Final Project – Report

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***Abstract*—This paper details a hardware solution for enhancing virtual reality experiences in an inexpensive way for regular consumers. This problem needs to be addressed for more consumers to get into VR and push the industry forward, as greater adoption by game developers will be more difficult otherwise. To address the market area I can came with a haptic glove, which I dubbed the Haptic Glove Lite. It is a haptic glove that provides haptic feedback to events in the game world. Existing haptic gloves and VR research efforts were analyzed to look at where the industry is, and what cues can be taken for the product development. The end result was a virtual prototype in Unity along with a small paper prototype, both of which were able to convey the idea behind the product. Feedback was also received on how to improve the product.**

Keywords—electronics, motors, sensors, virtual reality

I. Introduction

The hardware component for this project aims to improve virtual reality experiences. The specific problems being addressed, the importance of said problems, the proposed solution, and an overview of the product production are all covered in this section. The repository for this project can be found here, and the video presentation can be found here.

A. Identifying the Problem

Virtual reality is an immersive form of technology that is gaining more traction in the gaming space, but is still quite expensive to get into. Furthermore, to be effective VR must meet the user's senses as strongly as possible for them to feel enthralled in the simulation. As such, VR can be a difficult field for the average person to get into, and even then, they may not have the tools to use it effectively. As such, more cost-effective tools need to be developed to address these problems and make VR more accessible, which was why this project was gone with.

B. The Relevance of the Problem – Why it Should be Solved

While virtual reality is an interesting tool for game development, it does not matter unless a consumer base can be formed. Furthermore, innovations in gaming and related tech fields are often driven by competitors utilizing and iterating concepts to push the industry forward, not just research and development for the sake of it. As such, for VR to be successful in gaming it must see wider adoption by game developers, which also requires high-quality VR games to be put in the hands of consumers. This cannot happen if the entry price is too high for most consumers, hence why VR costs need to be cut down in some fashion without losing experience quality. This was the motivation behind making a VR enhancing tool for people of more modest means, as that will be necessary for bringing the hardware forward.

C. Addressing the Problem

My product idea is the Haptic Glove Lite, which is a haptic glove used to enhance VR experiences. The glove would induce vibration-based feedback in reaction to events in the virtual space, but not act as a motion controller or provide movement restriction/force feedback. This glove would be made inexpensive and compact so that the players could easily use it to enhance their gaming experiences, thus making it an add-on to existing game tools.

D. Report Overview for the Problem

This report will serve to explain the research done for this project, the design process and related methods for developing the tool, and the performance of the prototype. This is all done to detail the development cycle behind this project, takeaways, and potential future work that could be undergone.

II. Literature Review

For the project existing virtual reality systems and haptic gloves were reviewed to understand where the market is at, and what needs can be filled by the Haptic Glove Lite. So, for the literature review haptic technology, historical solutions, and current market solutions were all looked at to understand how one would go about designing a haptic glove.

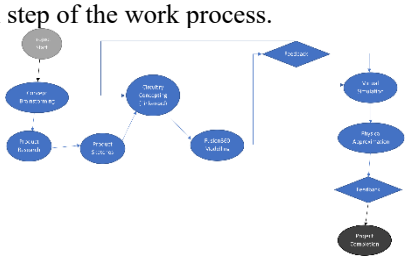
[1]–[8] Looking at haptic research for VR, the evolution of haptic glove technology was looked at. Haptic technology has existed for decades (first introduced in the 1970s), starting out as a full exoskeleton, getting smaller overtime, and being configured for use with specific body parts. The Teletact I and II were early 1990s area gloves that were very much experimental, and highlighted earlier haptic technology where air pressure was used with limited pressure ranges. Modern haptic technology is more digitized, and limited to mostly just buzzes and vibrations. Along with entertainment, haptic technology is being seen as means of improving tactile feedback for those with visual disabilities to improve the feedback they get from their items and thus confirm their inputs. It could also be combined with visual experiences for similar entertainment and disability needs.

[9]–[15] Looking at haptic glove products, the market available or market approaching haptic gloves were as follows: Cyber-Glove, Cyber-Touch, Cyber-Grasp, Senso Gloves, HaptX Glove DK2, and bHaptics TactGlove. Some of these

products had undergone multiple iterations, and did haptic feedback to different degrees, with some just being haptic gloves and others being full-on controllers. Furthermore, some were decently small and compact, while others were a bit larger, namely those with force feedback, as they needed to restrain the user's fingers. While some were optimized for VR gaming, most were general VR tools. This helped give an idea of where the market is at, pricing, and how small I could expect the glove to be.

