

Blind and Visual Impairment Orientation and Mobility Training Game

Final Report

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The problem and the characterizing goal

Our task is to design and develop a safe, enjoyable, and accessible Virtual Reality(VR) environment to train individuals who are blind or visually impaired the critical concepts of using sound to maintain orientation independently. Our specific focus for this prototype will be the act of crossing intersections.

Requirement Analysis

Blind and visually impaired individuals need orientation and mobility training. Traditionally, the training is assisted by O&M instructors, which adds to the cost and difficulty of receiving the training. Also, the training is performed in the real-world, where the safety from things like oncoming traffic, wildlife, and other unpredictable hazards can't be guaranteed all the time. People who are receiving training might have a high level of anxiety when they are exposed to the world that has unpredictable elements.

Our game will make it easy for people to access O&M training. They won't need to work with instructors all the time anymore. Instead, people receive training anywhere and anytime, monitored by their parents or teachers. Also, the game makes the training process more interesting and fun (and less scary). It will prepare people to be ready to receive training in the real world environment.

Our prototype will simulate the environment in the real world while adding playable elements in order to make the training process more enjoyable and fun. The environment in the game has sound elements for players to learn and practice aspects of sound localization such as recognizing distance, direction of sounds, and whether the sound is moving.

Our game's target audience are the children and teenagers with visual impairments that need to train their sense of sound. In this case, this game can also be used by the trainers of visually impaired individuals; state, country, and local schools; and the Department of Veterans Affairs in their O&M training efforts.

The target audiences have visual impairment, so this game is auditory-based instead of visual-based. In this case, it not only changes the core gameplay, it will also impact the whole UI/UX design since players will not see anything in this game. The target demographic is also very young. This will probably impact the maximum degree of difficulty we'll be able to reach with our game. If we use language, we should keep it within an average middle schooler's level of vocabulary. The stakeholder wants it to be used as a training system that helps visually impaired individuals obtain the ability to locate the direction of sounds and figure out the situation based on the sounds. Furthermore, they want this game to be attractive to new users.

There is a game we've found that is similar to what we're trying to do:



Legend of Iris is an audio-based 3D exploration game where players have to avoid obstacles and move to the destination. The game utilizes the head tracking capabilities of the Oculus Rift. *Legend of Iris* completely happens in a fantasy world, but our game will simulate the real world environment to help players understand and identify the dangerous elements in reality.

Our game will be played at home or school. They will likely need their parents or teachers to help them setup the device and load the game, but after that, the child should be empowered to play through the game on their own. Since our target audience are people who are blind or visually impaired, safety is our first consideration. Players need their parents or teachers to set up an empty and safe area for them before playing. Additionally, it will be important to carefully consider what hardware we will be developing for. If the set-up is too cumbersome or too expensive, that will not sit well with our stakeholders.

Research Overview

This project is made for blind and VI children to play and improve at orientation and mobility. It is also for O&M instructors to have more options for teaching skills. Blind and visually impaired children need orientation and mobility training in order to learn how to move through environments using only sound. We're going to make a game that simulates real-world training so that these children might have access to safer, more easily accessible virtual training alternatives and supplements. For that reason, we'll need to understand in appropriate detail how O&M training actually works.

Our **characterizing goal** is to train blind and VI children in orientation and mobility using virtual, three-dimensional sound. In order to find the requirements needed to reach this goal, we met with our clients, Scott Jaffray from the California School for the Blind and Christy McKerney, a journalist and mother of a blind, nine-year-old daughter. Through this meeting, we've narrowed down our direction considerably. There was a bit of a disagreement over whether the game should be playable with the participation of a trainer or not. We've included both sorts of ideas in the prototype section below.

On Monday, we had a visit to the California School for the Blind in Fremont. We went and watched real O&M training take place so that we may become better acquainted with the process. While we're there, we also might be able to talk with some of the students and get their opinions on what might be most exciting for them in a project like ours.

Additionally, we've looked at a few resources outside of the immediate surroundings of the project. There have been previous attempts to virtualize space for the education of the blind (Lahav and Mioduser, 2000). They used haptics in order to simulate the environments whereas we will use sound, but many of the fundamentals are the same. We also found that spatial audio is capable of delivering immersive sound environments for the player and the experience with sound that responds to where the player is looking in the VR game. (Bengali, H, 2016) Further studies of how human beings identify and locate sound, how spatial audio can simulate sound in real life, and how to implement audio in VR games are required for our game.

