Research Statement

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Introduction

My research in Human-Computer Interaction (HCI) lies at the intersection of immersive extended reality (XR), neuroscience, and hardware prototyping. I focus on designing and developing shared XR spaces that enhance collaboration and community building. Leveraging my expertise in perceptual sciences, psychophysics, and hardware development, I aim to advance our understanding of human sensory-motor control and create groundbreaking technologies for sensory augmentation.

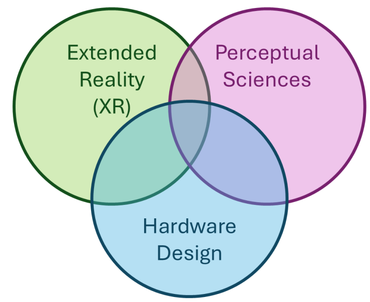

Figure 1: My research focus lies in the intersection between extended reality, perception, and hardware design.

Enhancing Collaboration in Shared XR Spaces

A central theme of my research is the development of immersive shared spaces in XR that facilitate collaboration among users in different physical locations. In the **Augmented Reality Music Ensemble** project, we bring together real and virtual musicians in a synchronized virtual space, allowing seamless interaction despite geographical separation. This work demonstrates the potential of XR in creating coherent virtual environments that reflect intended actions regardless of local physical constraints.

In our study on viewing angle effects in British Sign Language processing [9], we investigated how spatial orientation impacts communication in 2D virtual environments. Understanding these perceptual factors is crucial for designing more immersive XR spaces that support effective collaboration and community building.

Figure 2: Augmented Reality Music Ensemble enabling remote collaboration

Perceptual Understanding and Embodiment

My background in neuroscience and psychophysics informs my research on presence and embodiment in virtual environments. In my work at Meta Reality Labs, I explored how subtle virtual enhancements to the hands can augment users' motor abilities without disrupting their sense of embodiment. My work on virtual reality hand-tracking systems [1] provides a methodological framework to assess and improve the accuracy of these systems, which is essential to create immersive and believable simulations.

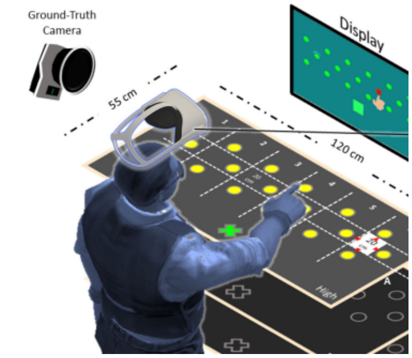

Figure 3: Assessing VR hand-tracking accuracy

Performing Complex Motor Tasks in XR

In another project at Meta Reality Labs, I investigated the effects of somatosensory feedback on the performance of complex tasks, such as a billiard-playing game. This work provided a first look at different feedback strategies, including real-time and terminal feedback, to support complex task execution and performance in a realistic virtual environment. This understanding is crucial due to a lack of physical objects and consequent constraints in XR.

Figure 4: Assessing VR hand-tracking accuracy

Physics-Based Realistic Object Grasping Framework in XR

An integral part of my research focuses on developing a physics-based realistic object grasping framework in XR. Traditional methods require coding separate interactions for each object, limiting scalability and realism. To address this, I utilized NVIDIA's PhysX physics engine to create a novel framework that leverages advanced physics solvers. This approach allows for dynamic and realistic object interactions without the need for coding.

The implementation of this framework has been praised and adopted by my former colleagues at Meta Reality Labs, with whom I am actively collaborating on further explorations. We are currently working on optimization approaches to automate physics parameter tuning in the Unity game engine using machine learning techniques. This work aims to enhance the realism and efficiency of virtual interactions, contributing to both the gaming industry and research applications.

In our project *PrendoSim* [2], we demonstrated the effectiveness of physics-based simulations for robotic grasping tasks. By integrating realistic physics engines, we improved simulation-to-real transfer, facilitating better training and development of robotic systems.

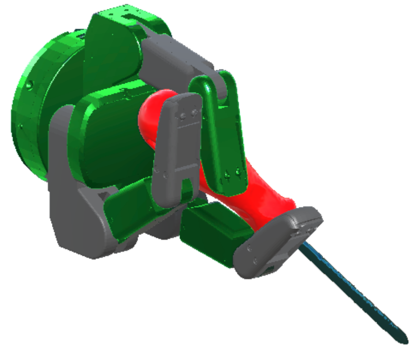

Figure 5: Robotic 3-Finger gripper performs physically realistic object grasping in simulation

Hardware Development for Sensory Augmentation

Through my startup, **Obi Robotics**, I have engaged in hardware prototyping to develop advanced data gloves for motion capture and sensory enhancement. Our gloves offer 22 degrees of freedom in a wireless package, supporting applications in XR, robotics manipulation, gesture recognition, and health.

