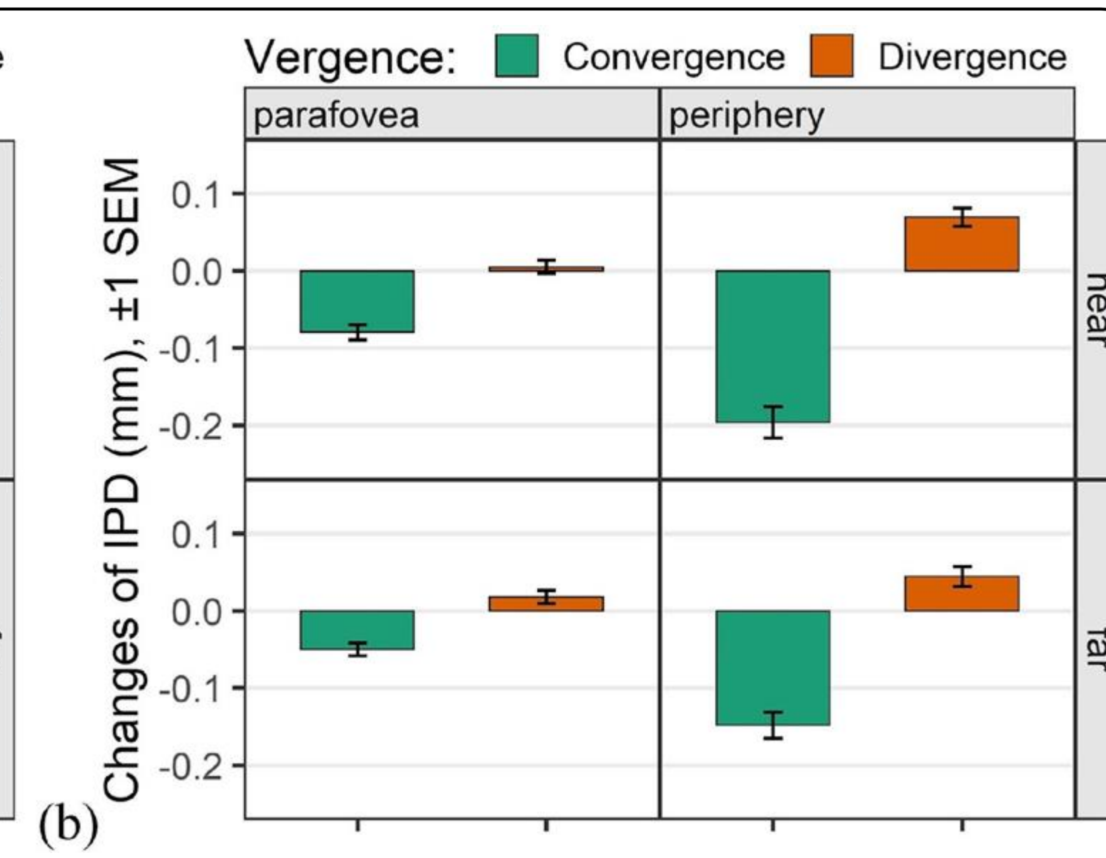
Hypotheses

- **H1:** When shifting the eye gaze from the far distance to the near distance, the eye vergence angle will increase and IPD will decrease.
- **H2:** When shifting the eye gaze from the near distance to the far distance, the eye vergence angle will decrease and IPD will increase.
- **H3:** The degree of change in these metrics will map onto the magnitude of expected perceptual depth changes.

Results







- Transition from the pre-event to the post-event during the *convergence phase* increased eye vergence angle and decreased IPD, as hypothesized in H1.
- Transition from the pre-event to the post-event during the *divergence phase* decreased eye vergence angle and increased IPD, as hypothesized in H2.
- Degree of change in eye vergence angle and IPD would reflect the degree of change in perceptual depth, as hypothesized in H3.
  - In the near periphery condition, the largest perceptual depth changes occurred, as eye vergence angle and IPD change values were largest in convergence and divergence.
  - In the far parafoveal condition, where perceptual depth discrepancies were expected to be the smallest, changes in eye vergence angle and IPD were the smallest in convergence and divergence.

Conclusion

- Successfully predicted perceptual depth changes with an eye tracker enabled VR display.
- Both EVA and IPD behaved according to our hypothesis, as well as consistent with the theory of how the human visual system responds to depth changes.
- Further experimentation will allow for developing this method to improve the interactive AR/VR display experience.

Corresponding author: arefin@acm.org