INFR3380U Final Hardware Assignment: The Hard Hats - The Modular Valley Controller

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***Abstract*—In the modern video game industry, there are not many controllers that focus on the comfort and health of the users. Users who want to play long hours need a comfortable controller without the cramps and health issues that will come up as a result. Our current prototype has functional inputs and outputs along with the joy-con function in place. The shape of the controller was shaped to be simple and comfortable. However the way the wiring is set up, makes the modular system clunky and takes an unacceptable time to rearrange the buttons and joysticks. Another problem is that the height of the module is too high, and is not ergonomically friendly. Modules should also be resized and remodeled to fit the components more properly. More time was needed to complete each prototype due to the lack of printers available. These problems will be fixed in the next prototype.**

***Index Terms*—Ergonomics, Modular, Controller**

I. Introduction

The controllers that are most commonly used in this era are the playstation, xbox, and the switch controllers. These controllers do not have the option to easily interchange the button to suit the preference of the users. This may lead to cramps or worse when using unpreferred layouts for long periods of times. Our prototype attempts to create an ergonomic shaped controller with the ability to rearrange buttons and joysticks to suit the user's preference. The shape of the controller should reduce the risk of injuries to the users and the modularity of our controller should give our controllers options for the users, which also prevents stress on the fingers. The separation aspect of our controller allows users to relax their arms when playing games. Players have more options in where to adjust their arms to play in more comfortable positions. Roman numerals will refer to sections of the document while numbers will refer to images at the end of the document. In this document there will be a literature review that will include sources that highlights the problems brought up above along with 2 potential competitors (II). The workflow for this project will be shown using a flowchart and shown along with the past prototypes that have been created (III). The progression of the prototype will be shown along with a timeline. (Figure 2) A QFD and a SUS analysis will be referred to and talked about further along the paper (IV). A section containing the takeaway from the project will be located at the last section of this document (V).

II. Literature Review

In 2001, Yesodha et al wrote an academic paper in a conference proceeding that described an ergonomic evaluation of the most common video game controller, the Xbox and PS4 Controller. This paper studied a focus group where out of the 12 participants, 10 of them preferred the shape and comfort of the Xbox, but 11 of them preferred the button layout of the PS4 Controller. [3]

Bhardwaj (2017) wrote a research journal article about tests he ran on different types of controllers to find the most ergonomic setup in terms of button position, hand grip, etc. According to the tests, the PS4 controller seemed to earn the most points in the button position category. In the end of the tests, it is shown that the controllers are made for the users to game better rather than game comfortably. [1]

On a medical website by Physiomed, Dr. Wilson (2021) wrote an article about the problems with carpal tunnel and how it relates to gaming. This website says, "When gaming, the same buttons or keys are pressed continuously, and this repetition is unnatural for the muscles and tendons of the body. It increases the risk of injury by putting excess strain on the affected parts of the body, in this case, the wrist, forearm, thumb, and hand, causing swelling and stress on the carpal tunnel and the median nerve." [2]

The articles that were mentioned helped justify the reason to create this type of controller. The study conducted showed how neither of the modern controllers has both the ergonomic grip that people liked along with the preferred button layouts. This is supported by the fact that companies would prefer to make controllers that focus more on gaming than user preference. This also may lead to carpal tunnel from playing too long. Companies that have patents of two similar devices that can fix this problem are the Thrustmaster and the Nintendo Switch. These devices contain aspects that the prototype controller contains.

