Lost in Spaze: An Audio Maze Game for the Visually Impaired

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Abstract
In response to the severe lack of video games geared towards individuals with visual impairment and blindness, we designed and developed a maze game ("Lost in Spaze") that can be enjoyed by players of varying visual ability. Using controllers, players navigate through four mazes of increasing difficulty, guided by audio cues indicating what direction they should take. Given that Lost in Spaze is a video game, there is still a visual component that is not meant to be used by players. However, the visual component may allow a non-player audience who are not visually impaired or blind to engage in the fun of this local multiplayer party game.

Author Keywords
Accessible Game; Blindness; Visual Impairment; Multiplayer Game; Audio Game; Party Game

CCS Concepts
•**Human-centered computing** → **Accessibility;** *Accessibility design and evaluation methods;* Accessibility systems and tools;

Introduction
In 2010, the World Health Organization estimated 285 million people to be visually impaired and 39 million people to be blind [5]. Given this large statistic, we have recognized

Figure 1: The game's intro menu (top), player selection menu (middle), and difficulty selection menu (bottom).

a need for video games that can be catered to individuals with visual impairment and blindness. However, designing a fully accessible game has been a long-standing challenge in the gaming industry. Even accommodations for the common issue of color-blindness are rare [2]. Most video games use visual interfaces as their main mode of feedback, which impedes accessibility to most individuals with visual impairment [1]. This lack of existing visually accessible games inspired us to design our game, *Lost in Spaze*, which has the potential to be fully accessible to individuals of all visual abilities. Taking advantage of the audio rather than visual affordances, in our game audio cues are served as the feedback provided to players.

Related Work

Accessibility

Recently, accessibility has become a prevalent area of focus in game research and development [3]. Game researchers and designers have been investigating optimal ways of game building for individuals with varying degrees of visual impairment. However, still very few existing games can be played by visually impaired players. Most games tend to use visual information as their primary form of feedback for players. Instead, by focusing on audio signals as the primary feedback, games can become more accessible for the visually impaired [4, 7].

Visual Impairment

Given that the authors are neither blind nor visually impaired, the game was developed by using blindfolds on individuals with full sight abilities. We recognize that blindfolding individuals who do not have visual impairments or blindness is not an accurate portrayal of blindness. However, Silverman recommended simulating blindness for sighted individuals using a blindfold [6]. Silverman also highlighted the importance of properly educating people about what it is like to be blind and understanding the biases that can result from improper blindness simulation. These biases include misinformation about what it is like to be blind as well as discrimination against people who are blind [6]. However, simulation can promote empathy towards individuals who are blind. Further, because our game is designed to be multiplayer and local, we encourage sighted individuals to play together with individuals who are visually impaired or blind.

Additionally, Silverman indicated that performing simple, repeatable tasks without the use of vision can show individuals without blindness how skills can be mastered without the use of sight [6]. We believe that using video games helps accomplish this goal, particularly in a game as straightforward as ours. The single goal, which is repeated in each level, is to navigate the maze. Players also enact similar moves in each level to accomplish that goal.

Game Design

Premise

Lost in Spaze takes place in a futuristic space zoo. Animals are trapped in the zoo, and must escape from the maze of corridors in pitch-black darkness in order to survive.

Motivation

Two years prior to the game's design, the second author played a series of card games with friends in a social setting, one of whom was blind. The second author and friends began a discussion about party games which are accessible to individuals of varying visual abilities, including those who are blind. Given the lack of party video games available to groups with varying visual abilities, the second author was inspired to create such a game. Therefore, the goal of the current project was to create an accessible party video game for players with visual impairment.

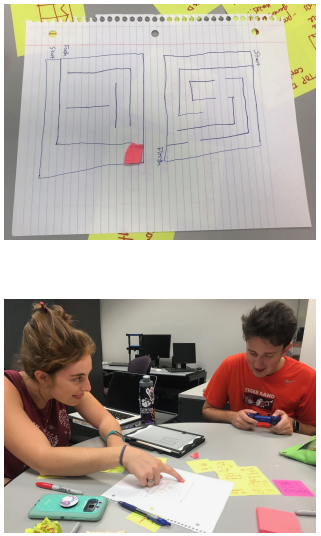

Figure 2: Paper mock-up of the game during the initial design phase (top). Concept and usability testing with team members (bottom).

Game Overview
Players must take advantage of audio cues to navigate through each maze. To this end, players who are able to see the screen must either blindfold themselves or face away from the screen.

Players use traditional game controllers (e.g. PlayStation 4, Xbox, or Steam controllers), and in-game audio instructions direct players how to use them. Controls are limited to an “Action” button (the primary button on a controller, often “X”) and directional controls on the D-pad. Audio instructions guide players through the start menu, player selection menu, and the level difficulty selection menu.

