Designing a Haptic Controller for the Visually Impaired

Roy Wales 100746617 - Maddin Thom 100751351 - Treyton Cowell 100745472

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Abstract

We have designed a controller for the visually impaired that focuses on capturing controller rotations and providing sufficient haptic feedback. Currently, the market offers limited and expensive options when it comes to controllers for the visually impaired. The visually impaired are severely underrepresented in video games and we want to push for developers to start designing games that can include visually impaired players. We ended up developing a working prototype that includes rotation capture, simple controls and haptic vibration feedback. Future iterations can be made to further the success of the controller but we are very happy with the current outcome. Data collected utilizing the System Usability Scale (SUS), Quality Function Deployment (QFD) and interview style questionnaires.

Keywords - Haptic Controller, Visual Impairments, Vibration Feedback, Sound Game.

1 Introduction

We hope to create a controller for visually impaired or even blind people to play video games with a higher sense of immersion as an alternative to braille keyboards or controller addons. We want to provide sufficient haptic feedback and utilize controller movement to improve and simplify the experience for the visually impaired.

Last year a member of our group made a Unity game with the concept of making a simple game for the blind. The game is a small maze in which each movement plays a sound cue that tells players which paths are open and which are closed, using these sounds they try to escape the maze in as few moves as possible.

The controller we intend to design is a cube-like shape in which an accelerometer can turn rotation into movement in the Sound Maze. The controller features three key buttons alongside the rotation feature. The first button confirms your movement direction, the second restart the level if you get stuck and the third button takes you to the next level. Additionally, the controller will house four vibration motors placed in the north, east, south and west quadrants of the controller respectively, which will give the directional haptic feedback required for blind gameplay. When you move in that direction the corresponding vibration motor will vibrate.

2 Literature Review

Creating a controller more accessible for the visually impaired and blind that can be reused for games with varying controls. The final controller submitted will be designed solely for the Sound Maze, with the goal of creating a controller that will allow future games to be designed around. Taking a look at our sources we were able to highlight some key points when talking about accessibility in games for the visually impaired. "Research in the field of computer gaming usability and accessibility is lacking. Very few empirical studies have been carried out to understand the software design requirements of visually impaired gamers" [Cha16].

It can be hard for the visually impaired to play video games with standard controllers due to a lack of innovation and inclusion. Very few if any games are optimized for the visually impaired or blind player base. Visually impaired players try they simply don't get sufficient haptic and auditory feedback from the controller. The first paper reviewed mentions. "The sense of touch plays a prominent role when engaging with traditional games" [Wal20]. Haptic feedback is extremely important for visually impaired players. The second major conclusion was that audio feedback can lead to significant improvements in accessibility and usability. The three major areas where the infusion of sound effects would have the biggest impact are navigation, in-game effects, and identifying enemies [Cha16].

This problem directly affects the visually impaired and blind players of the gaming community as they don't have the same resources as other players. In 2017 Canada, an estimated 1.5 Million Canadians identified themselves as having sight loss. Three Blind people who are looking to be able to participate in gaming, free of the usual issues raised are also directly affected [Bli].

In terms of companies trying to help Microsoft is doing fairly well. They created the Xbox adaptive controller which allows users to fully customize the controller and is equipt with accessible buttons [Fig. 1]. This is definitely a step in the right direction, yet more work could be done specifically for the visually impaired [Mic].

Their controller introduces a few problems. First, you need to buy and own the different attachments to make the controller accessible. That can cost a lot of money and be a hassle to obtain. The second problem is that the controller doesn't have vibration feedback in its components. The addons, such as the big buttons just sit on a desk so there is no real controller held to be able to produce vibration feedback. Our design opts for a handheld model to solve this.

Microsoft also has had a patent since 2018 for the creation of a game controller with haptic braille play capability. The controller configurations include various adaptations that provide alternative inputs and outputs to help sight-impaired or blind users. It's nice to see they are trying to help but they still have nothing available to the public [Mic19]. People have also tried to create noncommercial solutions such as 3D printing parts and add-ons for current controllers. These solutions may be feasible for some but would require materials and specific controls for each controller and game. Our controller aims to centralize and simplify controls for the blind by making a simple controller that can be adapted to games.

