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Context-Based Visual Search on a Mobile Map

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Abstract: Mobile mapping applications represent a widely adopted solution for navigation within urban environments. The pervasive accessibility of smartphones, combined with a diverse array of navigation platforms, facilitates rapid and convenient access to geospatial information. This technological integration enhances users' ability to efficiently orient themselves and plan routes, addressing the spatial complexities characteristic of urban areas. However, the operational context of the user and the visual information displayed on the map during navigation play a crucial role in successful interaction (Nivala & Sarjakoski, 2007). This aligns with psychological research findings, which suggest that locating an element within its natural context significantly improves the ease of identification and recognition (Wolfe, 2020).

In this study we have asked participants to identify the symbol presence or absence on mobile map, and also to find specific target symbol within the building structures and outside of them. This study aims to systematically explore and analyze the key factors that affect user performance in tasks involving mobile map applications. The primary focus is on understanding how users detect and interpret pictorial symbols within diverse spatial contexts while performing navigation-related activities. This capability is enabled by the integration of eye-tracking technology, a powerful tool that facilitates the detailed observation and analysis of users' visual behavior (Kiefer at al. 2013; Lloyd, 2005). By capturing and quantifying metrics such as gaze fixation duration, saccadic movement trajectories, and changes in pupil dilation, this technology provides valuable insights into how users interact with visual elements (Krassanakis & Cybulski, 2021). These measurements offer a deeper understanding of cognitive load, attention distribution, and information processing patterns during task execution (Rymarkiewicz et al. 2024).

For data collection, a Gazepoint GP3 HD eye tracker with a 150 Hz sampling rate was utilized. Calibration was conducted using the 5-point method, ensuring an eye-tracking accuracy of 0.5° viewing angle. A Samsung Galaxy M22 smartphone with a 6.4-inch screen served as the display device for the downloaded videos. To ensure stability, the phone was secured on a stand, preventing any movement of the display. Participants maintained an average distance of approximately 61 cm (SD = 2 cm) from the eye tracker during the study. A total of 58 participants (40 men and 18 women), with a mean age of 21 years (SD = 3 years), participated in the experiment. Participants were asked to report their average daily smartphone usage time over the past week, with this information verified using data from their mobile devices.

Participants faced tasks of varying complexity, with the most challenging requiring them to locate a point within a building. This difficulty likely arose from a mismatch between user expectations and the spatial context of the task. Since the accompanying video showed movement outside the building, participants were inclined to focus on external features, overlooking interior details. This observation highlights the significant influence of contextual cues and user expectations on navigation behavior. Moreover, it aligns with principles of visual perception, which stress the importance of context in simplifying visual search processes. Psychological studies further corroborate this idea, demonstrating that identifying elements within familiar or expected contexts enhances both accuracy and efficiency (Chun & Jiang, 1998).

This study addresses that gap by integrating eye-tracking methodology to investigate how users visually search for and interpret pictorial symbols in dynamic mobile map environments—specifically examining both interior and exterior spatial contexts. Unlike prior work, which typically evaluates map effectiveness based on general usability or user preferences, this research provides an objective, behavioral basis for evaluating map symbol recognition using metrics such as fixation duration, saccadic movements, and gaze patterns (Kiefer et al., 2013; Krassanakis & Cybulski, 2021; Rymarkiewicz et al., 2024). By systematically comparing task performance across spatial settings and examining how user expectations align or misalign with visual context, the study reveals how contextual congruence influences symbol

detection efficiency. In doing so, it bridges a gap between cognitive psychology, eye movement research, and mobile cartography. Furthermore, it extends earlier work by incorporating user behavior variability based on smartphone usage patterns—a factor rarely examined in connection with visual search in mobile map applications (Bartling et al., 2022).

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