III. Methods

The initial concept of this project involved solving the issue of users wanting to adjust the layout of their controller for greater comfort and accessibility. An early design featured a controller with modular components on the face to make it easy for users to swap buttons and joysticks. Following this concept a search for relevant materials needed to build the controller as well as a preliminary pitch of the idea was

conducted. It was found that the initial idea was in need of a characteristic that set itself apart from the rest of the competition. The design was then changed to reflect a modular controller that could also be split in half to allow users greater control and freedom over their position during a play session. The 3D printing process was then started to understand the sizing and positioning of features from the fusion360 models. The first print revealed that the handles similar to that of a typical controller were not ideal for users as they could not reach the inputs needed to use the controller. Designs were revised and the printing process was restarted to include updated models. Feedback on the feel of the controller was then taken into consideration in order to refine the design of the final prototype. Using inspiration from TinkerCad, electrical components were purchased and measured to further refine the final prototype. As for the techincal drawings, the following will be short explanations on each drawing. This is the bottom controller shell that'll hold the breadboard. There are three holes to accommodate three magnets that'll connect to the other magnets on the top controller shell (Figure 7).This is the other part of the controller shell that'll cover the breadboard and all the wiring. It will have the other three magnets to close and open the shell easily, along with the holes where the modules and LEDs will go in. There is also a hole on the vertical frontside of it where the wiring will come out of to connect to the Arduino (Figure 8). Top of the Arduino case that'll be the same as the bottom one but on top with the other set of magnets that will work with the bottom magnets to keep the case closed, while also allowing us to easily open the case in case we need to change the wiring (Figure 9).This is the bottom of the Arduino case that'll have one magnet on the left and right side each to close the case. The Arduino will be resting in the middle (Figure 10).This module will hold the button and circuitry that the button needs to be functional (Figure 11). This part will cover the circuitry inside the button module by covering the top of the module around the button component (Figure 12). The module that'll hold the joystick component and its wiring (Figure 13). Finally, Wiring and programming of the controller was started once the design was settled. Special consideration was taken into account for the actuators which was the final modification made to the controller. The interactive scene was then programmed to take inputs from the controller and send information to the LEDs that were used. (Figure 1)

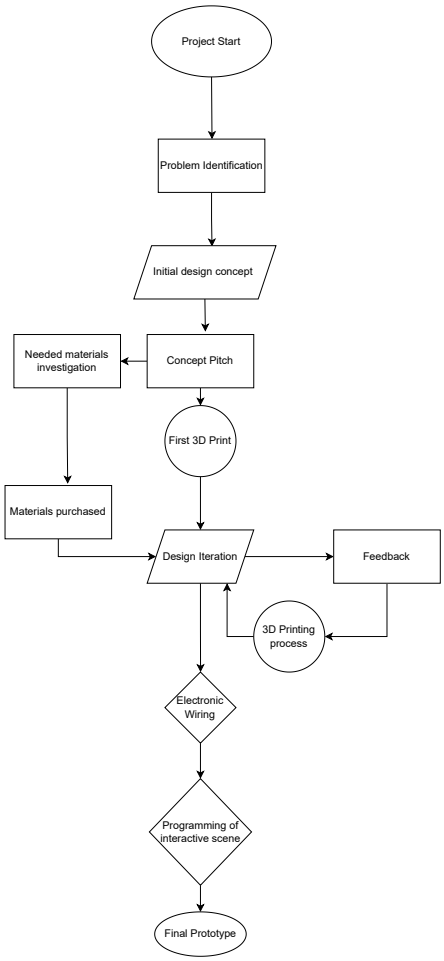

Fig. 1. Figure of Iterative Flow Chart

IV. Results

The results of our QFD showed that we needed to focus on certain areas of design for our prototype, as well as modifying some things to satisfy customer requirements. As shown in our QFD, most of the customer requirements were related to the ergonomics of our controller, with the bevelment of the edges being the most important to the customers. On the technical side, the customer requirements were translated into different requirements, with ergonomics having the strongest relationships.(Figure 3) The customer perception graph gave us insight on what we should focus on improving with our prototype in order to become more competitive against the Eswap pro controller and Nintendo joy-cons. An example would be the top finger rest where our prototype got a one, which is not good enough to be competitive against our competitors.(Figure 4) This resulted in us spending some time brainstorming, with us agreeing to bevel the corner edge more to allow the fingers to comfortably rest on it.

