Pro's Eyes: A Wearable System for Synchronous and Asynchronous Observational Pattern Learning

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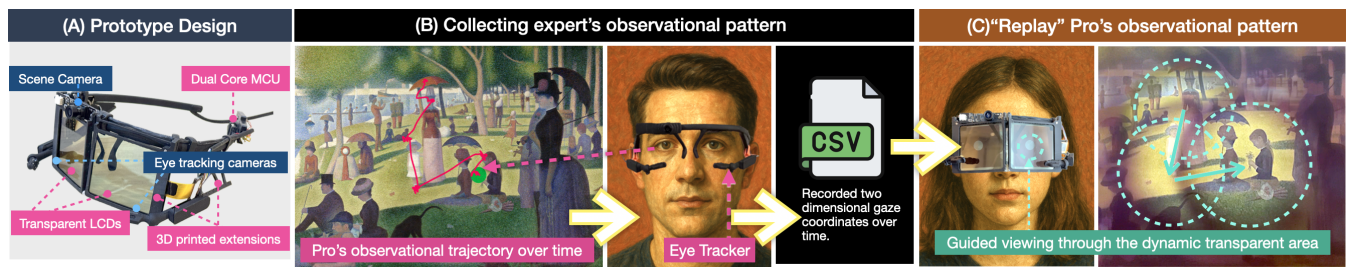Tokyo, Japan
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Figure 1: The Pro's Eye system workflow. (A) Prototype Design: The wearable prototype is built with custom 3D printed extensions housing dual transparent LCDs, eye-tracking cameras, and a scene camera. (B) Collecting expert's observational pattern: In the recording phase, an expert wears an eye tracker while viewing a stimulus (e.g., a painting). Their observational trajectory is recorded as two-dimensional gaze coordinates over time and saved to a CSV file. (C) "Replay" Pro's observational pattern: During the guidance phase, a novice wears the Pro's Eye prototype. The system replays the expert's recorded gaze path by creating a "dynamic transparent area" for the novice to see through, effectively guiding their attention while the rest of their vision is dimmed.

Abstract

Learning to see the world like an expert is a critical step in mastering complex skills, yet transferring these implicit visual strategies remains a significant challenge. We present Pro's Eyes, a wearable see-through display system designed to bridge this expert-novice gap by synchronizing a novice's observational patterns with an expert's. The system implicitly guides a user's attention by creating a clear viewing aperture aligned with an expert's gaze path while dimming the visual periphery. To validate our approach, we conducted a formal user study (N=17) focusing on an art appreciation task. The results provide strong empirical evidence of the system's efficacy: Pro's Eyes significantly improved gaze synchronization between novices and a pre-recorded expert's path ($p<.05$) compared to free observation. Subjectively, participants reported that the guidance helped them identify details they would have otherwise missed. Our work's primary contribution is an empirically-validated wearable system that demonstrates the potential of implicit gaze guidance for transferring expert observational skills.

Keywords

Eye Tracking, Gaze Guidance, Skill Acquisition, Observational Learning, Smart Eyewear, Augmented Reality, Expert-Novice Learning, Wearable Computing, Programmable Vision

1 INTRODUCTION

Experts across numerous domains, from medical diagnosis to sports, develop highly efficient visual strategies characterized by fewer, more meaningful fixations on task-critical areas [Mitchell et al.
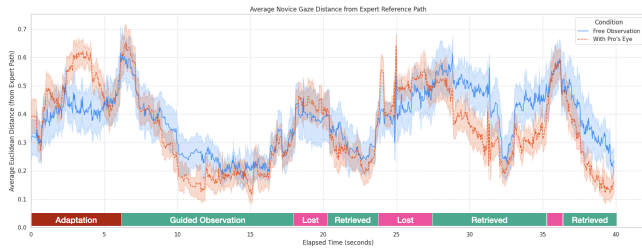
Figure 2: Average novice gaze distance from the expert's reference path, comparing the "Free Observation" condition (blue) with the "With Pro's Eye" guidance condition (orange). The colored bar below the time axis indicates the experimental phases (Adaptation, Guided Observation) and periods of tracking difficulty ('Lost') or regained synchronization ('Retrieved').

