Saber Support

Immersion Increasing Virtual Reality Peripheral for Realistic Swordplay

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***Abstract*—Virtual Reality successfully grants users visual and auditory feedback while playing but lacks a real-world counterpart to the virtual actions being performed. Saber Support aims to increase the immersion of realistic swordplay through passive haptics in the form of an external peripheral for the Oculus Rift S controllers. By adding this adjustable peripheral users can tune their experience to not only see a sword in their virtual hand but physically feel the weight of it in their hands as they swing creating much more accurate experiences. The fact that many actions in Virtual Reality are performed identically regardless of the perceptual weight of the virtual object is the driving force of the project. Through the creation of this peripheral, users are able to experience realistic swordplay simulations with something tangible to more accurately depict the weight of real swords.**

I. Introduction

Virtual Reality (VR) headsets are constantly being developed to have improved visual and audio quality to give the user a more immersive experience. While VR headsets are ever improving their ability to trick the eyes and ears into believing what is being seen and heard is real there is still an aspect holding a truly realistic experience from being realized: weight. Without weight simulation whatever object is being manipulated by the player will feel the same as physically, all virtual objects are represented by the same controller being held by the user in the real world. This lack of physical presence is the problem being targeted by this project. Specifically, this project focuses on replicating the weight and feeling of wielding a real sword while users experience realistic swordplay simulations in existing VR applications. If this problem were to be solved for all VR interactions it would be a major step forwards in terms of the levels of immersion that are able to be achieved within VR. Users would no longer have to alter their own actions to attempt to replicate the perceived weight of a digital object and could instead physically exert the necessary force it would take in order to move their digital object if it were real. With visuals and audio becoming more and more realistic, it becomes easier to notice the lacking passive haptic feedback, making players consciously pretend they are handling heavy objects when in reality they are experiencing no more weight than they were with empty virtual hands. In order to simulate the weight and physical presence of a sword a modular peripheral design was created, see Fig:1. It is designed to physically resemble a sword's silhouette and is 3D printed into modular pieces that can be added and removed from the grip of the sword as shown in Fig:2.This allows users to create a customizable physical sword that they can wield to best match whichever sword they are using inside VR. This modularity allows the user to decide what feels most realistic based on their own perception and allows for more options than a "one size fits all" peripheral. This paper will describe the iterative design process that has been used to develop the project thus far. Competitive analysis of existing solutions including QFD and Usability testing and how the current results will be informing the ongoing design moving forward.

II. Literature Review

In preparation for this project, some existing works were analyzed. Sources for accurate weight simulation projects and simple commercial VR controller peripherals were taken into account. The first solution for accurate weight simulation, the Transcaliber, used short-range weights that would automatically adapt their position and orientation to attempt to represent the weight of virtual objects picked up by users. This solution was attempting to use the unique weight distributions to match the feeling of holding oddly shaped objects that would be hard to perceive the weight of from visual alone. This strategy was able to allow people to identify unique objects based on their weight but struggles to be a full solution as its range is quite short and cannot replicate the feel of larger objects[1]. The second accurate weight simulation utilized a more unorthodox approach, focusing on air resistance over adding much actual weight. The Drag:On used two attached fans that would unfurl to create a large amount of wind resistance on the controller, in turn making the process of moving it more challenging. This solution does grant users an accurate feeling of moving an object through the air but has a few drawbacks. The fans do not create air resistance equally in all directions causing inconsistency and although while moving the controller becomes harder to manipulate, slow movements or simply holding an object in place will not feel very different than if a user was not using this solution[2]. The first commercial peripheral that was considered was the AMVR "Beat Saber Dual Handles Extension Grips". This solution does not attempt to replicate the weight of objects in a realistic manner, but rather provides a way to use the existing controllers in a way that more closely resembles the way a user would perform the action in the real world. In this case, the peripheral attempts to replicate the hilt of a sword to allow users a more realistic grip on their controllers while using swords in VR. The peripheral is designed to seamlessly connect to existing controllers and be used for Beat Saber Specifically. A major drawback that this peripheral has is that it takes the user's hands away from the actual controller, making them no longer able to utilize its functionality while holding the peripheral grip. While this does not become a large issue in Beat Saber where very few controller inputs are needed, it does prevent the peripheral from being able to be comfortably used in applications that require users to swing and utilize controller buttons in rapid succession or simultaneously[3]. Finally, the controller without any additional solutions or peripherals was also taken into account. The base controller does not house anything additional to help simulate the weight of virtual objects but was an important component to consider as the project developed. In order to say that this project's solution could be used across any existing VR application, the full functionality of the base controller would need to be preserved. Additionally, the base controller was able to provide an excellent comparison in terms of ease of use and comfort, if the peripheral made the controller difficult or uncomfortable to use, users would rather use the base controller without the peripheral which informed the design of the peripheral through the iterations[4]