Initial Ideas

Idea 1: A safe, progressive training game. There are various levels designed to reinforce a set of sound concepts. Players will be guided by their trainers, who can

adjust the difficulty of the levels to make sure it is suitable for the players. This idea would put a large emphasis on the trainers controlling the game worlds in which the players reside. They'd control traffic and summon cars and other sound elements when appropriate for their training. The pros are that this format allows the game insertion into preexisting O&M training regimens. The cons are that traditional game elements such as win conditions, loss states, NPCs, narratives, and moment-to-moment preprogrammed objectives might not fit and, therefore, might fail to make the game more interesting. Additionally, the child might not feel empowered to play the game when on their own or any time outside of their already scheduled O&M training.

Idea 2: An adventure game using audio instead of words or visual elements. Players need to locate the origins of sounds by turning their heads and move close to the sounds by clicking the button on a controller. They will interact with NPCs and items in the game. Players need to figure out the layout of their environment based on the sounds like cars' sounds and determine the safe time periods to move, so they can avoid being hurt by enemies and obstacles. The complexity of the situation will increase gradually. Pros: with this idea, guidance will be presented as audio and there is room for traditional gaming ideas like narrativity and mission structure. Cons: This idea will not fit into O&M trainers' existing regimens and the quality of the training will need to be held to a much higher standard as it will no longer be actively driven by authorized O&M trainers.

Idea 3: A hide & seek game. It's a multiplayer game, where the students use VR headsets to hide and the teachers use a computer to seek. The student acts as a character who is invisible to the teacher's character. The teacher's character makes some noise constantly so the student can locate their position and flee from them. The teacher has some hints to help him catch the student when he gets close to the student.

Prototype

After we considered all requirements of our stakeholders and discussed with them about our ideas, the stakeholders and our team agreed that we would make a game that is self-contained so that O&M instructors won't need to take time monitoring students during the visual training.

Our characterizing goal is to provide people who are blind or visually impaired a safe and fun environment to practice orientation and mobility training, and an essential part of the O&M training is learning to use sound cues so that the trainee can locate themselves and navigate to their destination. We decided to make the game to be a

purely sound-based game. In this way, players can better focus on audio in the training so that later, in the real practice, they don't need to depend on their vision which sometimes can be unreliable.

Players will have the ability to play the game with little intervention from trainers or parents so that they don't need to cooperate with others' time when they desire training. In this way, they can maximize their training time and receive better training results. Once the game is set up, they don't need to control the gameplay anymore. In our game, all instructions are given by sound, and players give their input through the controller.

In the game, the non-player characters have some trouble and need help from the player. Players need to finish their tasks (such as retrieving items in order to get rewards). In this way, players don't feel they are training. Instead, they feel empowered by helping others solve problems. The story and task system creates fun moments and motivates players to play more so they will develop a better relationship with the sound.

Crossing an intersection is an important part of the O&M training, but it is more dangerous than an indoor environment and can raise the anxiety of people who are receiving the training. The advantage of using a virtual environment is to guarantee the safety of people and lower the level of anxiety. Therefore, we decided to make the main gameplay to be virtual interaction crossing.

After the player receives a task, they'll need to cross the intersection to complete the task. The intersection in the game simulates the real traffic condition. Players have to decide when to go based on the sound they hear and where they are hearing them from. In order to complete the task, players will have to cross the intersection several times. Only when they fully grasp the skill can they proceed to the next level.

During our visit to the California School for the Blind, trainers showed us how they train at the intersection. First, the instructor lets trainees face a road, and follow the traffic sound by turning their head, body or just pointing the sound till it disappears. Next, the trainees need to orient their bodies parallel to the road. After it is confirmed that trainees can identify the car sound, then they are ready to face the intersection. Thus, in our game, we designed three parts to simulate real training. the players need to do the following: 1) turn their head to follow the sound; 2) align their head to turn parallel to the direction of the sound; 3) pass the intersection.

They also showed us some devices their students are using. These devices all have strong audio feedback so people know what button they are pushing or what content they are reading. Similarly in our game, we decided to add feedback as a

response to players' input. For example, after players click a button in order to accept a task, the system will tell players that they are accepting the task and confirm whether they want to continue.

Our next step is to refine the accuracy of sound. Since people who are blind or visually impaired depend on sound to navigate, it's important that we simulate the sound in a natural, accurate way. Later when they are involved in real training in an intersection, it would be easy for them to recognize the sound if they've already developed an accurate relationship with sound.

