MatchMe: a VR Game for The Visually Impaired Utilizing Haptic and Auditory Feedback

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***Abstract*—Virtual Reality (VR) is a medium that relies heavily on the sense of sight. This disallows anyone and everyone with visual impairment from playing and enjoying any games or programs that utilize VR. This is an issue with the medium because it should be accessible to all people, no matter if they have an impairment or not. In order to solve this problem, we have developed a game that utilizes systems, such as spatial audio and haptic feedback, to create a sense of immersion in a simple VR game that has no visual component in order to test their effectiveness. This game requires players to use these forms of feedback to locate and match 2 blocks together. We received a lot of feedback and created several iterations of the game, from low-fidelity to high-fidelity, to get us to our final prototype. This prototype was made in Unity and it utilizes what we have learned in our Emerging Technologies course to create the best sense of spatial awareness and immersion possible.**

***Index Terms*—Visual Impairment, Accessibility, Haptic Feedback, Spatial Audio, Virtual Reality, Iterative Design, Matching Game**

I. Introduction

Due to a lack of games that are accessible to people with a sight impairment, this group has decided to create a game that can be played by both normal players and visually impaired players. In order to create a game with these requirements, research was done to find out how visually impaired individuals can play a virtual reality game. One such research pertains to a paper that talks about a VR racing game that was made for the visually impaired called, Racing in the Dark. This is a game played against several AIs. The game gives the player haptic vibrations to indicate the direction and the intensity the player needs to steer to [1]. Another game that was looked into was a multiplayer game that requires at least one non impaired player playing. The goal of this game was to get a visually impaired individual to play a game with an unimpaired player. This is a game of tag, The unimpaired player is running away, whilst digging a tunnel and the player chasing is visually impaired, only guided on with haptics and auditory feedback [2]. With the overall research, the team has come to the conclusion that the game should require haptics and auditory cues to guide the player to the goal. The group brainstormed possible game ideas, and landed on a simple matching game using haptic and auditory cues to guide the players to the goal. The game has gone through a few prototypes and is now able to be played by someone with a sight impairment. This game requires the player to be seated and to listen to the objects that are making audio signals. The player should be able to follow the sound and feel around the said object using haptics. Player wins the game by finding the matching objects.

II. Methods

To begin our project, we came up with an issue to solve. We brainstormed some ideas and then we began the ideation process and landed on a final idea: we were going to develop a VR experience for the visually impaired. Next, we performed a literature review in order to collect knowledge about past studies and approaches to the problem we were addressing. Once this was done, we came up with our own solution to the problem based on the data we found: we were going to create a simple VR game, with no visual component, that utilized haptic and auditory feedback in order to create a sense of spatial awareness and immersion. Finally, we ended the initial phase of this project by creating a persona of our intended user (Fig 1).

Next, we had to test our concept before spending time programming and creating assets. In order to do this, we conducted a bodystorming session that utilized a paper prototype (Fig 2). We used 6 sticky notes, 3 pairs, to represent objects. We then blindfolded the participants and tapped various items on each sticky note to create a sound. The participant then had to match each pair together to the best of their abilities. The results of this were mostly positive, telling us that we should continue developing this idea, but with acknowledgment of some areas in which we could improve. Specifically, players were able to understand the task and were effective in matching each pair. However they had trouble actually locating the exact position of the sticky notes.

Using this feedback, we began planning our Unity prototype. First we used Mozilla Hub to create another low-fidelity prototype that used spatial audio (Fig 3). In this prototype, much like the bodystorm, we used 6 objects to generate sound for the player to match. This was determined to be too overbearing and, as a result, we made the decision to only use 2 objects in the final prototype.

Finally, we began development in Unity. This high-fidelity prototype included everything we had learned throughout our previous iterations in order to create something close to a final prototype. Next, we playtested this version and utilized a survey to gather feedback on details like sound level, feedback and immersion as well as conducting an SUS, PQ, and TLX test. Now, with all of this final feedback gathered, we updated the current version to finally arrive at our final prototype (Fig 4).

III. Results

Our literature review gave us good insight on how other projects have been developed and how haptic and auditory feedback can be utilized. Based on findings and utilizing design thinking we set up the entire plan for this project. We gathered information on similar VR games for the visually impaired and what needed to be included for this type of project. We found that to best design for this type of impairment, other senses would have to be heavily relied on, most notably haptic and auditory feedback, ie. the senses of touch and hearing. We brainstormed several ideas on how to design and develop an enjoyable VR experience for people with visual impairments. We decided that our area of focus would be on VR controller's haptic/vibration feedback as well as Unity's spatial audio support. After prototyping and testing along with a series of project iterations, We fully developed a scalable high fidelity prototype game which utilizes both haptic and audio feedback in the core game mechanics.

The use of audio and haptic feedback work together to create a sense of spatial awareness to the player by relating to things we understand in the real world. The spatial audio lets us know the direction something is in and the haptic vibration is there to emulate the sense of touch, allowing someone to know when they have touched an object. These core senses were key to designing and developing for the visually impaired throughout the course of this project.

