Developing An Accessible Arcade Stick Controller

Accessible to users who only have use of one hand.

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***Abstract*—This report will discuss the production of a prototype for a game controller with an Arcade Stick layout that can be comfortably used with one hand.**

I. Introduction

We noticed there were no commercially available controllers that had an arcade stick layout and that were also designed to be used in one hand. While there are some controllers that were designed to be used with one hand, many of these were not designed with fighting games in mind and many of them are also very expensive. Another issue we are addressing is a vertical layout compared to a horizontal layout. Several studies have shown that a vertical mouse with a more neutral wrist position lowered perceived fatigue in users. This lead us to thinking of a solution that took design cues from vertical mice and combined them with a traditional game-pad. Our resulting controller looks to address both ergonomic and accessibility issues by having an arcade stick layout that can be used with a single hand, using less expensive materials in order to lower costs, and by using what we learned about vertical mouse ergonomics to reduce wrist and hand fatigue.

II. Literature Review

When doing more research to find out if this idea was worth pursuing, we learned that in the USA alone, there are over 50 000 amputations a year, and the most common among those being a hand amputation. [1] After learning how many people are amputees, we continued with our original idea of a one handed controller. We looked into different types of mouse designs since that was the main one handed-controller design we could think of. There was a study that found a vertically tilted mouse could reduce wrist strain compared to a fully horizontal one. This study also found little to no impact in user performance. [2] We decided to look into vertical mice patents to see where we could take inspiration in our controller's design. [4] We also decided to look at some other commercially available controllers that were either designed for ergonomics or one handed accessibility. The main product in the ergonomic arcade stick space is the HitBox, but it has the same issue as other arcade sticks where the layout doesn't really work for one handed use. It also uses the standard horizontal layout which according to our research may not be ergonomically optimal. There are also some custom made solutions, but our controller is designed to be a plug and play solution. For accessibility the main other controller is the Xbox Adaptive Controller. However an issue with the Xbox Adaptive Controller is that the one handed joystick they offer does not have enough buttons to work as a suitable replacement for an arcade stick.

III. Methods

We started by making a basic sketch of how we wanted our controller to look. [Figure 1] We then made a 3D model using Fusion [Figure 2] and used a 3D printer in order to test out the design. When we had this model printed, we realized that in order to press the buttons users had to hold the controller in a very uncomfortable way. The main issue is that the design being flat all the way to the back didn't give the hand any room to go down and reach the buttons. Another ergonomic issue was the buttons being in a vertical line. Since fingers have varying lengths, users would have to bend their fingers at a very awkward angles in order to reach all the buttons from a resting position. In order to address both of these issues, the second iteration of the controller shell had a large dip in the back where the users hand can rest. A slight curve was also added between the buttons in order to match the length of fingers more accurately. [Figure 3]

For electronics, we used an Arduino Micro as our microprocessor. We chose it for 2 reasons, the size and the built in USB 2.0 communication. The Arduino Micro is the smallest Arduino board, and since we wanted as much room as possible for the rest of the electronics we chose it. The other reason is the built in USB 2.0 communication. Since the Micro is based on the Arduino Leonardo, it has the Leonardo's USB 2.0 features. This allowed us to program our controller to function as a generic gamepad and not just as an Arduino which greatly increases how many games will be compatible with the controller. For the inputs we used a generic analog stick and 8 buttons, 6 buttons for game inputs and 2 for Start and Select buttons. The circuit was designed very early on, with only minor changes to accommodate the different types of breadboards we would be using. [Figure 4] The main difference from this sketch is that we used a solderable breadboard for the final version, however TinkerCAD which is what we used for the circuit diagrams did not offer a way to have this type of breadboard. The final design also has 1 analog stick instead of 2 potentiometers, but the inputs

back to the board are the same. We soldered our circuit because any disconnections from a breadboard would break our controller and would have to be opened up again to fix it. For cable management, we tied every bunch of wires that went to 1 component together. For example, a button has 2 power wires and a digital signal wire so those 3 wires would be tied together. We also wrapped electrical tape around any exposed metal since a short would either prevent a button or the analog stick from working properly or even worse damage the electronic components.

The assembly process was relatively straight forward. When we were putting the buttons in place we found out that some buttons would not be fully pressed at it was because the button caps were just larger than the holes for the buttons. To get around this we cut off all of the button caps in order to make the buttons actually go down. When it came to putting it all together we just used hot glue to attach everything to the case.