“Paper” Prototype

For an audio-based game, a paper prototype would not be representative. What we did instead was use the real-world intersections and sidewalks outside of the school to simulate our own simulation in an analog way. Linked below are video files of this experience:

<https://drive.google.com/a/ucsc.edu/file/d/1BT-0QkXlhBWPjMmtzgQYa5aR2HymGqIF/view?usp=drivesdk>

https://drive.google.com/a/ucsc.edu/file/d/1fq_K-jPOcY-_OA8K2dl-vOzdavS88eYj/view?usp=drivesdk

We used a blackout blindfold called “Mindfold” (donated to us by the very generous California School for the Blind) in order to simulate sightlessness. For our first task, we asked our player to use several listening techniques to align themselves to be parallel to the traffic. They were spun around and had to reset their orientation.

Next, they were told to do this and then walk in a straight line. In the full game, we will not actually have the player physically walk at all, but this should test whether the player is able to use the parallel traffic to continuously correct their angle.

Thirdly and finally, we had the player actually cross the street. We functioned as a guide so that they would not ever be in any additional real danger that a sighted person wouldn't be when crossing the street. In order to make sure that the participant understood what we were going to be doing and that it had potential risks involved, we asked them multiple times before the playtest began whether or not they understood, whether they were okay with it, and whether they would hold the experiment accountable for any danger. Once this was all-cleared, we were able to begin.

Our player was instructed to grab one of our elbows and push out when they felt that it was okay to cross the street. They knew which time to cross because they had been instructed how to listen to near- and far-parallel traffic surges. Timing when you leave the street corner will be a pivotal part of our full game prototype, so seeing that it was possible for a relatively untrained person to do it quickly was helpful.

This playtest showed us which tasks are and aren't going to be practical to include in our game. For example, dressing up the timed-crossing to feel more gamey is going to be a slam dunk. Our player described the experience of listening for idling cars as "eye-opening," which is both ironic and practically useful. Additionally, the fact that the player needed to be spun around in order to retest traffic-alignment was something that we hadn't previously taken into account, but makes a lot of sense. In order to perform this task in-game, the player's angle will need to be randomized in relation to where the street is so that this can be repeatable.

Interviews and results

We had one interview with our client's visually impaired daughter. Young blind and visually impaired children who still need orientation and mobility training, like her, are where our focus is going. Her feedback was immeasurably useful in trying to determine exactly where our level of difficulty should be.

Additionally, we have spoken with a couple other relevant parties. We were invited by one of our clients to visit the California School for the Blind and speak with four of the orientation and mobility trainers who work there. These are people who are employed full-time assisting and instructing blind and visually impaired youths of all ages so, although they are not within our player demographic, they will potentially be impacted by our game.

When we met them, we sat down and explained what it is we were doing with our game and they seemed excited to help us out. We explained that our project was going to use VR, which, understandably, led to some confusion at first. Once they were caught up on what exactly the game was, they had a number of questions for us.

They were interested in how we were going to represent sounds in three-dimensional space using only game making software, which we assured them possible to do in Unity and that we, in fact, had already made a prototype that demonstrates this. They were also interested in how the trainer could interact with the

player as they were playing. This was before we had landed on the trainerless format we have now, so we discussed possible options.

For our questions, we were mostly concerned with the practical details of how O&M training worked at the school. What does a trainer actually do in the moment? How often does training need to occur? What are some of the common problems in training that the student might run into?

We were told that training occurs around once or twice a week and that, sometimes, children have very interesting misconceptions of how the real world around them is shaped. One child assumed that a “straight road” they were standing in front of actually curved in accordance with their field of hearing. Another was completely unaware of the concept of traffic lights and that cars were even taking turns. Things like this were helpful. Now we know what level of granularity with which we need to explain things in the game. We cannot take things for granted.

As for the specifics of how training is conducted, they offered to briefly train us as though we were their students. We were taught to align ourselves with passing by cars, how to deal with masking sounds like loud trucks and buses covering sound sources, and use the sound of cars surging to know when it’s safe to start walking. All of what we learned from these trainers will be funneled directly into the game. Our game mechanics will be fluffed-up versions of these exact sound-localization techniques, from sound tracking to traffic timing.

While we were at the school, we also spoke with their Assistive Technology Coordinator. We asked her what kinds of computers are used in classrooms and what sorts of technology the students might be used to. She showed us a few pieces of hardware and software that are common in blind and VI education. Unfortunately, most of that was not compatible with what we wanted to do, but we did learn a lot about which modes of inputs work best (localized buttons) and which do not perform as well (analog tracking like computer mice and joysticks).

We were very interested in how much she said everything cost. The prices of these things are extreme. One braille-compatible tablet cost an upwards of \$7,000. We are dedicated to making something that can be played using only commonly owned equipment, considering that blind and VI equipment is often price-inflated because of the comparatively low demand.

