Synchronized multi-person eye-tracking in dynamic scenes

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Introduction

- Eye movements are linked to audiovisual perception, attention and aesthetic evaluation.
- Real world applications provide ecological and external validity to eye-tracking studies.
- However, current methods are limited to controlled, single-person setups.

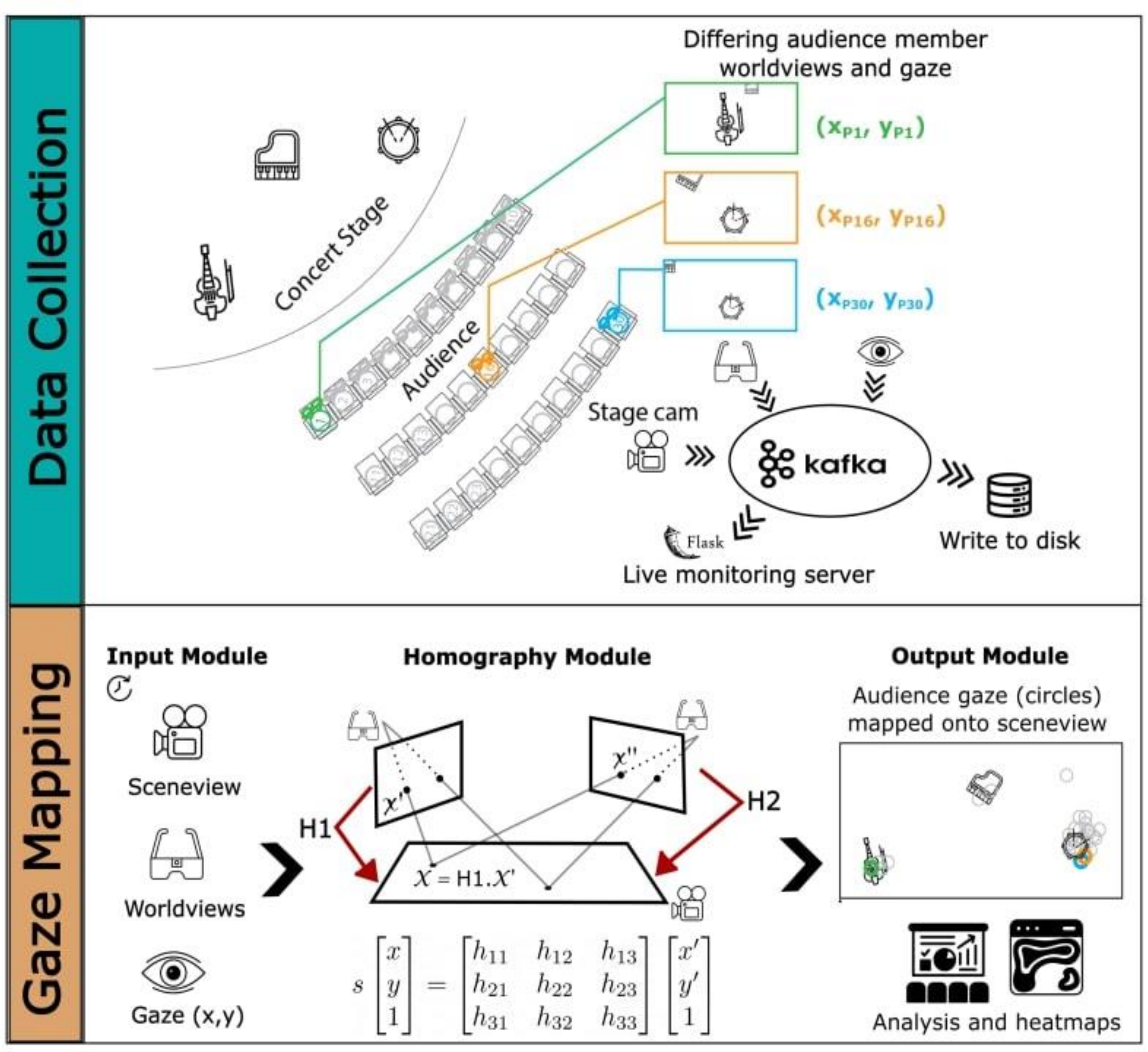
Challenges

- Synchronized data collection from multiple sensors in a shared physical space.
- Joint analysis of egocentric gaze data from differing viewing perspectives.

