

Multimodal Eye Behavior Analysis for Gaze Estimation and Refractive Power Monitoring

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Abstract

Eye movements serve as a rich source of physiological and behavioral information. On the one hand, eye movements can be voluntarily controlled, enabling their use in hands-free human-computer interaction systems. On the other hand, involuntary eye movements are closely associated with underlying physiological mechanisms. They have been shown to correlate with alterations in visual function. Consequently, involuntary eye-movement behavior can serve as an informative indicator of visual impairment and other functional changes in the visual system. The objective of this thesis is to investigate two commonly used eye-movement recording techniques—electrooculography (EOG) and video-based eye tracking—and to explore their potential for eye-movement-based inference under varying visual conditions. This work comprises two studies. The first study focuses on gaze direction estimation under both open-eye and closed-eye conditions. A proprioceptive-based approach is proposed to guide eye movements in the absence of visual input. The second study investigates a vision-healthcare application, exploring the feasibility of refractive power monitoring through eye-movement analysis. By analyzing eye-movement patterns under simulated refractive conditions, this study aims to achieve early detection of refractive disorders. Together, these studies highlight the robustness of eye-movement-based inference, showing that meaningful information about gaze behavior and visual function can be extracted even under degraded or absent visual input.