Below is a bank of other questions we either have asked or plan to ask when able:

Questions:

With the trainers:

Q1: How do you train a kid to cross an intersection? Can you show us the detailed steps?

A1: We first make sure the kid can identify the sound, follow the sound, and also be able to orient his/her body parallel to the traffic to help them walk along the sidewalk. Second, the kid will be taken to the intersection to learn the aspects at the intersection, for example, if the car is waiting for the light, what is near parallel traffic, and what is far parallel traffic

- To design our game core loop and game mechanics

Q2: How many types of intersections do you teach to kids?

A2: Intersections with the traffic lights, intersections with the stop signs, three-leg intersections, and four-leg intersections.

Q3: Which intersections do you want us to include in the game?

A3: Four-leg intersections with the traffic lights and the stop signs.

- For the level design

Q4: How often does a kid get trained for his/her orientation ability?

A4: About twice per week.

Q5: Does the kid need to have basic knowledge about how traffic works?

A5: Yes, the kid should understand the basic traffic rules like the signal cycle and traffic pattern

Q6: Is there any prerequisite for the player before they can play the game?

A6: Yes, besides the knowledge of how traffic works, they also need to know the situation of uncertainty which means if there is no car sound or they are unsure of the sound, they need to wait before they cross.

- For the level difficulty design

With the technology coordinator:

Q1: What equipment are you currently using in the school?

A1: Software running on the desktop with sound instruction to let the blind can use the computer without using the mouse, keyboard for the blind, and a tablet for the blind.

Q2: Why do you choose to use these types of equipment?

A2: The first thing is if our kids can play with the new software of the hardware. Additionally, as California School for the Blind, we need to support other blind schools in the whole state. Every time a new device comes out, we first need to learn, and train others working in other schools to learn how to use it. Also, if a family buys the device we are using in school, we also need to teach them how to use it. It's very busy work.

- To figure out how to assist the trainee access the game and the game equipment
- To decide what kind of hardware we are going to use

For our target demographic:

Q1: Do you play games? If so, what kind of game do you play?

A1: They primarily play educational games. Specifically, math games.

Q2: Do you like the game you play? Why do you like it? What kind of feedback do you get from the game?

A2: A general sense of fun is appreciated. The game she likes has a large world of adventures and quests to complete. The game she doesn't is mostly just math drills.

Q3: Do you know what an intersection is?

A3: They were very familiar with the ins and outs of how intersections work.

Q4: Have you crossed an intersection on your own? How does it usually work?

A4: They have not, and they think it would be frightening.

Q5: How do you feel about the sound at the intersection?

A5: It sounds more like one big mass of sound than individual, disparate sounds.

Q6: Have you ever gotten trained for orientation by using sound? If so, how often?

A6: They get trained once every two weeks, but they also said that this might be uniquely infrequent compared to other children in the same situations.

Q7: Do you know about traffic lights that control the traffic?

A7: They did.

Q8: How many different lights can you tell?:

A8: They cannot always see the lights, but they understand that green means go, red means stop, etc.

Q9: Can you tell if the sound is turning right or turning left or going straight? How can you tell the differences?

A9: They cannot.

Q10: Can you tell if the sound is going towards you or going far away from you? How can you tell the differences?

A10: They cannot.

Q11: What does a car sound like? What makes it different from other sounds?

A11: They can recognize the sound of a car fairly distinctly.

Incorporating feedback

When we did the real life analog playtest, we found that the player needs to be spun around to retest orientation with the street. We'll randomly rotate the player's orientation in the game world before each testing to account for this. Additionally, because of the width of the real life street corners we were testing on, it was difficult to pick up any far-parallel traffic stalling at the intersection. While this is a legitimate problem to have in the real world, we're trying to ease the player into O&M, not provide a perfectly realistic version of real intersections. Therefore, we'll try to make our intersection a little smaller and make it a bit less busy so that the critical information needed for the player to localize themselves is always there.

From the interview with a member of our target demographic, we knew that one of the current M&O training activities they are getting is a board model of the street, and she would learn the concepts from this board model. The board is soundless so, after she got all the concepts, bringing the concepts into real life still requires real-world

practice. That said, using the board is their favorite part of the training because of it's toy-like quality. A focus on making our game feel intrinsically fun like that will be important.

Our interviewee thinks they are capable of crossing intersections, but they are not willing to do it because it is too scary. Our game can provide players with a safe practice method that doesn't risk any real bodily harm. We will use voice instructions in our game to encourage players, give feedback, and help them build confidence. Also, our interviewee said that they can hear cars, but when they stand at an intersection, they hear one big car noise. We are going to exaggerate car sounds in different paths by using different engine sounds instead of a single one with different volumes to make the player feel the distance of the sounds and, hopefully, make it easier for the player to pick the sounds apart.

