Course Project Report

Industrial Design for Game Hardware

Dylan Moore
Undergraduate Student
Ontario Tech University
Oshawa, Ontario, Canada
dylan.moore@ontariotechu.net

Nathaniel Moore
Undergraduate Student
Ontario Tech University)
Oshawa, Ontario, Canada
nathaniel.moore@ontariotechu.net

***Abstract*—The industry standard for home console video games since the early 2000s has used a controller design with two thumbsticks, two triggers, and twelve digital buttons. These controllers are effective at playing a wide variety of games with many control styles, but they require using two hands to operate. Therefore, people who possess an upper limb disability are unable to play most video games effectively. Our prototype sought to address this by providing a non-compromised one-handed alternative to a traditional XInput gamepad, using the form factor of a typical flight-stick peripheral as a base. The result came from adding a number of additional inputs to create a 1:1 equivalent to an Xbox game controller and while flawed, is a functional demonstration of how the design's approach could prove effective if further refined.**

***Index Terms*—controller, joystick, accessibility, xinput**

I. Introduction

The problem we aim to solve is simple to explain - the standard controller input for modern video games requires two hands, and we believe that people who are unable to use both hands should still be able to play games made for this standard with one hand at the same level of ability. This includes the ability to simply plug in a controller, and have it work as expected in any XInput-supporting game.

Current existing solutions either don't offer that plug-and-play capability, or are missing core features. This project aims to solve that through the creation of a one-handed XInput controller that uses a flight stick form-factor to provide all necessary inputs accessible by a single hand. The primary idea that allows this is the positioning of face buttons on the grip of the controller. These buttons are positioned in such a way that they can be pressed in the same combinations possible by use of the thumb on a typical gamepad.

One of our most important factors to our final design was how we grouped inputs with what finger a typical controller's layout would encourage using, for instance, A and X could be accessed at the same time by the same finger, and B and Y as well. Left and right bumpers and triggers needed to be accessible simultaneously (Such that players could aim-down sights and shoot in a shooter). This led to the "Left" trigger and bumper being remapped to the twisting of the stick.

In the end, this re-imagined form factor for an XInput gamepad provided a steep learning curve, but with (theoretically) full XInput capabilities with only one hand required.

II. Literature Review

For our literature review, we explored sources detailing upper-limb disabilities to effectively evaluate and justify our approach's effectiveness in providing a real benefit to a not insignificant number of people. We also explored two devices which provided alternatives to our approach that could fulfill the same niche we were aiming for in providing a one-handed control option - the Gypard prototype controller [1], and the Xbox Adaptive Controller [2].

The first scientific paper we reviewed was one written on the subject of an assessment which seeks to measure the overall level of ability and quality of life afforded to upper limb amputees and patients with upper limb injuries with a quantitative score, known as the DASH, or Disability of the Arm, Shoulder, and Hand [3]. This assessment was given to two hundred and seventy-four patients in 2004 and used to gauge how strongly patients were affected by their disabilities, separated between recoverable injuries and amputations and categorized further based on specific types of each.

The Gypard prototype controller [1] provides a similar solution, however the replacement of the right-stick with a gyroscope means less accuracy than a traditional joystick. The Gypard also provides multi-function buttons, which makes it more difficult to use every function of the controller. We address these issues through giving each individual input its own dedicated component, and using the main stick (the "flight-stick") to provide a more accurate right-stick alternative.

The XBox Adaptive Controller [2] provides a fairly versatile solution to the issue of physical disabilities preventing the use of a typical gamepad. This, however, is not a simple plug-and-play feature. Users require to assemble individual components and wire them to the adaptive controller in order to customise it to fit a specific disability. We are looking to provide a plug-and-play solution for those with full use of one hand.

III. Methods

As seen in the flowchart provided (Appendix A, Fig. 1), our prototype was something that needed continuous iteration leading up to the point of having a complete, working design that could be tested in the same use case as what would eventually be a finished product. We had to make numerous iterations due to both technical requirements, as well has issues in assembling the prototype.

The designs started with iterations of the plasticine prototype. Changes were made to ensure an ergonomic design that fit well in a majority of user's hands. Lots of iteration went into play here, with different peers testing the shape and size of the model. Iterations were also made on the side button placement as well as the shape of the pinky-rest.

Iteration continued as the technical limitations of the 3D-printers cause a couple of parts to fail. The part designs went back through the cadding process, this time with the limitations of 3D-printing kept in mind. These changes allowed the twist function to work as intended, and measure up to 30° of rotation using a potentiometer.

The outer shell also had to be expanded later, as the parts used were a slightly different size to the ones that the shell was modeled around. This iteration did however, negatively affect the ergonomics of the design for those with small hands.

The final design did encounter an issue which would be room for more iteration if we had more time, and that is more room for wires to be routed through the bottom of the controller. Our quick fix for that was to cut away some material from the side of the shell to allow wires to be routes through a different hole.

IV. Results

Our initial prototype started as a plasticine model in order to easily test ergonomic shapes and try different shapes and layouts out with different sizes of hands. (See timeline: Appendix B, Fig. 2) This prototype was put directly into CAD, and was the basis for all future CAD work.

This version was modified to include the twist functionality, as well as to add 3D-printable buttons and a hat switch. This version was the first to be printed, and also the first point of failure. The twist design as well as the trigger failed.

The twist design didn't print properly at the lab's printer resolution, so we modified it to be more printer-friendly. The Trigger failed due to the hole for the axle not being large enough, and the standoff/holder combo piece being too thin. A couple of adjustments to make it thicker and with a slightly larger hole made the trigger work (mechanically) as originally intended.

