Human Computer Interaction – SWE 503

Project Literature Review

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1. Introduction

As VR/AR systems become vital to fields like surgical training, industrial design, and remote collaboration, the methods by which users interact with digital content are critically important. A primary design choice is between using tracked physical controllers, which provide concrete haptic feedback, and controller-free hand-tracking, which offers a more natural, intuitive user experience. This creates a fundamental trade-off between the explicit confirmation of haptics and the intuitive nature of direct hand manipulation. Understanding this trade-off is important, as an interaction that feels natural but leads to poor performance or low user confidence can undermine the effectiveness of a VR/AR system.

This review addresses the specific research question: **In Virtual Reality/Augmented Reality applications, how does the presence or absence of haptic feedback in an interaction mode (e.g., tracked controllers vs. hand-tracking) affect a user's sense of confidence and task performance?**

2. Proxy Paper

The key paper that serves as the methodological foundation for this research is:

Steed, A., & Lai, J. (2025). Comparison of hand tracking-based and controller-based interaction in a consumer virtual reality game. *Virtual Reality*, *29*(3). https://doi.org/10.1007/s10055-025-01190-5

This paper is an ideal proxy as it was published in 2025 and provides a direct, empirical comparison that aligns perfectly with the research question. The researchers compared the performance of tracked controllers and hands-free gestures for standard object manipulation tasks in the VR game Cubism. The authors conducted a user study measuring performance metrics, such as efficiency, and collected user perception feedback on experience. The authors concluded that while there is no significant performance impact between controllers and hand-tracking overall, there was a significant difference in the rate of object placement.

We propose extending it by primarily focusing on measuring user confidence, as Steed, A., & Lai, J. (2025) primarily focused on objective performance and general user experience and user confidence was not directly measured.

This study will adapt the core task-based comparison in Steed, A., & Lai, J. (2025), while adding measurement tools to specifically investigate user confidence.

3. Thematic Summary

The referenced research is organized into two key themes that reflect the core tension between performance and user experience.

Theme 1: The Quantifiable Performance Gap in complex Interactions

Recent literature demonstrates that the presence of haptic feedback provides a significant, measurable advantage in task performance. (Gusai et al., 2017) and (Masurovsky et al., 2020) found that controllers led to higher accuracy and a lower perceived workload compared to hand tracking. Similarly, (Neamoniti & Vlasios Kasapakis, 2022) suggested that tasks requiring fine motor skills and dexterity, controllers provided superior control and performance. The suggested performance gap can be attributed to more than manipulation; The common methodology across these studies is a controlled experiment where users perform a specific task. It is worth noting that Steed, A., & Lai, J. (2025) found no significant impact between the two interaction methods,

Theme 2: Subjective Experience and Bridging the Haptic Gap

While hand-tracking sometimes underperforms in objective metrics, it offers a perceived naturalness. in Steed, A., & Lai, J. (2025), 8 out of 12 participants favored hand-tracking for task completion. This led to research in "bridging the performance gap" by adding haptic feedback to hand interactions. (Cai et al., 2024) developed a finger-worn device capable of rendering rich haptic textures, demonstrating a path toward more realistic tactile sensations. Hamad et al. (2025) showed that even simple haptic feedback added to a pinch gesture via a small wearable could significantly improve the interaction. explored focusing ultrasound to create tactile sensations without physical contact, or mid-air haptics, showing the increasing viability of creating localized feedback on a user's hand. These emerging solutions suggest that the field is actively working on combining the naturalness of hand tracking with the essential feedback of tracked controllers.

4. Research Gap

The reviewed literature suggests a trade-off between the precision of controllers and the naturalness of hand-tracking in more complex tasks such as assembling and manipulating complex objects. The specific gap this study addresses is the limited focus on user confidence as a primary research finding. This work aims to adapt the direct comparative methodology of Steed, A., & Lai, J. (2025) and extends it by specifically measuring user confidence and perceived competence.

For high-stakes applications in VR/AR, such as medical training, remote operation of machinery, or complex industrial assembly, a user's confidence in their interaction could be as crucial as their performance, as low confidence can lead to hesitation and inefficiency, while the lack of corrective feedback can lead to critical errors. By isolating and measuring user perceived confidence, this research can provide design guidelines for creating VR/AR systems that are performant, trustworthy, and reliable for users.

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