Assessing Dexterity - A Study of Virtual Reality Haptic Gloves and Alternate Input Methods

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Hello, my name is Ryan Blocker, and I am a senior at Colorado State University. I am currently working on my CS464 research project, which involves the development of functional haptic gloves for virtual reality applications. The main objective of this hardware is to enhance user immersion and provide realistic feedback when interacting with virtual objects. It is crucial to replicate the sensation of using one's actual hands to pick up objects to achieve a truly immersive experience. I have come across several research papers during my literature review that focus on assessing user dexterity in virtual and mixed reality settings. While most of these papers primarily explore the concepts in clinical contexts, my study will have a broader scope. Below, you will find a summary of each study and its relevance to my research.

B. Joyner, J. M. Cagle, A. M. Simon, and T. A. Kuiken, "Comparison of Dexterous Task Performance in Virtual Reality and Real-World Environments," IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 29, pp. 1-9, 2021

In this study, the objective was to assess able-bodied individuals who interacted with both a virtual prosthesis and a real-world prosthesis in order to accomplish eight activities of daily living. The research revealed significant variations in results across different tasks, with manipulating smaller objects posing greater challenges. This study proved valuable in informing the design of my own experiment, particularly in terms of selecting appropriate tasks for participants under examination.

H. Martinez, A. Garcia, and F. Molina, "Assessment of Manual Dexterity in VR: Towards a Fully Automated Box and Blocks Test," in 2019 IEEE 5th International Conference on Virtual Reality (ICVR 2019), Chengdu, China, 2019, pp. 1-6

In this study, a virtual rendition of the BBT (Box and Blocks Test) was employed. The key finding, relevant to my own study, is that participants who successfully accomplished the task manually in real-world settings also demonstrated equivalent proficiency when performing it in virtual reality.

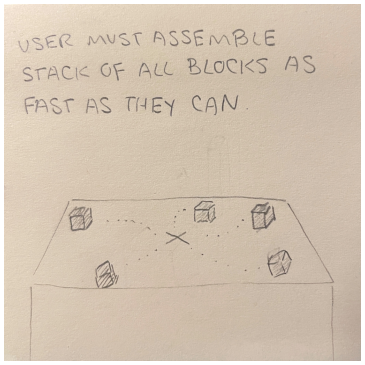
E. Collins, J. Freeman, S. Chatterjee, and P. Haggard, "Comparing a Finger Dexterity Assessment in Virtual, Video-Mediated, and Unmediated Reality," IEEE Transactions on Haptics, vol. 8, no. 3, pp. 299-306, 2015.

This study examines the NHPT (Nine-Hole Peg Test) by comparing task completion in VR, AR, and real-life settings among healthy participants. The objective was to assess user accuracy. The findings indicate that the disparity in performance between virtual reality and real-life conditions was statistically insignificant.

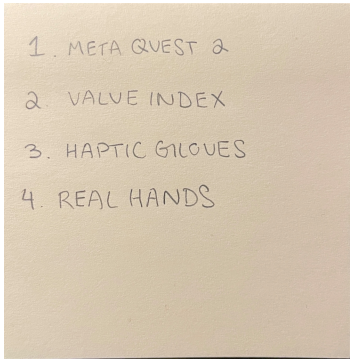
For this study, I will be assessing the user's dexterity, which refers to their ability to articulate and manipulate objects in a virtual environment based on the input method being used. The goal of this study is to enhance our understanding of the most intuitive and precise ways to control virtual objects with our hands. This study differs from previous ones mentioned as it primarily focuses on comparing different input methods, rather than testing multiple types of tasks.

Please refer to the attached photo of the current state of the haptic glove. Unfortunately, I encountered a setback as one of the 3D printed parts snapped, so I am unable to provide a photo of the glove with the haptic modules installed at this moment. Additionally, the rigid mount also snapped at the last moment, necessitating their removal for now. However, I am currently in the process of printing a new one at the RDC prototype lab.

View of the task within the headset:



Types of Input:



Current Haptic Glove:

My proposed experimental plan involves conducting four rounds of testing with participants, where they will perform the same task each time. The task will involve building a stack of blocks in a virtual reality environment, requiring the user to move, grab, and balance the blocks. During the task, I will measure the completion time, the number of dropped blocks or instances of the stack being knocked over (errors), and the deviation of the participant's stack from the ideal position. Following the task, I will administer a survey to gather information on grip strength, post-task fatigue, and the intuitiveness of the input method, among other factors. The independent variable in this study is the type of input method. Currently, I plan to compare the use of four different methods: Meta Quest 2 Controllers, Valve Index Controllers, HTC Vive Controllers, and my own haptic gloves. By analyzing the collected data, I hope to draw meaningful conclusions about how the different input methods either hinder or enhance dexterity performance.

I am excited about conducting this project and expanding my knowledge of conducting experiments in the field of Human-Computer Interaction (HCI). Furthermore, I look forward to successfully developing a pair of functional haptic gloves that can be utilized in future experiments conducted by the lab.