The solutions or attempts that have been made to solve the problem are to create specific games designed to fit the needs of blind players or to design controllers and add-ons to those controllers with things such as braille, sound or vibration to make the experience enjoyable.

3 Methods

As a team member developed a game for the blind, we decided to build a controller that works with this game, and could be used further by visually impaired individuals [Fig. 8]. Originally, we went with a triangular model as we initially thought it would be the best for users and orientating the controller. However, we realized this shape could be confusing for users, so we decided to switch to a rectangular model. For buttons, we realized that they could be difficult to find for users, and difficult to differentiate between them. Therefore, we added braille to create shapes as other developers like Xbox will put shapes on their controllers. The use of braille makes it possible to tell the difference between each button with just touch. The original design of the controller's shape was too large, so we created a smaller version so it can fit better in an user's hands. Additionally, we split up the components of the controller, separating the grips, base, lid and other components so that they would be easier to 3D print. Through our design thinking interviews, we were told the most important things were the users' ability to orientate the controller, which was handled by our rectangular shape of the controller. Additionally, interviewees thought the controller needed simplistic controls, utilization of several touch-based concepts like rumbling and needs to be user-friendly. As the controller only has three simple buttons and rumble motors along the sides of the controller, we felt we met those expectations. We improved the user-friendliness by adding a resting stand to make it easy to put down and pick up. Once the controller began being printed, we got feedback that the button caps were too large and hard to use, especially with the similar shapes in braille on top. Therefore, we re-printed the buttons as a smaller model, and changed the diamond braille on one of them to a triangle.

4 Results

Throughout the design process, we encountered many different prototypes, problems and iterations to come to our current design today. Before starting our design process we first focused on the electronic portion. We wanted to figure out what parts our controller needed and how to properly wire it all together. We opted for three buttons, rotation capture and four vibration motors for feedback. Below is our wiring diagram [Fig. 2].

After our electronics were chosen we were then able to start designing our controller. See the timeline below for a quick overview of our main iterations [Fig. 3]. Our initial triangle idea didn't meet our comfort requirements when we put it into practice, we quickly transitioned to more of a standard box shape for comfort. We opted for larger ergonomic handles so that people of all sizes could hold them. Our next main focus was on the creation of our braille buttons and their placement. Initially, we had larger buttons and we received feedback that their placement felt awkward. In later iterations, we focused on shrinking the size of the buttons as well as focusing on better placement. Our controller also utilizes a gyroscope to measure controller rotation. We want to use physical movements for our controller to minimize button presses to increase accessibility. After playing around and testing with users, we've discovered a nice tilt sensitivity that doesn't strain the player when angling the controller. Our next major iteration was the size problem. We found our controller was way too big to print and hold so we had to reduce the size of everything. It worked out well because our final product is a good size that's comfortable to hold. The next event was to integrate our four vibration motors into our controller. These rumblers provide directional haptic feedback on all four directions which will help to further convey information to the player. The iterations past this point consisted of optimizing our product for printing by splitting it up and adding room for error with our connecting parts. Our loose parts are connected together with epoxy to form a solid connection and our electronics are designed to fit snugly in the base. Here is a picture of our final controller. Near the end of our design process, we conducted SUS and QFD analysis.

In terms of our SUS score [Fig. 5], we obtained a 75 percent. We were very happy with that rating as it is above average but there are some key points that we can agree with and look to improve from. In terms of positive feedback, most participants agreed that our controller was simple to use and easy to understand. People agreed that they wouldn't need help using it and it would be simple to interact with. Overall, people agreed that it had a simple and straightforward design which was what we designed for. In terms of reinforcement feedback, people found the design to be quite cumbersome and thought that the button toppers and layout could've been designed better. Due to the limited time, we were unable to design a more sleek model with an optimal layout. In future iterations, we would like to make our design smaller, and more rounded and have groves that guide your fingers to the buttons. We also would like to make our buttons flush with the controller for a better feel and to improve usability.