Overall, the SUS scores individually we're above average for the most part with the total average being a score of 73.(figure6) This places our controller in the above average category, which was very good for us, but we've also been able to identify some potential improvements based on the response distribution. One of these improvements was making our controller less cumbersome by making it less bulky in size. Another potential improvement was to improve the way we integrated the many different functions in our system as majority of responses for that question were neutral.(Figure 5)

V. Takeaways

- Fusion360: Using Fusion, we have learned how to create a physical prototype through fusion. The shape was created with precise measurements through sketches and

measuring the equipment. Drawings of our prototypes were done in software to create the technical drawings assembly and exploded view. Exploded view animation to show how it was put together, and the prototype was stress tested using Fusion's simulation function.

- Electronics: TinkerCad was a useful tool to test preliminary versions of the circuits used in the final build of our controller. Looking back on how the wiring was done for the controller, a larger arduino would be recommended to fit all the potential connections that could be used as space was a limiting factor for the controller. Bluetooth implementation would also be considered. (Figure 14)
- 3D printing: 3D printing was integral to the project. Constant printing was necessary for understanding how the controller would feel in the hands of the user. Skills acquired for this process include knowledge of where supports should be placed on models, how to maximise integrity of the build with minimal print time and how to calibrate 3D printers to ensure a successful print.
- Arduino Programming: This project has taught us how to code instructions into an arduino using the Ardity Unity package. It encouraged us to do our own research on how to read inputs like buttons or joysticks connected to the arduino into Unity and make it interact with the scene. On the scene creation side, it has made us more familiar with the Unity editor and how some of the ideas that go into coming up with a scene idea depend on the type of controller that's going to be used.

Reflecting on what could have been done differently, understanding how to better implement the modular components so that it is easier to manipulate the components to a custom configuration is the biggest takeaway. More suitable wire connectors should have been purchased beforehand to solve this issue. Acquisition of materials should have been sooner to avoid this issue as well.

References

[1] Bhardwaj R (2017) The Ergonomic Development of Video Game Controllers. J Ergonomics 7: 209. doi: 10.4182/2165-7556.1000209 209. doi: 10.4182/2165-7556.1000209

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[3] Patents assigned to Thrustmaster, Inc. - Justia Patents Search. Justia. (n.d.). Retrieved from https://patents.justia.com/assignee/thrustmaster-inc

[4] Yesodha, Narasimhan, V., Li, Y., Craig, B. (2017). Ergonomic Evaluation of Videogame Controllers. Advances in Usability and User Experience, 384–391. https://doi.org/10.1007/978-3-319-60492-3$_3$7