IV. Results

During the design process, we did Quality Function Deployment and System Usability Scale assessments. [Figures 5 and 6] We had two iterations of the QFD House of Quality done. The first iteration was completed before the final controller was completed. We used the shell to explain what our controller was supposed to feel like in the hand, while explaining the use case to our testers. We asked them to compare to four competitors. We chose our competitors based on popularity in the fighting game scene, as well as how they are used for comfort ability. The Qanba Drone [Figure 7] was used as our common fightstick product to compare to our product. A typical fightstick is very plug-and-play like our controller, but is cumbersome to use one-handed due to the location of the joystick lever. The Xbox One controller [Figure 8]was used because we think it is the most common controller for people to use on PC. This controller is built really well compared to our 3D-printed solution, but is also nearly impossible to use one-handed without third-party input rebinding software allowing for the right analog stick to be used for movement. Even in this case, you would potentially be limited to four action buttons, which does not work for all fighting games. We also compared our product to lever-less fightstick solutions, like the HitBox and its smaller variation, the SnackBox Micro [Figure 9]. These controllers are every ergonomic as they utilize four buttons for movement instead of a lever or analog stick. However, this makes it impossible to use one-handed as the design forces you to use your left hand for movement. These controllers also need additional set up to have the four movement buttons recognized as a joystick like other fightsticks do.

Our second QFD - as well as the SUS analysis - was done after the final controller was finished. We had eight testers in total and found that our controller strived in ease-of-use and simplicity to set up compared to our competitors. We had an average SUS score of 76.25 [Figure 6], which is fairly above average [3] and a lot higher than we initially anticipated. Our testers found that they could easily use the controller with very little help or learning curve. However, the general consensus was that our product was not a great all-in-one solution for one-handed gaming. It was agreed on that this is tailored specifically for fighting games - as we intended - and would not get much use outside of that genre.

V. Takeaways

If we were to do this project again, we would probably use more paper prototyping for the controller ergonomics. Due to limited 3D printer access, we were not able to make as many revisions as required to have very good ergonomics. If we used a modeling clay we could have more easily refined our ergonomics with more rapid revisions before fully modeling and 3D printing another shell. Jumping straight to 3D printing also caused unnecessary waste of material. If we were to use modelling clay before committing to a design change, it would be less likely for us to use a significant amount of filament to print our parts. Another takeaway is to plan more for the internal construction and to have an internal structure that buttons can be mounted to, since hot-glue and tape is not a totally permanent solution. However, it worked well enough for an initial prototype. Another thing we would do for future prototypes is to measure wire lengths for the final electronics. We had wires that were too long and it was much more difficult to assemble and cable manage because of this. Luckily, we managed to fit everything within the compact shell we designed; however this would not be ideal for a final consumer release. Finally, if we were to ever design a version two of the One-Handed Fightstick, we would hope to have a more prominent focus on hardware modularity in our design. Having a design that allowed users to swap a analog stick for something with microswitches, like a D-Pad or a clickstick, would make our product even more user-friendly and accessable. Being able to add expansion modules for making the controller size bigger or smaller would also allow for people of all different hand sizes to use the controller comfortably. Having a design that allowed for the location of the analog stick and buttons be swappable would also for easy left-handed operation, something that we looked into during development but was too out of scope given our timeline.

References

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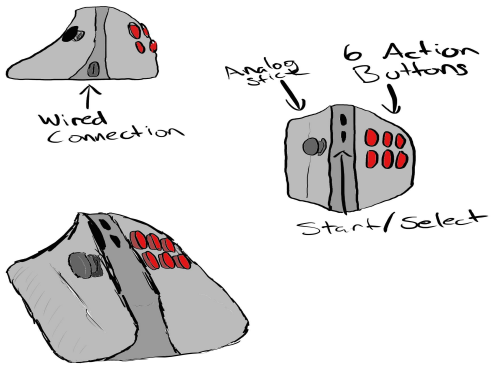