III. METHODS

This project began by conducting the design thinking process. 5 initial interviews were conducted to help generate potential problems to solve. Those interviewed included 2 who were very familiar with using VR controllers in swordplay scenarios and 3 who were very inexperienced with VR in general. Those with more experience leaned towards solutions that would remake the controller from the ground up to be lighter and faster to move with an emphasis on keeping the center of gravity in the palm of a user's hand. Their insights provided excellent knowledge on some of the physical mechanics of how the controllers are used and held, but the proposed solutions lead farther away from something that would feel realistic. The inexperienced users were able to provide more unique solutions that were not previously thought of and raised points that apply across a wider range of users. These inexperienced users believed that they would benefit from some form of real-world feedback to help them better understand and perform virtual tasks. For more information about these conducted interviews and other steps of the design thinking process see Appendix:A "Design Think Process". The next step in the creation of the project was to begin digital prototyping of the electronics and technical drawings. The technical drawings in their early iterations focused heavily on how the separate parts of the sword would connect. A Dovetail joint was chosen for strong resistance to forces when swinging while still being able to intentionally remove pieces without much struggle. For more information about the early stages of design see Appendix:A "Hardware Assignment 2". The project then began to be realized in a physical form beginning with cardboard prototypes. Two cardboard versions of the peripheral were developed. The first was a 2D approximation of the sword to begin understanding the scale and shape of the peripheral when compared to the VR controller. This prototype iteration suffered catastrophic failure soon after testing began. The connection between the grip section and the rest of the sword was too thin and caused significant warping and eventually broke away from the rest of the peripheral, see Fig3. The second cardboard prototype was created according to the measurements present in the technical drawings and aimed to be a more accurate representation of the design. This second prototype was built to be stronger and was built to match the full 3D design. Once more upon testing, catastrophic failure was experienced where the grip connects to the remainder of the peripheral, see Fig 4 Alongside the creation of the second prototype the first 3D printed piece was made to test if the controller sleeve seamlessly fits onto the existing controller. This was successful and the casing held firmly onto the controller while allowing for a simple attachment and removal, see Fig 5 After both cardboard prototypes suffered the same point of failure the design of the grip was altered to no longer contain both the controller sleeve and electronics housing. The grip would only be the controller sleeve and the electronics sleeve would become a removable part of the sword that could be attached similarly to the other pieces. The point of weakness was given added thickness to allow it to hold more weight. The remaining pieces of the peripheral were 3D printed including the re-designed grip to grant the first fully 3D printed prototype. QFD and Usability testing was performed on this prototype iteration. These tests provided new insights from users able to interact with the physical prototype. Important points for users included the product's durability, and the creation of multiple versions of the same pieces with different weights to allow further customization of the peripheral. In Usability Testing the peripheral's newly designed grip was found to be stronger and lasted through two tests before suffering a catastrophic failure similar to the prototypes before it, see Fig 6. For more information on the QFD and Usability processes, see Appendix: A "Saber Support QFD" and Appendix: A "Saber Support SUS"

