Gesture vs. Touch Controls in VR/AR applications

Waleed Al-Amri G202421440

October 6, 2025

SWE 503: Literature Review of Final Project
Dr. Omar Hammad

1. Introduction

Research Area and Importance

In virtual and augmented reality (VR/AR) systems, interaction modalities such as gesture-based and touch-based controls define the user's sense of immersion, efficiency, and comfort. As VR/AR technologies move toward more lightweight and mobile systems, identifying the most natural and efficient interaction mode becomes crucial. Gestures promise intuitive and contactless control that mimics real-world behavior, while touch interfaces provide familiarity, precision, and reduced fatigue.

Specific Research Question

This study explores:

Which interaction mode—gesture-based or touchpad-based—is more efficient, natural, and usable in lightweight VR/AR systems?

---

2. Proxy Paper

Selected Paper

Khundam, C. (2015). ***First Person Movement Control with Palm Normal and Hand Gesture Interaction in Virtual Reality*****.**

Summary of Study

Khundam proposed a gesture-based system combining Oculus Rift (HMD) and Leap Motion sensors for first-person movement control in VR. The method allowed users to steer and adjust speed through real-time hand gestures using Unity3D. The study focused on immersive, continuous control rather than discrete button input, emphasizing user naturalness and system synchronization.

Findings

- Gesture-based control produced smoother, more immersive navigation compared to traditional keyboard input.
- Users felt increased embodiment and realism when gestures replaced discrete key presses.
- However, challenges included fatigue and tracking errors, particularly over long sessions or under lighting variations.

Relation to Current Research

This study extends this foundation by comparing gesture-based and touchpad-based controls within both VR and AR contexts, assessing efficiency, user comfort, and usability across lightweight systems. While Khundam's work explored immersion, the aims to quantify comparative performance and ergonomics in mobile or portable setups.

---

3. Thematic Summary

Theme 1: Gesture-Based Interaction – Naturalism and Limitations

Gesture-based input is celebrated for its intuitiveness and immersive engagement.

- **Hürst & van Wezel (2012)** evaluated *finger tracking for mobile AR* and found it enhances engagement but sacrifices precision. Gesture input in mid-air was "fun and natural" but less accurate and slower than touch-based alternatives, especially in object manipulation.
- **Ibraheem & Khan (2012)** reviewed *gesture recognition technologies* and noted that vision-based systems offer natural interaction but face technical issues like lighting, occlusion, and computational complexity, limiting consistent usability
- **Khundam (2015)** demonstrated that gesture-based VR navigation increases immersion but requires precise calibration and causes fatigue in extended use

  Synthesis:
  Gesture control excels in naturalism and embodiment, vital for immersive environments, but it suffers from accuracy loss, physical strain, and hardware dependency. Lightweight VR/AR devices exacerbate these issues due to limited sensors and battery constraints.

Theme 2: Touch and Smartphone-Based Control – Precision and Efficiency

Touch interfaces, though less "natural," consistently outperform gesture systems in accuracy, speed, and usability, especially in mobile AR and lightweight setups.

- **Knierim et al. (2021)** introduced the *SmARtphone Controller* system, where smartphones serve as both input (touch) and output (visual) devices in AR. Their user study (n=24) revealed that touch input achieved significantly higher precision and lower task load than mid-air gestures.
- **Matulic et al. (2021)** developed *Phonetroller*, integrating smartphone touch input in VR. They found that users with visual thumb feedback performed tasks faster and more accurately than those using pure gesture or hover controls.
- **Pirttikangas et al. (2008)** compared touch, mobile phone, and gesture control for large-screen browsing. Results showed that touch and mobile input were more precise and less error-prone than gesture, which excelled only in exploratory, large-distance interactions

Synthesis:
Touch interaction remains superior in precision, task efficiency, and user comfort, particularly in portable or mobile AR systems. Its tactile feedback supports stable control without significant physical effort, aligning well with lightweight VR/AR designs where fatigue and sensor drift can undermine performance.

---

4. Research Gap

While numerous studies have evaluated gesture-only or touch-only interactions, few have directly compared both modalities under identical conditions especially within lightweight VR/AR systems that emphasize portability, low-cost sensors, and minimal hardware.

Most gesture studies (e.g., Khundam 2015; Hürst & van Wezel 2012) focused on immersion and movement realism, while touch studies (e.g., Knierim 2021; Matulic 2021) emphasized precision. However, no unified evaluation yet contrasts gesture vs. touch across both efficiency and naturalness dimensions**.**

Importance

Filling this gap will provide actionable design insights for developers of next-generation portable VR/AR systems, informing trade-offs between immersive naturalism (gesture) and efficient control (touch) in future human–computer interfaces.

---

5. References

1. Khundam, C. (2015). *First Person Movement Control with Palm Normal and Hand Gesture Interaction in Virtual Reality*.
2. Hürst, W., & van Wezel, C. (2012). *Gesture-Based Interaction via Finger Tracking for Mobile Augmented Reality*.
3. Knierim, P., Hein, D., Schmidt, A., & Kosch, T. (2021). *The SmARtphone Controller: Leveraging Smartphones as Input and Output Modality for Improved Interaction within Mobile AR Environments*.
4. Matulic, F., Ganeshan, A., Fujiwara, H., & Vogel, D. (2021). *Phonetroller: Visual Representations of Fingers for Precise Touch Input with Mobile Phones in VR*.
5. Pirttikangas, S., Milara, I. S., & Riekki, J. (2008). *Comparison of Touch, Mobile Phone, and Gesture-Based Controlling of Browser Applications on a Large Screen*.
6. Ibraheem, N. A., & Khan, R. Z. (2012). *Survey on Various Gesture Recognition Technologies and Techniques*.