Fig. 1. Our first design sketch

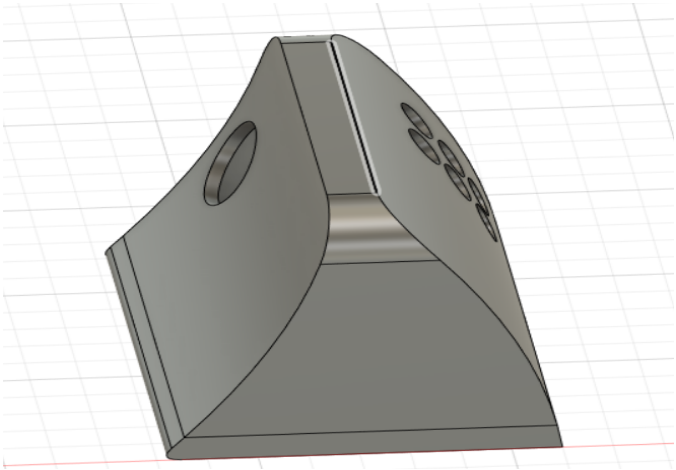

Fig. 2. Our first design 3D model

Fig. 3. Our second design 3D model

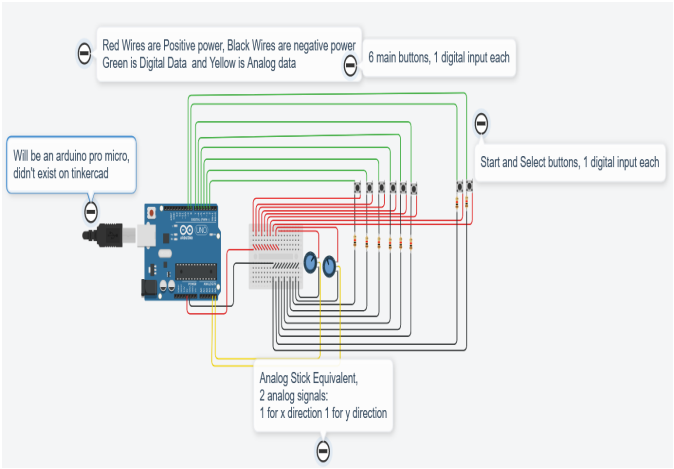

Fig. 4. Our original circuit diagram

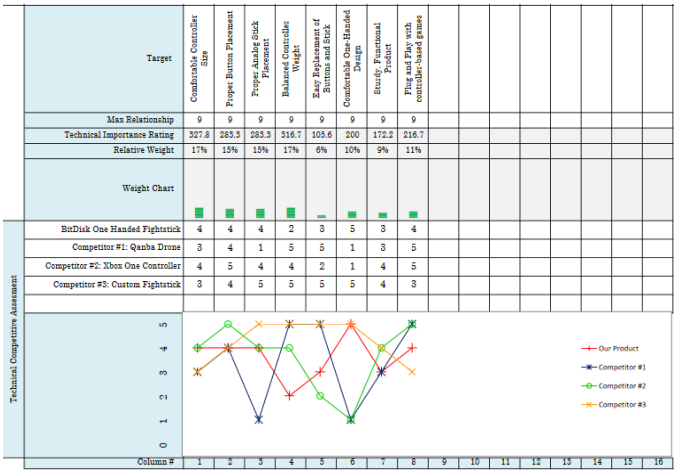

Fig. 5. Our QFD results

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Strongly Disagree	0	4	0	4	0	1	0	1	0	3
Disagree	1	2	0	4	0	7	0	4	0	5
Neutral	3	2	0	0	2	0	0	2	3	0
Agree	4	0	7	0	5	0	4	1	4	0
Strongly Agree	0	0	1	0	1	0	4	0	1	0

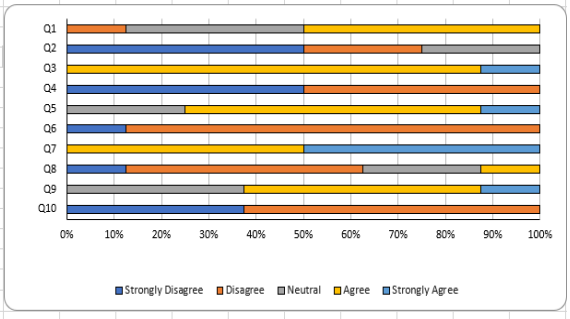

Fig. 6. Our SUS results

Fig. 7. Qanba Drone Fightstick

Fig. 8. Xbox One Controller

Fig. 9. SnackBox Micro (Left) and HitBox (Right)