How do visitors explore a virtual museum in XR? Behavioral profiles from an in-person study

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Background, research program, and stage

Virtual museums offer new ways to explore cultural content, but visitors may differ in how they move through the space, direct their attention, and engage with exhibits. This undergraduate thesis study analyzes visitor behavior in MusePlore [2] , an XR virtual museum, using data collected during free exploration. The study and analysis are complete; the findings are exploratory and need testing with broader samples.

Research objective and question

The study aims to identify interpretable patterns in how people explore and interact with a virtual museum. The research question we aim to answer is "**Can movement, head-motion and attention, and exhibit-interaction data reveal distinct behavioral profiles among visitors exploring a virtual museum in XR?**"

Motivation and connection to the state of the art

Prior work has studied visitor types using spatial and interaction data in virtual museums, and analyzed behavioral patterns in museum settings [1, 2]. This study examines how multiple behavioral signals (e.g., movement, head movement, attention states, and exhibit-panel interactions) can be combined to characterize visitor behavior in an XR museum.

Main contributions

- A feature-based approach for analyzing visitor movement, attention, and exhibit interactions in an XR virtual museum.
- An exploratory clustering analysis that characterizes **two behavioral profiles** in a sample of 46 participants.

Innovation potential and applications

The findings suggest that visitor interaction traces could help museum designers understand different exploration styles and inform future adaptive experiences. For example, adjusting exhibit guidance or information presentation. Further work is needed before using these profiles to personalize experiences.

Methodology

- Recruited 46 participants for an in-person study.
- Asked each participant to freely explore the MusePlore XR virtual museum using a Meta Quest Pro.
- Recorded navigation and interaction data during each visit.
- Derived 40 features per participant, covering movement and navigation, head movement and attention, exhibit interactions, visit timing, and proximity to exhibits.
- Selected a candidate set of 13 features and removed two highly correlated features, leaving 11 features for clustering.
- Standardized the selected features and applied hierarchical clustering and k-means to compare visitor groupings.
- Evaluated candidate cluster solutions.
- Compared the resulting groups on behavioral measures that were not used to form the clusters.

Implementation approach

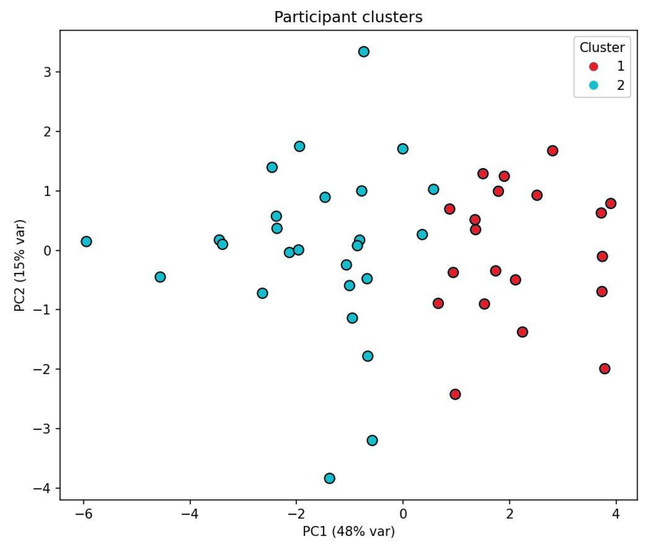
The study used MusePlore, adapted for XR with Unity and OpenXR. Visitors explored the museum using a Meta Quest Pro headset. The analysis used recorded navigation and interaction data, including head movement and exhibit-panel visibility.

Preliminary results

The outcome of the final clustering was a two-profile solution:

- **Efficient Explorers** (n = 26): faster movement, less time stationary, and lower exhibit-panel time and engagement efficiency.
- **In-Depth Visitors** (n = 20): slower movement, more time stationary, and higher exhibit-panel time and engagement efficiency.

The profiles are relative to the study sample. The selected two-cluster solution had a silhouette score of approximately 0.27 and bootstrap Jaccard stability of 0.51 – 0.53. More than 11 behavioral measures not used to form the clusters showed statistically significant group differences after false-discovery-rate correction (reported adjusted $p < 0.01$).



Expected impact and added value

The study provides an initial account of how movement and exhibit engagement can be analyzed together in an XR museum. It offers a basis for further research on visitor behavior and for designing museum experiences that better support different exploration styles.

Current progress, future work, and open questions

The thesis analysis is complete. Next steps include testing the profiles with a larger and more diverse sample, examining behavior around specific exhibits, and checking whether the patterns hold across museum applications and devices.

Questions for discussion:

- Do these profiles persist across different museums, exhibits, and visitor populations?
- Are the profiles best understood as visitor "types" or as points along a continuum of exploration behavior?
- Which forms of guidance or exhibit presentation could support each exploration style without limiting visitor choice?

References

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2. Panos, F., Raptis, G. E., Katsini, C., & Katsanos, C. (2024, June 27). Towards identifying visitor types in virtual museums using spatial and interaction data. Adjunct Proceedings of the 32nd ACM Conference on User Modeling, Adaptation and Personalization, 505–509. Presented at the UMAP '24: 32nd ACM Conference on User Modeling, Adaptation and Personalization, Cagliari, Italy. doi:10.1145/3631700.3664908