A Comparison of Hand Tracking and Controllers Effectiveness in VR

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Abstract TBD.

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1 Introduction

In VR, there are several ways of interaction, including the traditional controllers, and the newer hand tracking technology. In the recent past, controllers have been the most common form of interaction as VR technology advances and it is important to know how efficient, accurate and easy to use these different forms of inputs are. Hand tracking is slowly gaining popularity and if it proves to be as efficient as a control mechanism it could prove to be a better alternative to the currently prevailing controllers. There is little research that has been done comparing hand tracking with controllers in a controlled environment, particularly for gaming. Most of the studies are focused on certain tasks, for example, typing or medical applications when evaluating hand tracking instead of general interaction within the virtual environment. In our project, we seek to contribute to this gap by comparing the effectiveness of controllers and hand tracking in performing various tasks. We use Fitts' Law to determine the speed, accuracy, and comprehensibility of the interactions. This will enable us to determine when hand tracking is as effective as controllers and when it is not.

2 Related Works

There has been a lot of research aimed at figuring out the best way to interact in VR, but there is still not near enough information about hand tracking vs the use of controllers. These studies will have helped frame our research by providing information on how hand tracking performs in VR and where it struggles.

In a study by Monterio et al.[3], different hands free ways of interacting in the virtual environment such as eye tracking and hand gestures were investigated. The study revealed that gaze based selection with a short delay could be as efficient as using a controller, but it depended on the task. This indicates that other means of control can be quite efficient in certain applications but their efficiency depends on how they are applied.

Another study, by Masurovsky et al.[2], dives into how accurate and efficient hand tracking is compared to traditional controllers. The study found that hand tracking is generally less precise, mostly due to hardware limitations, but allows for a more natural interaction experience. This trend is offten found in a lot of VR research: controllers are usually more precise, but hand tracking feels more immersive.

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Finally, we have a study by Babu et al.[1] focused on Fitts' law and how different input methods impact speed and accuracy in VR. The results showed that controllers tend to be more reliable for tasks that require fine motor control and precise movement, while hand tracking can be more intuitive and easy to use, but often less accurate.

Like in some of the study's above Fitts' Law helps us compare speed, accuracy, and usability so we can clearly see how hand tracking stacks up against controllers. Through the comparison we will be able to find out what scenarios best suit controllers vs hand tracking. Each study hits on pieces of what we are trying to find. Our study will combine studying the efficiency of different VR control methods using Fitts' law to continue this related work.

3 Method

Our means of testing user accuracy and success when comparing hand tracking vs controllers was to create a virtual reality(VR) space that the user would enter and be expected to complete 3 tasks, each testing an array of different actions a user would take when in an actual VR game or experience.

3.1 Apparatus

To develop this VR space, Unreal Engine 5 was used for its easy to code blueprints and previous experience all members of the research group had with the software. To allow for online collaboration during the development process, GitHub was used to allow for simultaneous work on different components. Hardware used in development varied, but the headsets used for testing and participants were the Oculus Quest 2 and 3.

3.2 Procedure

The Participants will begin the experiment in a start area designed to access each level at their will, and will be instructed by the researcher to choose one of the 3 levels. The order in which the 3 levels will decided randomly, to eliminate any variance the order of level completion has on the results. The content of each level is as follows.

The first level is a target selection class to accurately measure Fitts' Law and a participant's throughput, where a ring of spheres is presented to the user. To start the trial, one of the spheres will light up, prompting the participant to hover their hand/controller over it, or select it. Once this sphere has been selected, the selected sphere will return to its original color, and a different sphere will change color. This occurs 10 times, and the total time to completion will be recorded, allowing an average movement time to be calculated.

The second level focused on object manipulation, making the participant walk through a series of sorting activities led by the researcher, sorting the same colored objects into their respective bins by grabbing them.