2020]. When novices adopt these expert-like viewing patterns, they show accelerated skill development and improved performance [Vine et al. 2012]. However, traditional training methods struggle to effectively transfer these implicit observational patterns.

Current technological approaches often rely on explicit visual cues such as arrows or highlighting [Litchfield et al. 2010]. While useful, these methods can increase the novice's cognitive load and divert attention to the cue itself rather than the task. There is a need for a more implicit and direct method to convey the authentic, dynamic nature of an expert's observational process.

To address this challenge, we developed Pro's Eyes, a novel smart eyewear system that enables novices to directly experience expert observational patterns through first-person visualization. This work builds upon and formally validates our previous exploratory prototype, GazeSync [Zhang et al. 2022], which first established the feasibility of transferring eye movements using a similar transparent LCD mechanism. While the initial work demonstrated the core concept, Pro's Eyes introduces a refined design and the first empirical study to quantify the system's effectiveness and its impact on skill transfer.

2 PRO'S EYES SYSTEM

The core of Pro's Eyes is a novel guidance mechanism that leverages the principle of bottom-up attention [Treue 2003].

Implicit Guidance via Salience Modulation: The system uses dual transparent monochrome LCDs mounted on eyewear to modulate the user's visual field. Based on a pre-recorded expert's gaze data, it renders a clear, circular aperture at the expert's point of focus while dynamically dimming the surrounding periphery. This creates a perceptual "spotlight" effect that implicitly guides the novice's gaze without distracting explicit pointers.

Justification for Custom Hardware: This method of guidance relies on subtractive lighting—selectively blocking ambient light to dim the real world. This effect cannot be readily achieved by most off-the-shelf AR/XR displays (e.g., HoloLens, Magic Leap), which use additive lighting to overlay bright virtual content onto the world. Our custom hardware is therefore essential for creating this specific, less intrusive form of guidance.

3 EMPIRICAL VALIDATION

We evaluated Pro's Eyes in a controlled user study where seventeen novices observed a complex painting under two counterbalanced conditions: (1) unguided "Free Observation" and (2) "With Pro's Eye" guidance replaying an expert's gaze path.

Objective Performance: The average Euclidean distance between novice and expert gaze paths was significantly lower in the guided condition ($p<.05$), as visually demonstrated in Figure 2. This provides strong quantitative evidence that the system successfully aligns a user's observational pattern with an expert's. **Subjective Experience:** A majority of participants agreed that the guidance was easy to follow and that it helped them find details in the artwork they would have otherwise missed. *Evidence of a Learning Effect:* Analysis of the free-viewing phases revealed a significant carry-over effect. Participants who first experienced the guided condition subsequently followed viewing patterns that were quantitatively closer to the expert's path compared to those who began with unguided observation. This suggests that Pro's Eyes facilitates a transfer of observational skill, enabling at least short-term retention of expert viewing strategies. However, a critical issue, noted both quantitatively (e.g. 'Lost' phases in Figure 2) and frequently in interviews, was the difficulty novices experienced following rapid, saccade-like movements inherent in the expert's observational trajectory.

4 EXPERIENCE

At SIGGRAPH Asia, attendees will experience Pro's Eyes firsthand. Our demonstration will feature a large display and two interaction modes. In Asynchronous Mode, participants will wear the eyewear to follow pre-recorded expert gaze paths from domains like art appreciation and medical imaging. In Synchronous Mode, a live expert-novice pair will transfer gaze patterns in real-time. To ensure attendee comfort, the raw expert gaze data have been smoothed to filter out rapid saccades, addressing a key finding from our study regarding potential eye strain.

Acknowledgments

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