In terms of our QFD results [Fig 6 7], we found that people wanted our product to include simplistic controls, a comfortable design, be lightweight, fall resistant, and have good vibration. To meet those requirements we had to design with ergonomics, minimal inputs, durability, vibration feedback and its weight in mind to create a product that encapsulates the wants. We prioritized our features with a higher importance in our final model. In terms of our competitors, we were rated against the Xbox adaptive controller and braille controller attachments. Our product held its own and beat out our competitors in terms of vibration feedback, motion controls and sturdiness. We do have room for improvement and we can see what our user wants and what our competition offers.

5 Takeaways

We have learned a lot from this whole process. One key takeaway is how important iterative design is and how key it is to incorporate user feedback and wants into your iterations. After conducting our usability tests, we were able to realize how much the user's wants and needs can change our design. By getting users' feedback first and iterating around it, we were able to come up with a better product. The big changes we would like to make would be around the size, lid securing and button grip optimization. We would've liked to make the size of our controller smaller to lower weight and the overall bulky feel. Our lid-securing mechanism was an oversight and we found out too late in our process that it was insufficient. We would've liked to design a better mechanism that's reusable. Finally, we would've liked to design better grips that guide the user's fingers to our buttons that would be flush with our controller.

References

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Appendix

Figure 1: Xbox Adaptive Controller

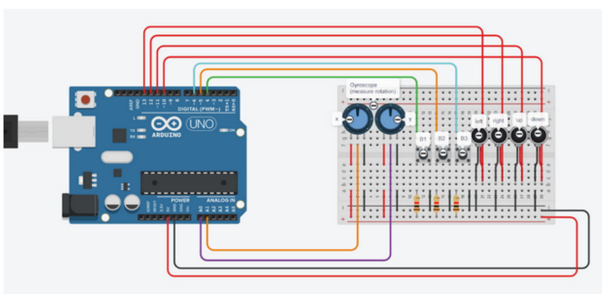

Figure 2: Wiring Diagram

Figure 3: quadVibe Iteration Timeline

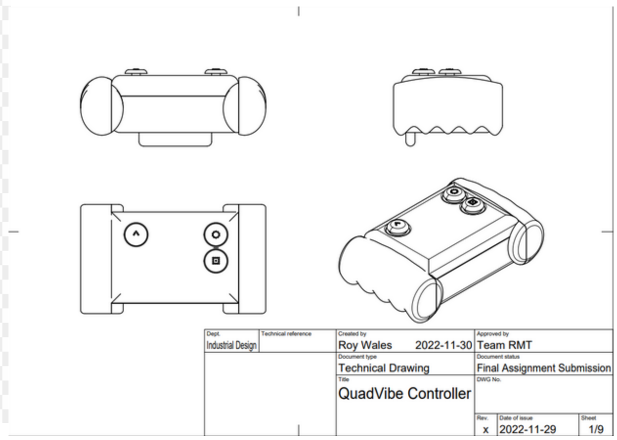

Figure 4: quadVibe Technical Drawing

A	B	C	D	E	F	G	H	I	J	K	L
Paticipant	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	
	I think tha	I found the	I thought t	I think tha	I found the	I thought t	I would im	I found the	I felt very c	I needed t	Score
1	3	2	5	2	2	3	2	3	4	2	60
2	2	1	5	2	4	2	5	3	4	2	75
3	1	1	4	2	4	1	4	3	4	2	70
4	3	1	5	1	5	1	5	1	5	1	95
5	4	1	3	1	4	1	4	4	4	1	77.5
6	4	2	4	3	4	2	4	1	5	4	72.5
									Average:	450/6	75