The final result of our work is a game is called "MatchMe". In this game, the player is given the task to locate objects within a small game space through spatial audio cues or jingles and match a pair of objects together. Once the player thinks they located an object they have to reach out and grab the object. When the player's hand collides with the object, the controller will vibrate which informs the player that there is something to grab. When the player finds two objects that match based on the object jingle or cue, they must bring the objects together to their chest and match them. In terms of the controls, the player can rotate with the right controller stick. Reach for the objects with either hand, when you touch a matchable object your controller will vibrate, you can pick up the object with the grip button usually positioned with the middle finger on each hand. If the player releases the grip trigger, the object will release.

IV. Conclusion

At the end of this project, we were happy with the end result, however there were some issues along the way. The largest problem we ran into during development was a collider issue to trigger when the user would try to match both objects together while holding the objects. Basically, when the user picks up an object it's collider would be recreated with the controller shape and set the triggered value to true based on the Oculus integration package in unity which caused the collision to have problems. This would be a future fix which would give the game a better feel.

Another thing that proved difficult was simply perfecting the process. Through testing, we noticed that there were several mirror issues in the gameplay that added up. Objects were too far away from the player's starting position, people would forget that they could rotate, the volume was too low, etc. Through iteration, we were able to remedy most of these issues, but further work, outside the scope of this course, would be required to perfect the system and create a "final product" quality game.

Based on the feedback from testing there are a few features that could be added to the game as well, but they were out of scope for this phase of development. One notable feature is a matching zone or area so the player has more feedback on whether they can match the objects being held.

In the end, however, we believe that our prototype is a success. Our final prototype was everything that we wanted it to be and, due to gathering feedback iterating, was even better than our initial plan. While there is always room for further iteration and improvement, the prototype is successful in creating a sense of immersion for the visually impaired in a VR environment. Throughout the course of this project, we learned a lot about developing for accessibility and what considerations need to go into that.

References

[1] Gluck, A., Boateng, K., & Brinkley, J. (2021). Racing in the dark: Exploring accessible virtual reality by developing a racing game for people who are blind. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 65(1), 1114–1118. https://doi.org/10.1177/1071181321651224

[2] Grabski, A., Toni, T., Zigrand, T., Weller, R., & Zachmann, G. (2016). Kinaptic - techniques and insights for creating competitive accessible 3D games for sighted and visually impaired users. 2016 IEEE Haptics Symposium (HAPTICS). https://doi.org/10.1109/haptics.2016.7463198

Appendix

A. Figures

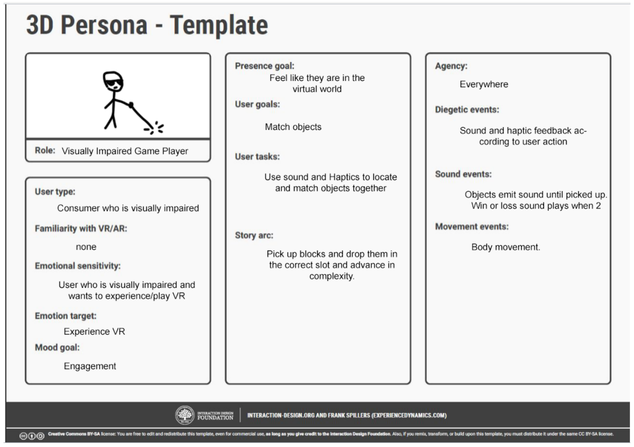

Fig. 1 - Persona

Fig. 2 - Paper Prototype (first iteration)

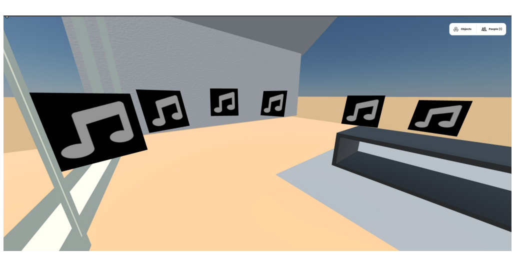

Fig. 3 - Hubs by Mozilla (second iteration)

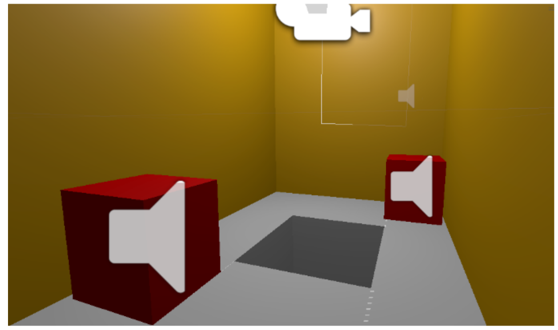

Fig. 4 - Unity Build (Final Iteration)

B. Team Contributions

Matthew McPherson: Game Design, report writing
Jonathan Leung: Sound Design, report writing
Jelani Garnes: Programming, report writing