Current Study

- Validate multi-person eye-tracking in a concert hall setting.
- Stream simultaneous gaze data from eye-tracking glasses worn by audience members.
- Synchronize incoming streams and add timestamps for event triggers.
- Perform homography to map each wearer's egocentric view to a central view of the stage.
- Characterize performance over a comprehensive battery of tasks.

Software Design Pattern



- Gaze and worldview recorded from the viewer's perspective.
- Sceneview recorded from a stationary stage camera placed centrally.
- Data Collection layer initiates synchronized recording from all devices.
- Incoming gaze, worldviews, and sceneview are efficiently streamed using Apache Kafka.
- Deep-learning-based feature mapping[2] and homography projects gaze to sceneview.
- Transformed gaze is analyzed and plotted in the output module.

Utility test

- 2 participants seated at extreme angles in a concert hall (row 1 left & row 2 right).
- Pupil Labs Invisible devices used to record gaze during a percussion concert.
- Homography: SuperGlue[2] method outperformed standard SIFT+RANSAC.
- Projections were robust to motion artifacts, occlusions and low-textured or dark regions.
- Projected heatmaps show diverging heatmap clusters highlighting varying optimal experiences characterized by varying attentional interests and viewing angles. (Fig. 1)
- Gaze coordination was highest during the "performance" parts of the concert. (Fig. 1)