This hands-on experience in hardware development complements my academic research by providing practical tools for investigating sensory-motor control and enhancing user interaction in XR environments. Our collaboration with the Centre for Neurorehabilitation (UCL) on hand rehabilitation after brain injury (stroke) using this type of motion capture highlights the potential of these technologies in medical applications.

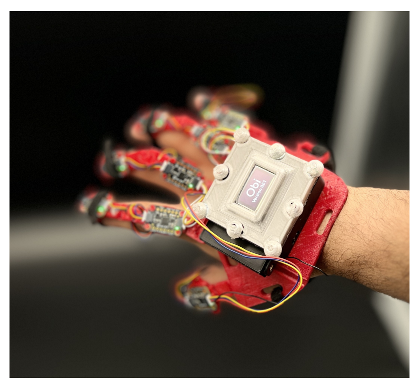

Figure 6: Obi Robotics data gloves

Future Research Agenda

In the future, my research aims to address fundamental questions in immersive presence, sensory limitations, and collaborative interactions within intelligent virtual environments. Despite technological advancements, key aspects such as perceptual systems in XR, social dynamics in virtual contexts, and sensory overload remain under-explored. Therefore, my aim is to focus on the following areas:

- **Investigate Sensory Overload**: Examine how sensory overload affects user experience and develop strategies to optimize engagement without discomfort.
- **Enhance Social Interactions**: Explore methods to improve social dynamics in virtual shared spaces, ensuring natural and effective collaboration.
- **Advance Physics-Based Interactions**: Continue developing physics-based frameworks for realistic object interactions, integrating machine learning for automated parameter tuning.

Figure 7: Hand rehabilitation assessment and training in XR

Interdisciplinary Collaborations

Industry Collaborations: My work with *Meta Reality Labs* involved creating immersive simulations with real-time haptic feedback, influencing future haptic technologies. The physics-based grasping framework developed during this collaboration has been integrated into their research pipeline.
At *Google*, we addressed the critical challenge of text entry in XR, leading to a pre-print [5] and an accepted paper at CHI 2025. This included the development of a web tool for researchers and designers to easily search this vast field.
Academic Collaborations: Collaborating with experts in motor control, we studied how immersive VR can enhance physical training [3]. Our research on robot handovers [6] integrates robotics and human interaction, while studies on hand assessment and rehabilitation [4] contribute to medical technology advancements.

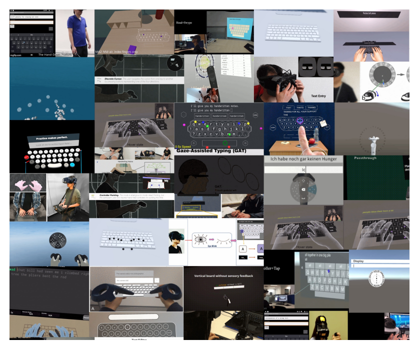

Figure 8: Text entry techniques in XR

Impact and Contributions

Advancing Hand-Tracking Technologies: My paper on VR hand-tracking accuracy [1] has become a key resource, informing best practices for reliable XR applications.

Physics-Based Interaction Frameworks: The development of a physics-based object grasping framework has significant implications for XR and robotics. By automating interactions and enhancing realism, this work contributes to more immersive and efficient virtual environments.

Industry Implementation: Contributions to the *Meta Quest headset* and collaborations with industry partners have led to practical applications of my research, enhancing product capabilities.

Resource Development: The text-entry database and web tool [5] support the design of next-generation input methods for XR, driving innovation in user interface design.

Neuroscience and Perception: My work on viewing angles in sign language [8, 9] and emotion expression [7] contributes to our understanding of human perception in virtual environments.

Conclusion

As immersive technologies become more prevalent, understanding and optimizing user interaction in shared virtual and smart environments is crucial. My research integrates neuroscience, hardware prototyping, and XR development to push the boundaries of HCI. By exploring perceptual understanding, developing physics-based interaction frameworks, and creating tools for sensory augmentation, I aim to contribute groundbreaking research that enhances collaboration and community building in shared XR spaces.

References

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