Exploring Alternative Methods for Two-Handed Object Manipulation in VR Using Standard 6-DOF Controllers

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1 ELEVATOR PITCH

I plan on creating a scenario in virtual reality where a task must be completed using an object that requires the use of two hands, such as hitting a target with a rifle. Each task will be completed three times by the player, each time utilizing a different interaction model for manipulating the object using two hands. This test will be administered to a large group of participants from the general population and each will be scored for each interaction mode, based on their ability to complete the task with the given model. A verbal assessment of comfort and preference will also be recorded, to determine the most comfortable and accurate model for 2 handed object manipulation

2 EXTENDED OVERVIEW

Current methods of utilizing two-handed objects in VR has posed a challenge for those attempting to maintain a sense of realism within a virtual scenario.In the physical world when manipulating objects with two hands, the grasped object determines the position and orientation of the hands based on its own position and orientation. If one hand attempts to manipulate the position of the grasped object, the other hand must adjust accordingly to allow the object to reach the desired state. In VR, the lack of a physical object to guide our hand movements poses a challenge when attempting to manipulate two-handed objects, as now each hand can move independently.

Special controller accessories have been introduced as ways to fix this problem, by providing a physical guide that restricts the degrees of freedom that controllers may move. However these accessories tend to be rather expensive. Despite the increased presence of VR in the home entertainment sphere, the price point still remains relatively high, making the need for a design solution using current hardware much more prevalent.

The simplest solution that is commonly presented in VR gun games such as Robo Recall is to make the trigger hand be the primary pivot point of the object. The second hand may snap to the foregrip when close enough to simulate realism, but does not effect the aiming of the gun at all. This method essentially treats the object as a one handed weapon.

Another common solution is to again use the trigger hand as the primary pivot point, but instead aims the weapon based off of the position of the forward grip hand. This method allows for actual two-handed manipulation, but eliminates the rotational degrees of freedom provided by the touch controllers. This is most commonly used among VR gun games such as Pavlov VR.

A better method of solving the rifle problem employed in Boneworks VR, introduced a third contact point on the shoulder as the primary pivot, limiting the aiming angle by moving the trigger hand in relation to the shoulder, however this still essentially eliminates the use of grip hand, except for reducing simulated weapon sway.

If we can attempt to mimic the limitations of motion presented by physical objects, we can achieve a more realistic and comfortable result. Previous studies have shown that VR can cause the mind to disassociate from our regular hand eye coordination, and using a design solution to exploit this may be a path to an ironically more believable simulation.

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2.1 Technical Challenges

This project will propose the following technical challenges:

- Creating a simulation environment allowing the user complete a task. The player must be able to pick up items and be prompted to complete the objective. The result of the objective must be logged for further analysis after trials.
- Implementing at least three methods of two-handed object interaction that improve upon the aforementioned methods. Creating enough variability between the three will be important to get meaningful test results.
- Conducting testing of interaction methods with at least 50 subjects. In order to get a meaningful result and form a definitive conclusion, getting a large group to sample from will be extremely important.

2.2 Key Risks and Mitigations

Potential Risks include:

- Potential for performance issues on current hardware. My laptop is on the low end of VR capable, and the quest should be able to run smoothly, but if the applicaiton is too performance intensive, I may have to move the setup to a higher powered computer in the reality lab.
- Potential for development to run over scheduled time frame. I plan to start implementing and testing rather early so this shouldn't be a major issue, but if devlopment runs too long, I will most likely shorten the task to perform and decrease the number of users surveyed.
- Lack of test subjects could be a major issue. The general plan will be to find an area in public on campus and allow people passing by to play the experience. If this plan does not provide enough voluntary test subjects, the backup plan will be to ask members of the 490v class, reality lab, and friends and family, although this may provide a somewhat biased test sample based on competency with virtual reality.

3 HARDWARE AND SOFTWARE

Hardware:

- [Personal] Oculus Quest headset with 6 DOF controllers
- [Personal] Oculus Link Cable
- [Requested] VR capable Desktop computer in event of application performance issues

Software:

- [Personal] Unity Game Engine
- [Personal] Blender

4 RESPONSIBILITIES

As the sole person on this project, my responsibilities include:

- **Andrew Rudasics**: Responsible for: (1) implementing interaction techniques, (2) creating and procuing assets for demo scene, (3) implementing the demo scene, (4) implementing data logging capabilities, (5) conducting user testing, and (6) analyzing results of user testing.

5 DEVELOPMENT PLAN

Final projects should be completed over three weeks (i.e., February 29 through March 19). Students are encouraged, but not expected, to start earlier. To assist in assessing the complexity of your project, please provide a high-level development plan, including major milestones (i.e., dates that

significant hardware or software features will be tested or completed). Include time for writing your final project report and preparing for the final project demo session.

- **March 3rd**: Have Task logic and demo scene completed with data logging capabilities.
- **March 8th**: Complete 3 interaction models and be ready for user testing.
- **March 15th**: Complete User Testing.
- **March 17th**: Complete Data analysis for poster presentation
- **March 18th**: Have poster completed and demo ready for poster presentation.

6 REFERENCES

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- Lee, Hyeongmook Billinghurst, Mark Woo, Woontack. (2011). Two-handed tangible interaction techniques for composing augmented blocks. Virtual Reality. 15. 133-146. 10.1007/s10055-010-0163-9.
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