VI. Appendix

Fig. 2. Figure of Iterative Timeline

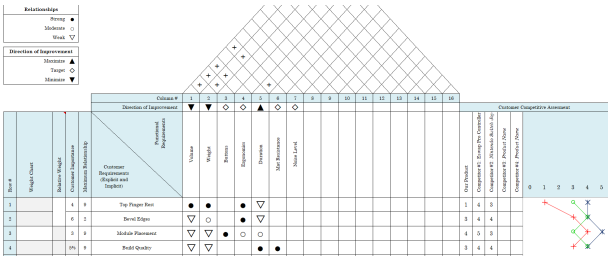

Fig. 3. Figure of User/Project Requirements

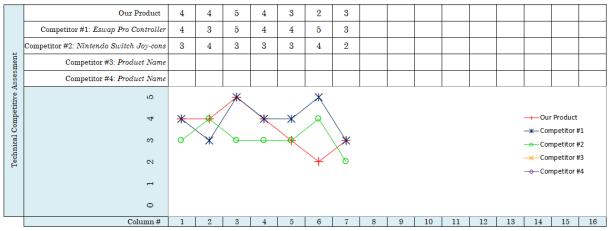

Fig. 4. Figure of Technical Comparisons

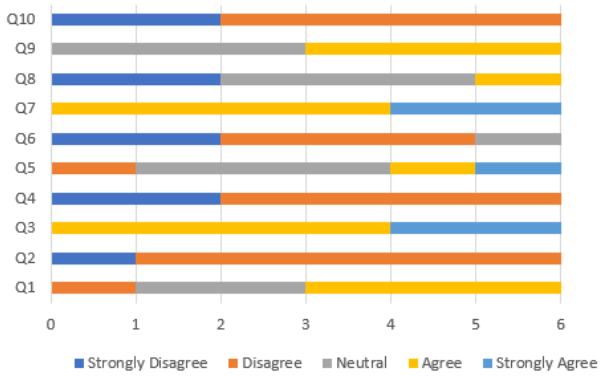

Fig. 5. Figure of System Usability Scale Graph

Paticipant	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	
	I think that I found the I thought t I think that I found the I thought t I would im I found the I felt very I needed t Score										
1	3	2	4	1	3	1	4	4	3	2	67.5
2	4	2	5	1	3	3	4	3	4	2	72.5
3	3	2	4	2	3	2	5	3	4	2	70
4	4	2	4	2	4	1	4	1	3	2	77.5
5	2	1	5	2	2	2	5	3	3	1	70
6	4	2	4	2	5	2	4	1	4	1	82.5

