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# Efficiency of Mini-Map Navigation in Virtual Topographical Space

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**Abstract:**

The efficiency of mini-maps as indispensable tools for navigation in virtual topographic spaces is a critical aspect of cartographic research that has not yet been sufficiently explored. Mini-maps are traditionally used for spatial orientation in various applications, but their design and performance in complex, three-dimensional environments enriched with topographic data require further investigation (Johanson et al., 2017). Existing literature emphasizes the importance of thoughtful cartographic design as it directly affects user comprehension and task performance in navigation contexts (Medyńska-Gulij et al., 2022; Kapaj et al., 2023). Despite advances in cartographic visualization and human-computer interaction, there remain gaps in understanding how mini-maps function as effective cartographic tools in dynamic virtual environments, particularly when combined with detailed topographic data (Tahir and Krogstie, 2023). This study seeks to address these gaps by examining the relationship between specific mini-map attributes and user navigation performance, thereby offering new insights into cartographic interface design in virtual spaces.

A key component of this research is the development of a conceptual database of mini-map attributes, including variables such as shape, position, orientation, centering, projection, base layers, proportions, and additional navigational elements (Zagata and Medyńska-Gulij, 2023). These features are synthesized based on a comprehensive review of cartographic design principles, video game design, and user interface literature. To simulate realistic navigation scenarios, a 3D virtual topographic environment has been constructed using detailed geographic data. Within this controlled setting, eight different mini-map prototypes, differing in visual and functional characteristics, are tested to assess how specific design choices influence user performance (Figure 1).

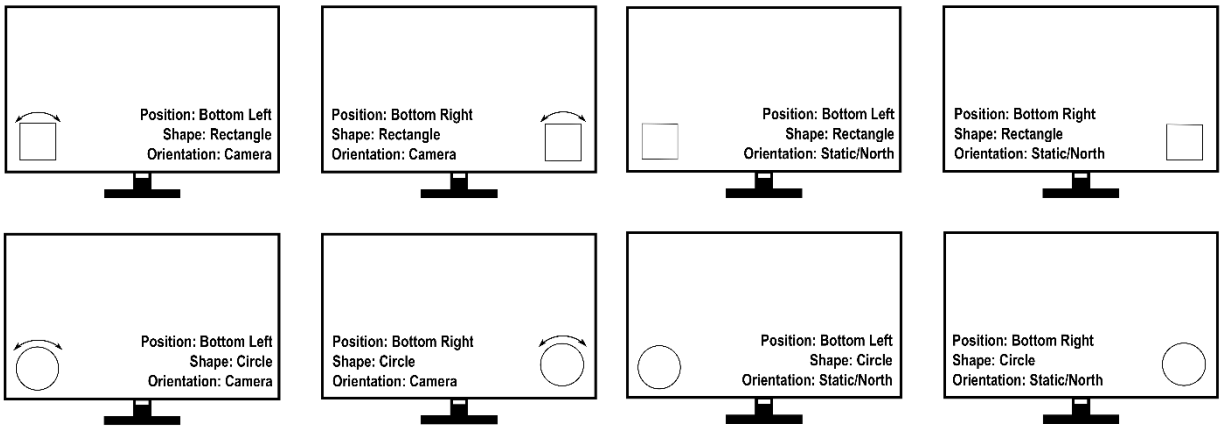


Figure 1. Types of mini-maps in the interface used in the study in topographic space

The empirical study includes over 200 participants, all of whom are geography students representing both video game players and non-players. After completing a standardized tutorial introducing the virtual environment, participants perform a series of tasks such as navigating from point A to point B based on textual and visual instructions. The independent variables in the study are the mini-map design parameters, for example shape, position, and orientation, while the dependent variables include navigation time, path length, eye-tracking gaze patterns, turn frequency, and spatial accuracy. Statistical testing is applied to analyze relationships between map design and user performance.

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This research provides a structured framework for the evaluation and optimization of mini-maps as effective navigational aids in topographic virtual environments. The study emphasizes key design principles such as simplicity, clarity, and interactivity, supported by user-centered testing and eye-tracking data. A novel aspect of this work lies in its large-scale integration of controlled topographic environments with detailed behavioral analysis, offering a comprehensive perspective on user navigation strategies. The methodological approach contributes to the advancement of digital cartography and its practical applications in spatial interaction interfaces. The findings are expected to inform future developments in geographic visualization, human-computer interaction, and virtual navigation systems. Further research may explore the scalability of this framework across diverse platforms and user groups, as well as its integration with emerging technologies including augmented reality.

**References**

Johanson, C., Gutwin, C., Mandryk, R.L., 2017. The Effects of Navigation Assistance on Spatial Learning and Performance in a 3D Game. In Proceedings of the Annual Symposium on Computer-Human Interaction in Play. Association for Computing Machinery, New York, NY, USA, 15–18 October 2017.

Kapaj, A., Lanini-Maggi, S., Hilton, C., Cheng, B., & Fabrikant, S. I., 2023. How does the design of landmarks on a mobile map influence wayfinding experts' spatial learning during a real-world navigation task? Cartography and Geographic Information Science, 50(2), 197–213.

Medyńska-Gulij, B., Gulij, J., Cybulski, P., Zagata, K., Zawadzki, J., Horbiński, T., 2022. Map Design and Usability of a Simplified Topographic 2D Map on the Smartphone in Landscape and Portrait Orientations, ISPRS Int. J. Geo-Inf., 11, 577.

Tahir, R. Krogstie, J., 2023. Impact of Navigation Aid and Spatial Ability Skills on Wayfinding Performance and Workload in Indoor-Outdoor Campus Navigation: Challenges and Design. Appl. Sci. 2023, 13, 9508.

Zagata, K., Medyńska-Gulij, B., 2023. Mini-Map Design Features as a Navigation Aid in the Virtual Geographical Space Based on Video Games. ISPRS Int. J. Geo-Inf. 2023, 12, 58.

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