Figure 5: quadVibe SUS Score

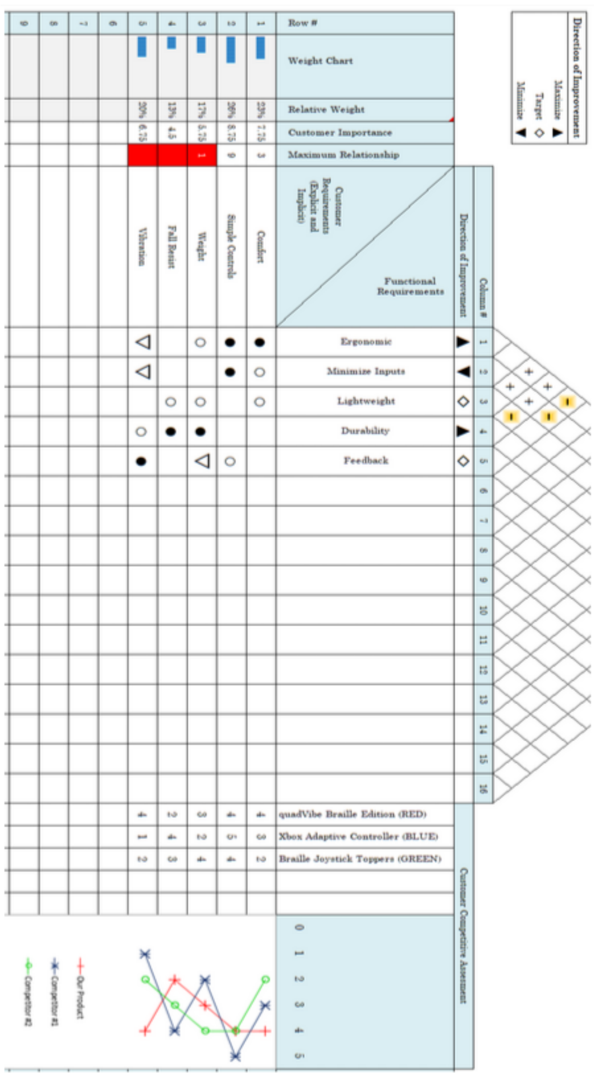

Figure 6: QFD Part 1

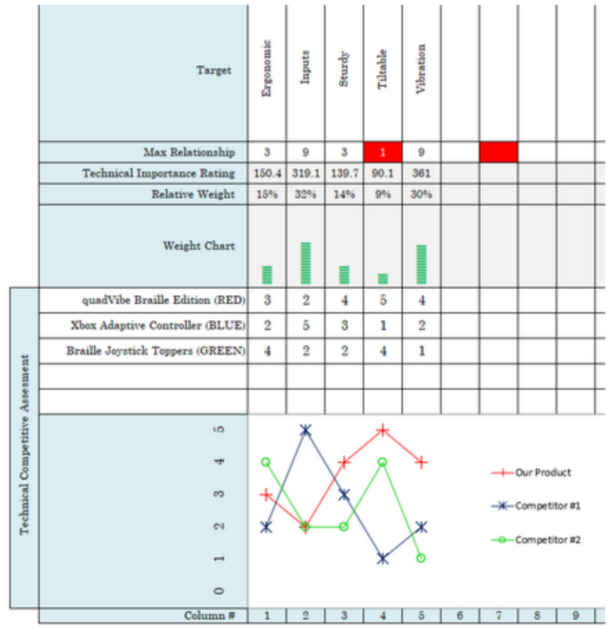

Figure 7: QFD Part 2

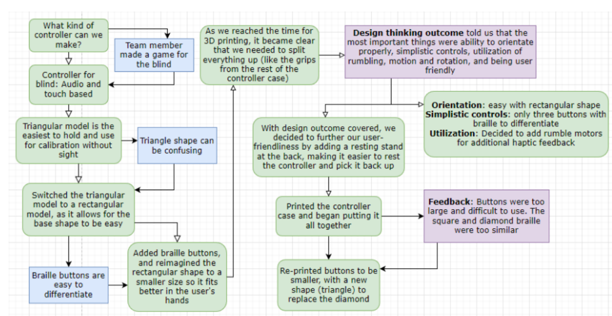

Figure 8: Method Flowchart