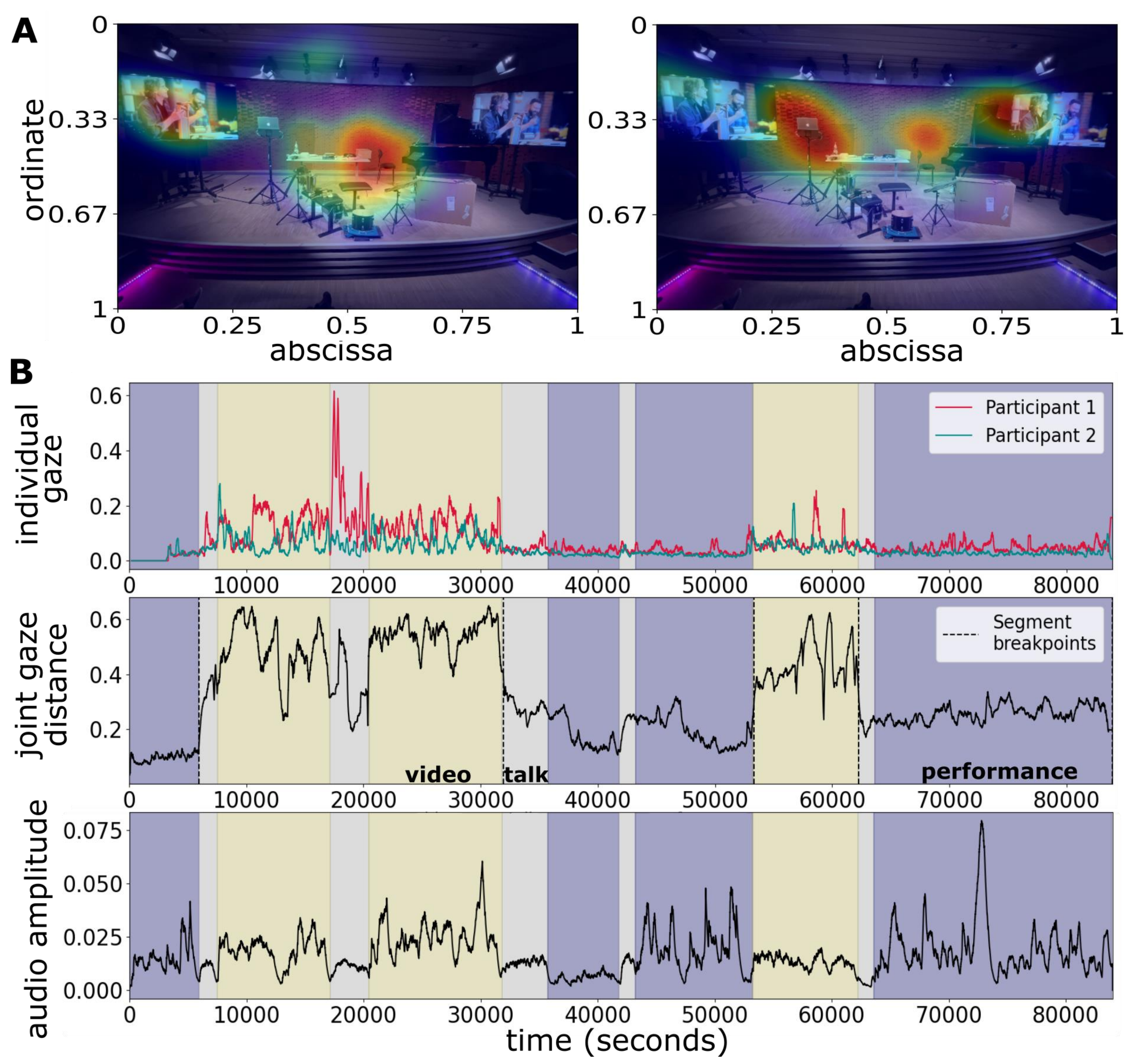
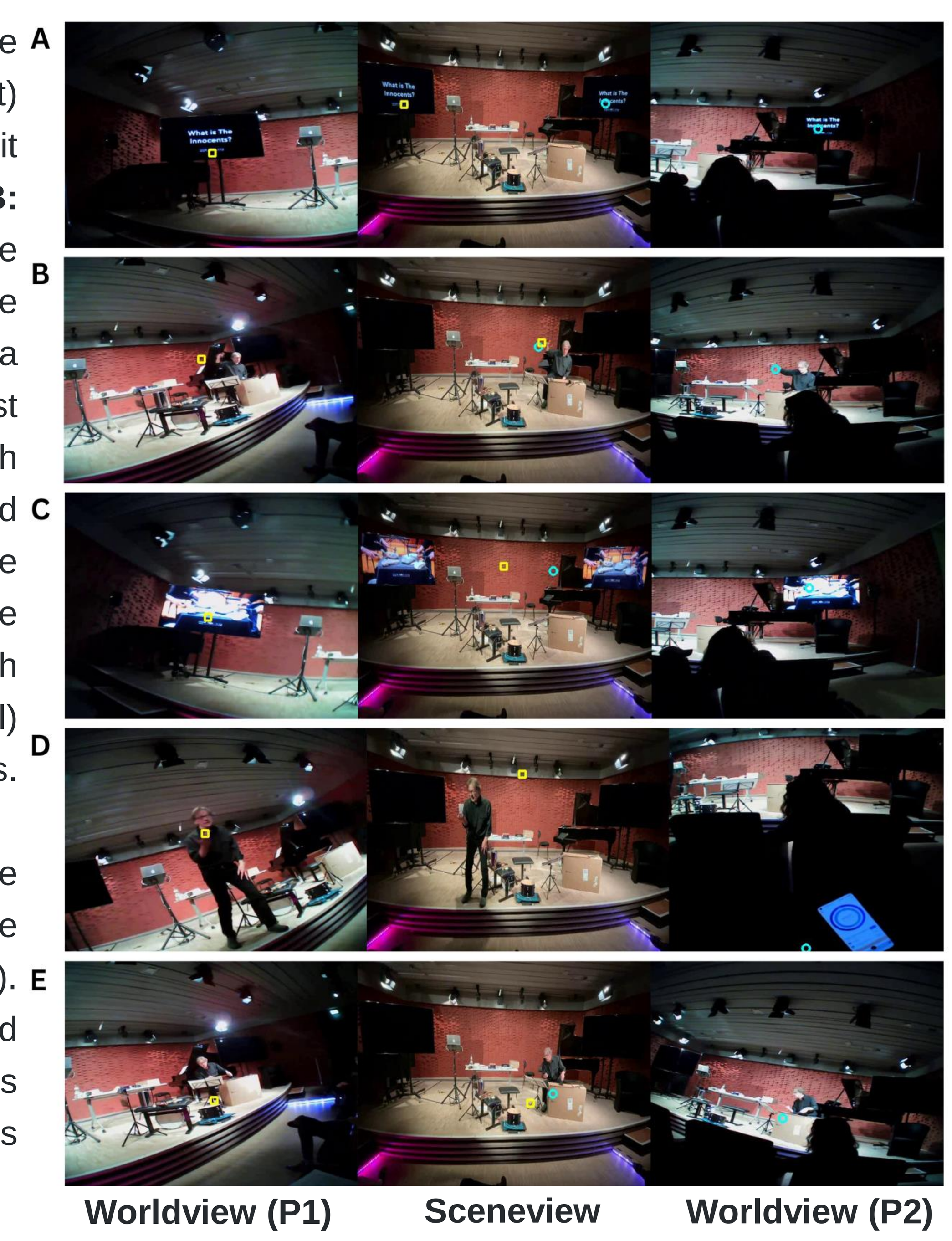