III. Methods

Shown below is a flowchart outlining the process behind the production of the prototype. This section will also go into each step of the work process.



The design of the product was done conceptually, so no actual electronic hardware was ever made. These designs took inspirations from existing tools on the market and what presumably would work best for practical use of the product.

IV. Results

The timeline and results from the project are shown below. It linearly follows the assignment requirements for the course.

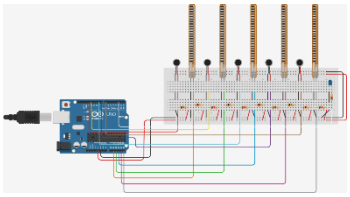
Sketches → Tinkercad Simulation → Fusion360 Model → Cardboard and Virtual Prototype → User Review → Final Revisions

A. Initial Design Planning

The project started out with sketches for the haptic glove's design, along with its logo. Since the glove is meant to be used with game controllers it was important to keep in small and compact. The design sketches are shown below.

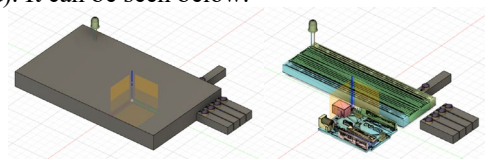
B. Tinkercad Designs

The circuitry for the model was planned out in TinkerCad. The setup is composed of 5 flex sensors and 5 vibrators, which would be used to convey the haptic feedback. An LED was also added to indicate that the device is on. Initially it was thought that 3 mini-breadboards could be used, but in the end it was decided that one long breadboard would be best. The final design with one breadboard is shown below, and can be seen at the following link here.



C. Initial Model

The hardware piece was designed in Fusion360, and simply incorporated the design from Tinkercad, given a casing to hold everything together (connecting pieces like wires are not modeled). It can be seen below.

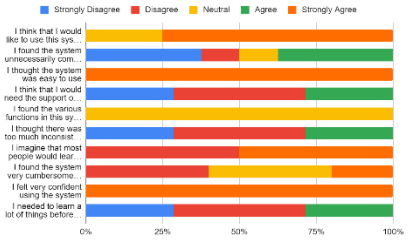


D. Virtual and Cardboard Prototypes

I opted to make a virtual prototype and cardboard prototype for the final project. The cardboard prototype was just made to approximate the size and rough design of the glove. Meanwhile, the virtual prototype was made to highlight different parts of the model and show where vibrations would occur upon a collision. Some changes were made to the Fusion360 model as well, such as adding a button, some batteries, etc. The initial showing of the virtual prototype can be found here, and the cardboard prototype can be found here.

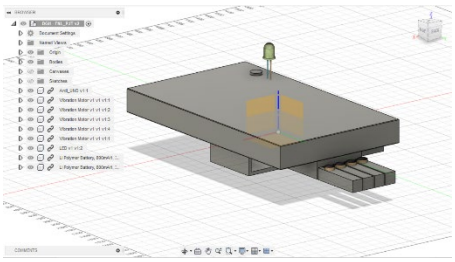
E. QFD and Usability Results

The QFD and usability results are shown below, which were sadly generally mediocre. The main criticism was that the hardware was rather large and clunky, which I admit was in fact the case.



F. Final Iterations

After the initial showing of the project some small changes were made to the simulation, such as adding in extra materials to better differentiate the models.



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V. Takeaways

Throughout the process I worked with relatively limited figures. Working with the tools used for this project was difficult, and I did not have any real perspective on how large the hardware tool was until I made the cardboard prototype. Furthermore, when it came to the design I found myself not fully thinking out every detail directly, such as power sources and casing materials. So while I think the project turned out all right, there is definitely some more planning and design work that could have been done to better account for problems down the line.

If I was to do this project again, I think I would use the smaller breadboards, and perhaps find a better way of constricting the model size. Speaking of which, I would want a virtual and cardboard prototype that's a bit more robust and solid for showcasing my idea. I recall being told my idea was a bit difficult to grasp, so making that clearer would also be something that I would want to improve.

Overall, I think the project went well all things considered. While I am not a VR person I am interested in seeing how haptic technology evolves going forward.

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