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A-DisETrac Advanced Analytic Dashboard for Distributed Eye Tracking

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ABSTRACT

Understanding how individuals focus and perform visual searches during collaborative tasks can help improve user engagement. Eye tracking measures provide informative cues for such understanding. This article presents A-DisETrac, an advanced analytic dashboard for distributed eye tracking. It uses off-the-shelf eye trackers to monitor multiple users in parallel, compute both traditional and advanced gaze measures in real-time, and display them on an interactive dashboard. Using two pilot studies, the system was evaluated in terms of user experience and utility, and compared with existing work. Moreover, the system was used to study how advanced gaze measures such as ambient-focal coefficient K and real-time index of pupillary activity relate to collaborative behavior. It was observed that the time a group takes to complete a puzzle is related to the ambient visual scanning behavior quantified and groups that spent more time had more scanning behavior. User experience questionnaire results suggest that their dashboard provides a comparatively good user experience.

KEYWORDS

Advanced Gaze Measures, Data Visualization, Eye Tracking, Information Retrieval, Multi-user

1 INTRODUCTION

With the spread of COVID-19, many organizations and individuals resorted to using online platforms to interact and collaborate amidst geographic restrictions. The education industry, for instance, witnessed a large uptick in virtual learning, video conferencing, and remote collaborative activities. However, the nature of remote interaction makes individuals more susceptible to mindwandering

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and task disengagement (Cotton et al. 2023). Being able to monitor the visual attention and mental effort of each interacting party in parallel, possibly in real-time, may help in navigating through such barriers. Moreover, such information may help in developing tools, communication strategies, and work processes that adapt to one's cognitive and visual capacity. Furthermore, realtime gaze analytics can be shared analogous to methods like shared gaze (Zhao et al. 2023), where individuals see each other's gaze position on AR/VR (Blattgerste et al. 2018). Overall, the advancements in eye-tracking technology provide a strong foundation to both assess and improve the quality of remote interaction (D'Angelo et al. 2021; Jermann et al. 2011).

Traditional eye-tracking measures such as fixations, saccades, micro-saccades, and pupil diameter, and advanced eye-tracking measures, such as focal/ambient coefficient and low/high index of pupillary activity, have been widely utilized to study human visual attention (Jayawardena et al. 2020b; Krejtz et al. 2014, 2015, 2016) and cognitive load (Duchowski et al. 2018, 2020; Jayawardena et al. 2022b; Krejtz et al. 2018). Despite wide adoption, these measures are geared towards single-user studies and are thus challenging to scale for multi-user studies. To elaborate, since eye trackers are designed to capture eye movements of one individual at a time, eye-tracking studies are often carried out as single-user experiments (Jayawardena et al. 2021b; Mahanama et al. 2022c; Michalek et al. 2019; Senarath et al. 2022) in isolated environments (Mahanama 2022a, 2021). Moreover, these measures only capture individual-level behaviors and do not account for inter-individual interactions. As a result, the development of advanced measures geared toward multi-user environments plays a crucial role in analyzing eye-tracking data in our natural collaborative environments.

Recent advancements in multi-user eye-tracking (Pathirana et al. 2022), such as distributed eyetracking (Mahanama et al. 2023), have enabled the real-time measurement of user collaboration during online activities (Garcia et al. 2003; Guo et al. 2013; Langner et al. 2022; Mahanama et al. 2023). These methods primarily use traditional measures to estimate visual attention and cognitive assessment. Unlike advanced measures, they do not leverage the underlying associations between pupil and gaze responses. Therefore, we design our system to support real-time computation of both traditional (fixation duration, saccade duration, and saccade amplitude) and advanced gaze measures, namely, Ambient/Focal Attention with Coefficient $\mathcal{K}$ (Krejtz et al. 2016) and Real-time Index Pupillary Activity (RIPA) (Jayawardena et al. 2022b). The readers are referred to (Mahanama et al. 2022b) for a comprehensive review of the various existing gaze measures including advanced measures. We improve the reproducibility of our system by allowing users to restream eye-tracking data, and thereby mimic real-time data acquisition. Our key contributions are as follows:

1. We propose a distributed multi-user eye-tracking system that supports both advanced and traditional gaze measures.
2. We visualize both advanced and traditional measures in an interactive dashboard with restreaming support.
3. We demonstrate the utility of our system via two distributed eye-tracking user studies.

A short demo of our system is available at https://youtu.be/20LzU9NmF4o.

2 RELATED WORK

2.1 Eye Tracking Visualization

Eye tracking technology allows researchers to gain insights into human behaviors, attention, and mental effort using their eye movements. While statistical analysis of eye-tracking data provides quantitative results to support or reject hypotheses, eye-tracking visualization provides a way for exploratory and qualitative analysis of data (Blascheck et al. 2017). Through eye-tracking visualizations, researchers