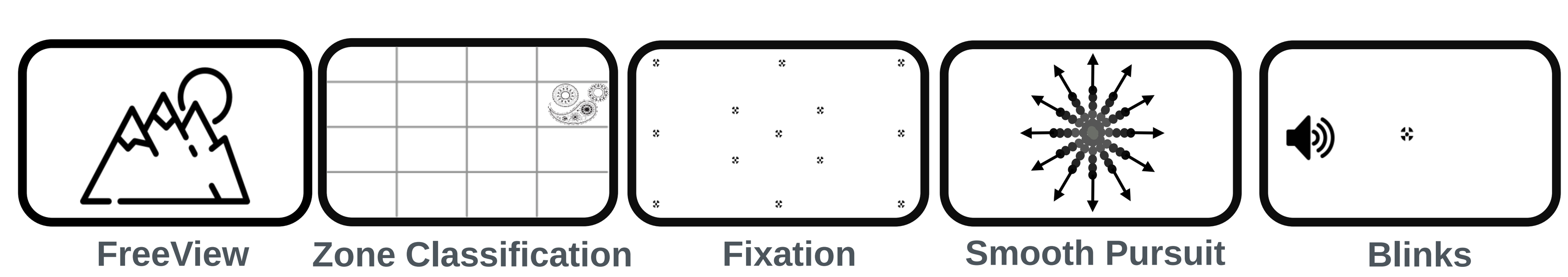
Figure 1 (Above) A: Projected gaze heatmaps for participant 1 (seated left) and participant 2 (seated right) exhibit noticeable and separate clusters. **B:** Timeseries of individual gaze dispersion (top panel) and joint gaze distance (middle panel) on a normalized 2D plane. Strongest heatmap similarity was aligned with lowest individual gaze dispersion and lowest joint distance during the 'performance' parts. Joint distance was also moderately correlated with the audio timeseries (bottom panel) during video parts.

Figure 2 (Right): Participants' gaze (left and right column) projected to the sceneview (middle column). Projections were robust to head movements and scene occlusions (**A**,**E**) but struggle with close distances and duplicate objects (**B**,**C**,**D**).



Next Steps

- N = 4 Pupil Labs Neon devices * 10 groups = 40 Participants
- Participants presented with an eye-tracking task battery proposed in our previous work[1].
- Runtime tests of streaming sample-rate, frame drops and time synchronization.
- Accuracy measures of projected gaze for tasks in the battery.
- Comparison with lab-based and online eye-tracking accuracy evaluated on same tasks.
- Develop Online and Offline modes for the proposed framework.
- Improve precision of projected gaze points by incorporating past temporal information.



References

1. Saxena, S., Lange, E. B., & Fink, L. (2023). Deep Learning Models for Webcam Eye-tracking in Online Experiments. *Behavior Research Methods* (accepted, in press). PrePrint, https://osf.io/42qej/
2. Sarlin, P.-E., DeTone, D., Malisiewicz, T., & Rabinovich, A. (2020). SuperGlue: Learning Feature Matching with Graph Neural Networks (arXiv:1911.11763). arXiv. http://arxiv.org/abs/1911.11763

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