PCB designs worked well as a way to mount components, and did not require any iteration (which was lucky for us as it could take a week or two to receive the new boards).

During the final assembly, it turned out we were short on space to route wires from the internal boards to the external breadboard. To solve this in the remaining time, we cut a new hole in the side of the controller. All buttons worked fine, both sticks worked as expected, however the trigger and twist potentiometers were not functional, and we did not manage to diagnose the problem yet.

With the final model, our QFD results (Appendix B, Fig. 3) show strong correlations between certain customer requirements and the functional requirements of our controller. The space needed to fit all electronics, for example, had a strong correlation with the comfort of holding our controller, as when we interviewed potential users, a large number of complaints about ergonomics couldn't be easily fixed due to electronic components being in the way. Please note that the export to PDF functionality of excel has an issue with retaining all the correlation values on the QFD chart, and all values selected are not necessarily present.

V. Takeaways

One thing that was new to both of us was 3D-printing. When we planned around 3D-printing we didn't expect for failure to happen, however it did. In the end, we are both a lot more prepared for any future 3D-printing, especially with regards to ensuring that parts are printable (the original twist mechanism was not able to be printed by the lab printers). The time required for such a large print as well meant that reworking bits of the shell was very time-consuming, and as such, we often opted to use 2-part epoxy to adhere modified parts to the existing print. This worked very well, and could often provide a stronger joint between small bits than reprinting the whole thing anyways. Overall this was a great learning experience for 3D-printing, and in the future, we would be designing parts from the beginning with the capabilities of the 3D-printer in mind.

One clear learning experience is definitely to maintain a reasonable scope. Our project was a large one, and we did not have nearly as much time as we thought we did to complete it. In future projects, we would like to spend more time on testing the final result and making sure that it works, as nothing is guaranteed to just work on the first shot.

Circuit boards are a nice clean way to hook up many small components in a small space, however the time required for manufacture means that it's best to get those designed and ordered much earlier, as we were waiting several days after already having the 3D-printed parts in order to assemble it.

Not all users were happy with the complexity of twisting the controller in order to access certain features. This information could likely have been gathered much sooner in the design process than we did, and possibly resulted in a different design that more users were happy with, so more surveys at the beginning after deciding on our intended solutions would have definitely been a better approach.

A large number of electrical components were salvaged from existing circuits, and it is very possible that that is the reason for the twist/trigger potentiometers not working correctly. It may be a better idea to order new components to ensure that they aren't worn-out and provide the intended functionality.

References

[1] (n.d.) Gypard one-handed controller. [Online]. Available: https://gypard.com/

[2] C. Kujawski, R. B. Johnson, and M. Goodrich, "Controller device," US uspatent USD848 423S1, 2009.

[3] J. Davidson, "A comparison of upper limb amputees and patients with upper limb injuries using the disability of the arm, shoulder and hand (dash)," *Disability and Rehabilitation*, vol. 26, no. 14-15, p. 917–923, 2004.

APPENDIX A

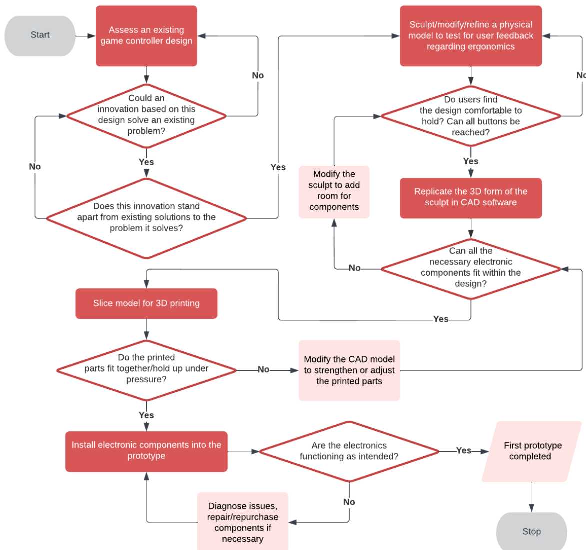

Fig. 1. Design Method Flowchart

APPENDIX B

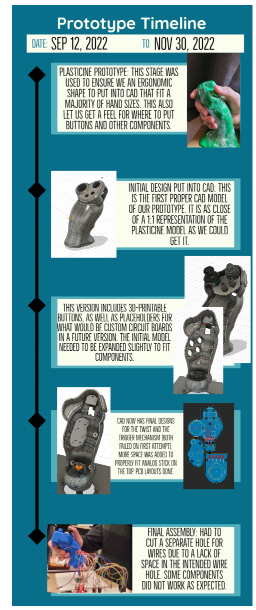

Fig. 2. Prototype Timeline

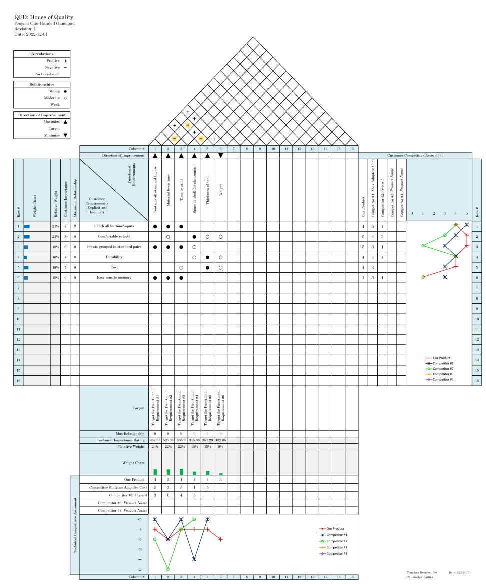

Fig. 3. QFD