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A pipeline for automated area-of-interest (AOI) eye fixation analyses for outdoor mobile map-assisted navigation studies

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Abstract:

Mobile eye tracking (MET), which includes the collection of a participant's gaze stream, synchronized with a scene video from a front-facing camera recording, has become popular in navigation studies conducted in real-world settings. Commonly, eye movements are captured with reference to pre-defined areas of interest (AOIs) in the scene video, allowing us to calculate fixation-related metrics based on these AOIs. MET-related dynamic AOI analyses, however, are a time-consuming and labor-intensive manual process, especially when MET scene recordings cover a long study period. This is because participants' visual input continuously changes during real-time gaze data collection, resulting in the analysis of dynamically changing AOIs. We thus set out to develop a MET AOI fixation processing pipeline using deep-learning models to automatically segment scene videos into AOIs and annotate AOI-related fixations semantically. This pipeline is developed specifically for MET data collected during mobile map-assisted navigation experiments outdoors. As illustrated in Fig. 1, collected raw gaze data is first processed with the velocity-threshold identification method (I-VT; Salvucci & Goldberg, 2000) to detect each fixation's start and end timestamps, and its location in the scene video. This information allows us to 1) extract the respective AOI frames from the scene video, 2) apply image segmentation models on these frames, and 3) semantically annotate the AOI fixations according to the image segmentation. Specifically, we trained a customized instance segmentation model using YOLOv5 (Jocher, 2020) on a pre-labeled dataset to segment a mobile map (Fig. 1: MMseg) from a scene video captured outdoors during a map-assisted navigation experiment. The dataset comprises 200 images featuring a mobile map, with 140 images utilized for training purposes derived from our outdoor study. A semantic segmentation model (Deeplabv3+; Chen et al., 2018) was further applied for fixations that are not located on the mobile map AOI. This model classifies these fixations into 19 semantic categories (i.e., building, road, person, etc.). Our developed pipeline is intended to increase the efficiency and effectiveness of MET data processing for pedestrian map-assisted navigation studies outdoors. This automatic AOI annotation pipeline will also benefit the joint analysis of further co-registered human sensor data (e.g., brain activities using EEG, emotional behavior captured with electrodermal responses, etc.).

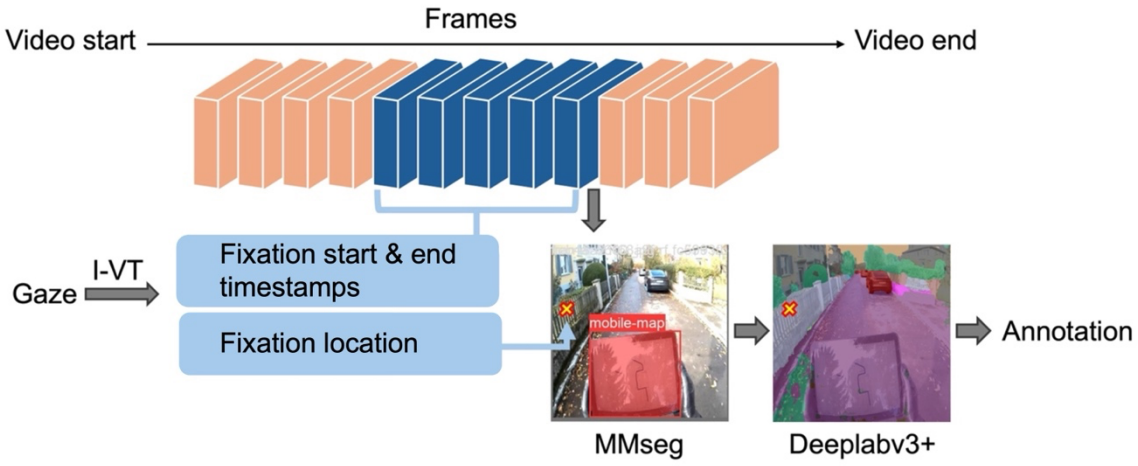

Figure 1 The proposed mobile eye tracking data processing pipeline for automatically annotating AOI-related fixations captured during mobile map-assisted outdoor navigation studies

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