Lastly, our interviewee also said she is not capable of identifying the direction of moving sound, for example, if the sound is turning right, left, or going straight in real life. In our previous prototype, players needed to first turn their head to track the sound. Next, players needed to align their head or body parallel to the direction of the sound. Finally, they walked along the sidewalk, reached the intersection, and crossed it. However, we noticed that we do not have a section that trains player's ability to tell the direction of the sound. Therefore, we designed a two-part plan to train this ability. The first part is that we give players sound instructions telling them the sound of left turn car, right turn car, and going straight car before they pass the intersection. The second plan is that, before we let the player pass the intersection, we add one more section where the player is tasked with following a car as they drive with their head-turning.

Final prototype description and justification

Purpose : The purpose of the game is to practice intersection crossing in an interesting and safe way using only the player's sense of hearing.

Aesthetics: An essential part of the O&M training is learning to use sound cues so that the trainee can locate themselves and navigate to their destination. We decided to make the game to be a purely sound-based game. In this way, players can better focus on audio in the training so that later, in the real practice, they don't need to depend on their vision which sometimes can be unreliable.

Narrative: In the game, the non-player characters have some trouble and need help from the player. Players need to finish their tasks (such as retrieving items in order

to get rewards). In this way, players don't feel they are training. Instead, they feel empowered by helping others solve problems. The story and task system creates fun moments and motivates players to play more so they will develop a better relationship with the sound.

Mechanic: The mechanics in our game helps to simulate the real intersection crossing process including head turning and button pushing. Considering operation difficulties for our target audience, we designed the game to be controlled using two buttons. Players need to utilize the stereo sound in the game to orient themselves by turning their head. When the player feels they are facing the right direction, then they can push the right trigger to move forward. In addition, if the street crossing button is close to the player, they can press the left trigger to push the button. By integrating the two-button control into the game play, players are able to easily control their movement while experiencing the simulation of a real intersection crossing.

Content/Information: The intersection crossing process is based on real training. We did this to make sure we can provide professional and correct guidance for players to practice maintaining orientation.

Framing: The player is placed in a virtual intersection they need to navigate, which empowers a user who can potentially only do this in real life with outside help.

With our game, young blind and visually impaired people will have access to an instructor-free, easily accessible way to practice their orientation and mobility skills. Because the game takes place in a virtual setting and has a bit of a story to it, it might even be more interesting to the trainee than real-world training, as well.

Implementation Plan

			Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri		
TASK NAME			Assigned	Progress	4	5	6	7	8	9	10	11	12	13
Player Controller	Luyao	30%												
Game Guidance Scripting	Yanjiao	100%												
In Game Sound	Ruizhe	20%												
Game Flow Implementation	Luyao	0%												
Head Turn and Align	Ruonan	0%												
Make Voice Guidance	Wolfe	0%												
Guidance Implementation	Yanjiao	0%												
Play Test	Group	0%												
Final Refinement	Group	0%												

Our implementation included three parts, programming for the game flow, creating sound for objects such as cars in the game, and scripting and adding audio guidance. The detailed implementation is shown in the gantt chart.

After we completed most functions of the game, we asked our classmates to play our game. According to the playtest, we found out that some guidance is not clear so that players are confused and didn't know how to finish the tasks at the beginning of the game. Based on the playtest, we changed and added some voice guidance to make the instruction more clear. Also, the playtest helped us to detect and fix some programming bugs.

Finally we completed all the tasks we planned on this Gantt chart. In addition, an extra local connection feature is made by our team members. Using the local connection feature, parents will be able to monitor how their kids are doing in the game using another computer. They can check the location of their kids visually while their kids are wearing the google gear and playing the game.

Future Plan

Since the playtesters we found before are all sighted people, if we want to further improve our prototype, we will look for people who are blind or visually impaired to test our game. We believe that we could make a lot of improvements based on their feedback. Also the playtest could help us to test if we are working in the right direction.

Another way to improve our prototype would be making more levels in order to satisfy the needs of people at different levels. People who only just started their O&M training are weak in some parts such as the car direction recognition part. They are not always capable of playing the intersection crossing level. Therefore our personalized levels could help them to focus on the basic parts of the training and make improvement quickly.

Of course, this project being just a prototype, there would have to be a massive expansion to the game's scope. We only have one level currently, and the story is very barebones. We'd want to expand both the number of environments and the depth of exploration within those environments.