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Inferring users' tasks on maps based on eye movement and EEG data

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Abstract:

Understanding and recognizing users' tasks on a map is vital for designing adaptive maps that can automatically tailor their contents and visualization to user needs and contexts. Eye tracking (ET) has previously demonstrated its effectiveness in helping identify users' activities on maps (Kiefer et al., 2013), while electroencephalography (EEG) has been employed to measure the cognitive load of users during map interactions. However, the integration of both ET and EEG to enhance the recognition of map tasks has not been extensively explored in prior research.

In our study, we proposed a computational method to infer users' tasks on maps using ET and EEG data. More specifically, we designed an experiment to collect both ET and EEG data from participants who engaged in four distinct map tasks on Google Maps: Global search (search the whole map area to find a specific point of interest POI), Distance comparison (given four POIs, identify which one is the closest), Route following (follow and navigate a predefined path on maps), and Route planning (identify the shortest path between an origin and a destination). A list of eye movement and brain signals features were proposed, extracted, and systematically selected from this combined ET and EEG dataset. Subsequently, we employed a Light Gradient-Boosting Machine (LightGBM) (Ke et al., 2017) to classify these map tasks based on these ET and EEG features.

The findings from our research were highly promising. We achieved an accuracy rate of 88.0% when we utilized a combination of both ET and EEG features throughout the entire map usage session. This accuracy significantly exceeds the accuracy obtained when using ET features alone (85.9%) or EEG features alone (53.9%). Furthermore, we also found that high recognition accuracy could be achieved very early in the session, with a 73.1% success rate in classifying map tasks within the first three seconds of a map session. In terms of feature importance, saccade features from ET contribute most for differentiating map tasks.

Our research highlights the feasibility and advantages of combining ET and EEG for enhanced task recognition in the context of map usage. The integration of these two methodologies not only deepens our understanding of the visual and cognitive processes involved in map use but also fosters the development of adaptive maps. Such maps can dynamically adjust their contents and visualization styles according to the user's activities on a map (Huang et al. 2024), potentially improving user experience during human-map interaction.

This abstract/presentation is based on the following publication (Qin et al., 2024): Qin, T., Fias, W., Van de Weghe, N., Huang, H. (2024): Recognition of Map Activities Using Eye Tracking and EEG. International Journal of Geographical Information Science, 38(3), 550–576.

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