A. Results

This project underwent five primary iterations through its creation thus far. The first iteration was a 2D cardboard prototype that was used as the first real-world visualization of the idea. Its purpose was to establish a target size and overall feel of what the product would become. The second prototype was also made from cardboard but now took on a properly measured 3D form based closely on the project's technical drawings at the time. This prototype was able to give a much better indication of how much physical presence the current design would have. The third prototype was not fully completed but brought about many important discoveries. This prototype was the first to be made of 3D printed material rather than cardboard. In order to print properly some pieces would need to be separated and glued together after printing, this led to the choice of having the large piece for electronics housing become a removable and optional piece just as the rest were. The fourth prototype was the first fully 3D-printed prototype. One of each component was created. This design created the first iteration of the newly designed grip and improved the dovetail joint connections to be flipped so as to work with gravity in most cases rather than against it. This prototype improved the grip's ability to sustain weight as well. The fifth and current prototype is designed very similarly to the fourth but aimed to minimize weight as much as possible to prevent breaks, the infill percentage of the grip itself was lowered to alleviate some of this weight. The electronics component was removed from the design at this stage as it could not be reasonably achieved and did not add value to the project as VR is already capable of giving users auditory feedback. This led to the part designed to house the electronics to be repurposed into a lightweight blade extender allowing swords to feel heavier even with limited pieces by focusing more weight towards the tip of the sword. For visuals of these prototypes see Figs 1, 3, 4, 5, and 6. For further details on the current prototype see Appendix: A "Saber Support Assembly Technical Drawing", A "Saber Support Explode View Technical Drawing", A "Saber Support Tip Technical Drawing", A "Saber Support Blade Technical Drawing", A "Saber Support Housing Technical Drawing", A "Saber Support Grip Technical Drawing", and A "Saber Support Cover Technical Drawing". From the QFD study customer needs were found to be placed heavily on the peripheral itself as opposed to its interaction with the existing VR applications or controllers. Presented needs include having multiple weight options for pieces and high durability. To monitor if these needs are being met focus will be placed on the overall weight of the peripheral using different part combinations and the overall durability of the peripheral will be tested at different lengths. The technical requirement targets to satisfy these needs will be to create 3 weight variants for each unique piece, and the peripheral should remain strong when being swung vigorously while 4 feet long. The weights will have a standard weight which is the current 20% infill prints but will have a lighter version made at 10% infill and a heavier weight at 40% infill. When comparing the project against the AMVR "Beat Saber Dual Handles Extension Grips" customers found the project to excel in its ability to adapt to different lengths and weights but struggled to surpass the commercial product in terms of spacial requirement and durability. The project does surpass the commercial product in terms of the technical requirements, but only due to the fact that this project is still being developed and is able to adapt and address the requirements more easily than the finished commercial product. For more information on the QFD results see Appendix: A "Saber Support QFD" System Usability testing was conducted with four testers. The results of the test confirm that users found the product to be very easy and consistent to use on their own. With a remarkable average usability score of about 92, the product's first round of usability testing was quite successful. For more information on the Usability testing see Appendix: A "Saber Support SUS".

B. Takeaways

Over the course of the project thus far a number of things have been learned to continue developing a better end product. The first and most important piece of improvement moving forward will be creating a much stronger grip able to hold more weight. Currently, the grip design is a thin sleeve that fits around the controller, creating a more seamless experience but limiting the amount of weight that can be supported. Moving forward a new design of the grip will most likely need to be given several iterations to find the balance between comfort and strength. The durability of pieces outside of the grip is already quite high and won't need many iterations to achieve a high-durability product. Increasing the amount of customization is an important step to take moving forwards. Including multiple weights of different pieces will allow users to further tune their physical prototypes to match what they believe they should feel while wielding virtual swords of many sizes. Additionally, a few variations on piece length should be created to again grant additional abilities to the user to achieve the most accurate peripheral possible. A new method of connecting the sword pieces needs to be attempted. The dovetail joints of the current model perform excellently under conditions for fast swings and rapid movement, but unfortunately, become much looser during slow movements and certain rotations. A few potential solutions would be to replace the dovetail solution with a solution that has the pieces screw into one another, to protect from all potential forces equally, while still having quick assembly that requires no additional tools to perform. In accordance with some points of feedback outside any formal testing, the project could benefit from having a more blunted sword tip, with the amount of weight that could potentially be present at one time using the peripheral and for the fact that users cannot actually see the peripheral while in use, some raised potential concerns for user safety or for the surroundings. Blunting the blade will not make it completely safe by any means but it could at least make impacts less damaging. If the project continues to be successfully fixed an improved potential for more peripheral options could arise. Other types of weapons could be created in a very similar fashion such as axes, maces, or hammers which could lead to an eventual armory of interchangeable and customize-able, VR peripheral weapons to help users replicate any combat situation they may encounter. If this point of the project's progression is reached a mirrored version of the controller that could be affixed to the left controller can also be created allowing a user to wield more than one of these peripherals at one time.

References

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[3] KnoxLabs.com. "Beat Saber Dual Handles Extension Grips: For Quest 2, Quest and Rift S Controllers." Knoxlabs. Accessed September 21, 2022. https://www.knoxlabs.com/collections/controllers/products/dual-handles-extension-grips.

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APPENDIX

Design Think Process
Hardware Assignment 2
Saber Support QFD
Saber Support SUS
Saber Support Assembly Technical Drawing
Saber Support Explode View Technical Drawing
Saber Support Tip Technical Drawing
Saber Support Blade View Technical Drawing
Saber Support Housing View Technical Drawing
Saber Support Grip View Technical Drawing
Saber Support Cover View Technical Drawing

Fig. 1. Current Prototype of the Project

Fig. 2. Current Prototype of the Project Seperated

Fig. 3. First Cardboard Prototype

Fig. 4. Final Cardboard Prototype

Fig. 5. First Printed Pieces

Fig. 6. Broken 4th Prototype