The third level is a typing exercise, where the participant will be expected to type out 3 different sentences, in a similar fashion to a typing website, being able to delete incorrect letters and incorrect words not counting towards wpm. Distance and Movement time between each key press was recorded to allow for another difficulty index to movement time comparison. Once the first level is chosen at random, the participant will be instructed to complete a series of tasks, to which their results will be measured in multiple ways, including time to completion, accuracy (if the user presses an interaction command and there is actually something to interact with), as well as distance their hand/cursor travels. The goal of these measurements is to find the Difficulty Index with a given task, and to compare time of completion across these different Difficulty Indexes and tasks between motion controllers and hand tracking. Due to being so early in the development/experiment process, not much can be said about errors encountered during the participant's trials.

3.3 Design

The participants had their inputs recorded, which were used to determine both accuracy and time to complete the given tasks, which were used to get a Quantitative value to compare across both input modalities. Additionally,

Table 1. Frequency of Special Characters

Non-English or Math	Frequency	Comments
Ø	1 in 1,000	For Swedish names
π	1 in 5	Common in math
$	4 in 5	Used in business
Ψ_1^2	1 in 40,000	Unexplained usage

the researchers prepared a questionnaire for the participants to complete once they had finished the VR portion of the experiment. This questionnaire would be used to gauge user satisfaction with both input methods, as well as what they felt they preferred independent to their success in the trials.

4 Results and Discussion

As noted in the introduction, the "acmart" document class can be used to prepare many different kinds of documentation — a double-anonymous initial submission of a full-length technical paper, a two-page SIGGRAPH Emerging Technologies abstract, a "camera-ready" journal article, a SIGCHI Extended Abstract, and more — all by selecting the appropriate *template style* and *template parameters*.

This document will explain the major features of the document class. For further information, the *LaTeX User's Guide* is available from https://www.acm.org/publications/proceedings-template.

5 Conclusion

6 CCS Concepts and User-Defined Keywords

Two elements of the "acmart" document class provide powerful taxonomic tools for you to help readers find your work in an online search.

The ACM Computing Classification System — https://www.acm.org/publications/class-2012 — is a set of classifiers and concepts that describe the computing discipline. Authors can select entries from this classification system, via https://dl.acm.org/ccs/ccs.cfm, and generate the commands to be included in the LaTeX source.

User-defined keywords are a comma-separated list of words and phrases of the authors' choosing, providing a more flexible way of describing the research being presented.

CCS concepts and user-defined keywords are required for for all articles over two pages in length, and are optional for one- and two-page articles (or abstracts).

7 Tables

The "acmart" document class includes the "booktabs" package — https://ctan.org/pkg/booktabs — for preparing high-quality tables.

Table captions are placed *above* the table.

Because tables cannot be split across pages, the best placement for them is typically the top of the page nearest their initial cite. To ensure this proper "floating" placement of tables, use the environment **table** to enclose the table's contents and the table caption. The contents of the table itself must go in the **tabular** environment, to be aligned properly in rows and columns, with the desired horizontal and vertical rules. Again, detailed instructions on **tabular** material are found in the *LaTeX User's Guide*.

Immediately following this sentence is the point at which Table 1 is included in the input file; compare the placement of the table here with the table in the printed output of this document.

Table 2. Some Typical Commands

Command	A Number	Comments
`\author`	100	Author
`\table`	300	For tables
`\table*`	400	For wider tables

To set a wider table, which takes up the whole width of the page's live area, use the environment **table*** to enclose the table's contents and the table caption. As with a single-column table, this wide table will "float" to a location deemed more desirable. Immediately following this sentence is the point at which Table 2 is included in the input file; again, it is instructive to compare the placement of the table here with the table in the printed output of this document.

Always use midrule to separate table header rows from data rows, and use it only for this purpose. This enables assistive technologies to recognise table headers and support their users in navigating tables more easily.

8 Figures

The "`figure`" environment should be used for figures. One or more images can be placed within a figure. If your figure contains third-party material, you must clearly identify it as such, as shown in the example below.

9 Citations and Bibliographies

References

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[1] [2] [3]

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Fig. 1. 1907 Franklin Model D roadster. Photograph by Harris & Ewing, Inc. [Public domain], via Wikimedia Commons. (https://goo.gl/VLCRBB).