Fig. 6. Figure of Results

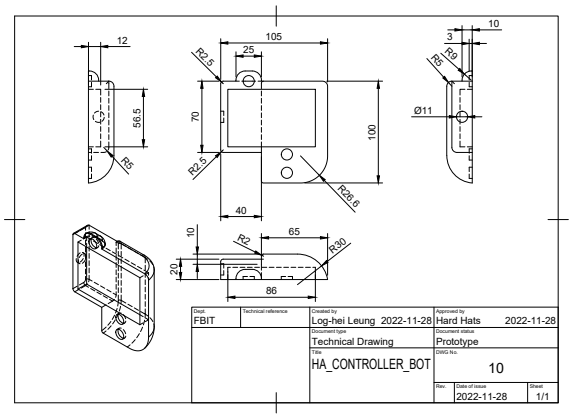

Fig. 7. Technical Drawing Bottom Controller

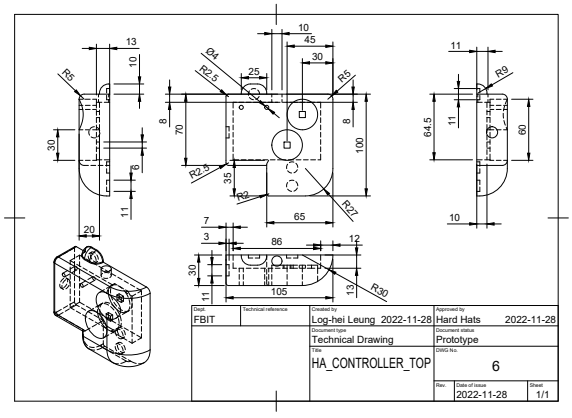

Fig. 8. Technical Drawing Top Controller

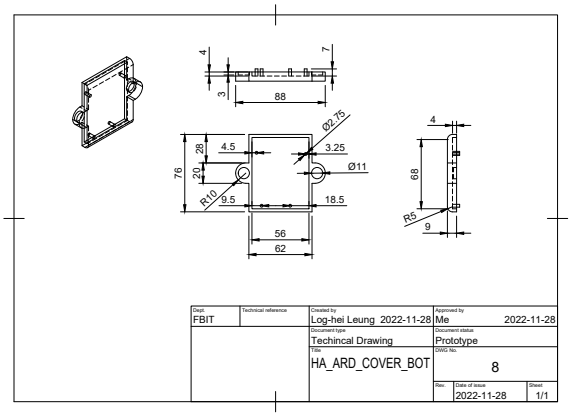

Fig. 9. Technical Drawing Top Arduino Case

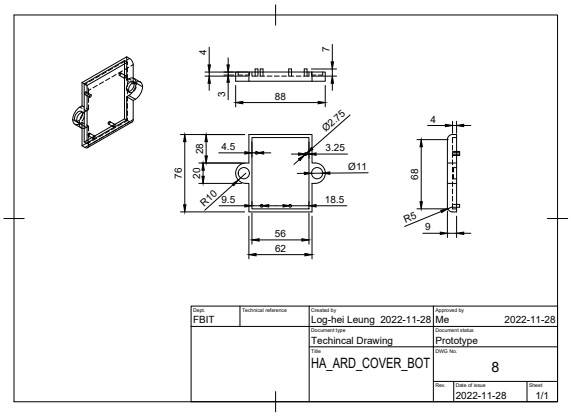

Fig. 10. Technical Drawing Bottom Arduino Case

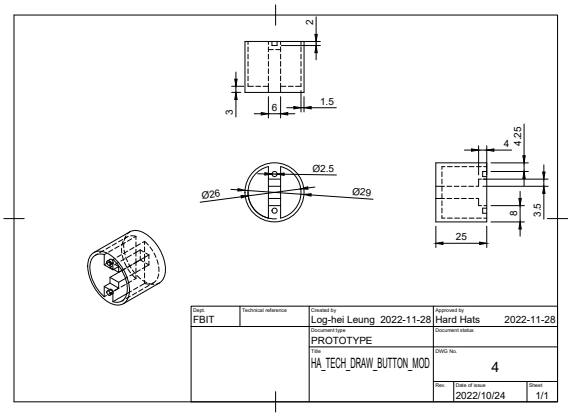

Fig. 11. Technical Drawing Button Module

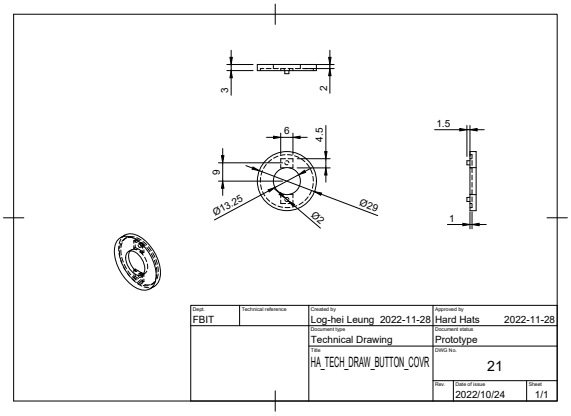

Fig. 12. Technical Drawing Button Cover

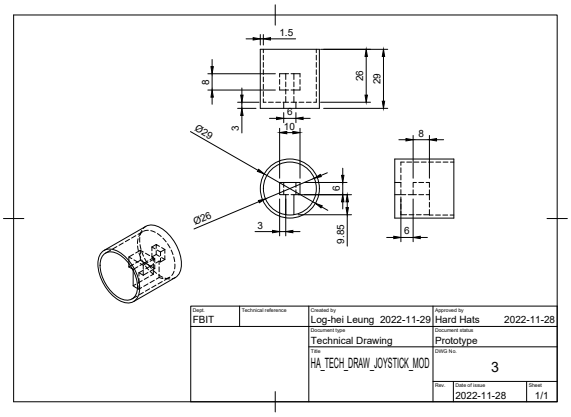

Fig. 13. Technical Drawing Joystick Module

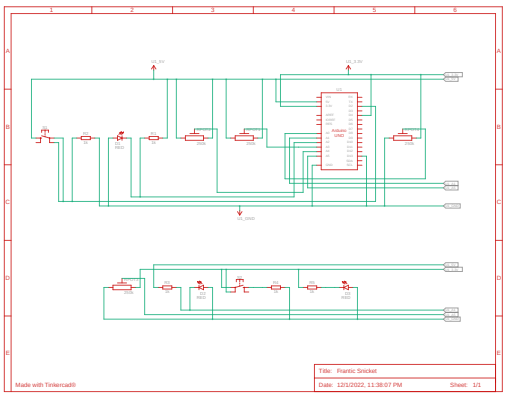

Fig. 14. Electric Schematic