On the player selection menu, players are able to add themselves to the game by pressing the Action button. Each player is assigned an animal based on the order in which they join the game: Player One is always a dog, Player Two is a cat, Player Three is a cow, and Player Four is a frog. Each animal has unique character sounds, which include a “Wall Collision” cue and an “Intersection” cue. These cues play for each player when they join the game so they can familiarize themselves with their cues before gameplay.

Levels include a Tutorial, an Easy, a Medium, and a Hard mode. Once Player One selects the desired difficulty through the auditory interface, the game begins. The player’s audio cues are their major asset when navigating through the maze. With no way to see the screen (which has visual cues strictly for audience participation), players use their audio cues to determine when they have hit a wall and when they have reached an intersection. Distinguishing intersections is important because it lets players know that they can travel in more than one direction at a given location.

The goal is to complete the maze the quickest; the level will advance once all but one of the players have finished the maze. Points accumulate when a player completes the maze. The more quickly a player completes the maze, they more points they receive. With up to four players, Lost in Spaze is intended to be a local co-op party game, though the game can also be played with just one player. Audience members can aid those playing by giving directional cues.

Gameplay Design
Project development for the game design began with brainstorming sessions using post-it notes for sharing and developing ideas. Accessibility was the most popular motivating factor, and primary game goals of “Accessibility related,” “Collaborative,” and “Feasible” were finalized through team discussion. Over time, our focus was narrowed down to gameplay by individuals with visual impairments. When the idea of “navigation through sound” was proposed, a maze solvable solely through audio cues became our primary goal.

With the aid of post-its, a collaborative and engaging team atmosphere, and fast-paced paper prototyping, we generated, tested, and analyzed game ideas over the course of a few meetings. Then, we created a paper mock-up and conducted preliminary user testing within our team (Figure 2). This helped us identify some challenges of playing an audio-only game and provided us with insights for our game mechanism design.

This game is not meant to be played using any visuals. However, given that this is a video game, we provided a basic visual interface. Notably, though, the visual interface is not meant to be used by players. In fact, if players would be able to view the screen during gameplay, the game would end much quicker than intended.

Audio Interface Design
Audio plays a crucial role in Lost in Spaze's accessible design. Players are completely dependent on auditory information when playing the game. The game is introduced through a vocal recording, and pre-gameplay menus are navigated completely through audio direction. Additionally, players must navigate through the mazes using audio cues tailored to their specific character. Background music adds to the atmosphere of the game.

Each game menu includes explanatory voice-over to guide players through the game. The Start screen vocally welcomes the players, explains the vision-less nature of the game, and prompts players with no visual impairments or blindness to turn away or put on blindfolds. The player selection screen vocally recognizes when a player has joined by pressing the Action button on their controller, and includes the two unique audio cues players will need to listen for to play the game. After a delay to allow for the new player to recognize their sounds, other subsequent players are allowed to join, and their audio cues will play with accompanying auditory explanation. The final pre-gameplay menu encourages players to choose a difficulty setting, and vocalizes which setting is currently selected. When a difficulty is chosen, the game begins, and the voice declares the start of Level 1. At the end of the game, an additional vocalization indicates which player has won.

Two essential audio cues are provided to help players navigate through the mazes. The primary audio cue indicates wall collisions. This sound is an animal sound that correlates with the players' characters ('bark' for Dog, 'meow' for Cat, etc.). This sound plays when a player is trying to move in a direction blocked by a wall, so that the player knows they cannot move that way. If the sound does not play, the player has successfully moved in their desired direction.

The other determinant cue is the intersection audio cue. During paper-prototype testing, we found that players tended to continue straight along a path once they have determined they could go in that direction. This caused players to miss possible routes they could have taken, such as a branched off path that deviates from the player's chosen route. To account for this, the game includes an intersection audio cue that indicates to a player when they have reached a point in the maze where they can move in more than one direction.

The authors provided voice recordings for game narration, instructions, and announcements of difficulty selections and level numbers. The animal sounds, background music, and character sprites were open source.

Game Development
Lost in Spaze was developed in Unity 2019 using C#. Development focused primarily on Menus and Mazes. The audio-dependent nature of both the menus and mazes required a degree of audio management, including timing and playing the correct audio recordings. Additional development included building a visual interface for audience members' enjoyment.

The menus are built as Unity's canvas objects, which overlay the game-play camera. The menus are designed to only require the use of four buttons: the four directions on the D-pad and the predefined Action button. The menus also highlighted the selected menu components.

The mazes is represented with a 2D matrix structure and its size depends on the size of the maze. Maze cells are stored within the Maze matrix and include a list of the cell's edges by cardinal direction, and whether these edges are walls or passages. A player's position is stored as a Maze cell position. When a player moves, a request to the Maze will return either a passage (and the player moves) or a wall

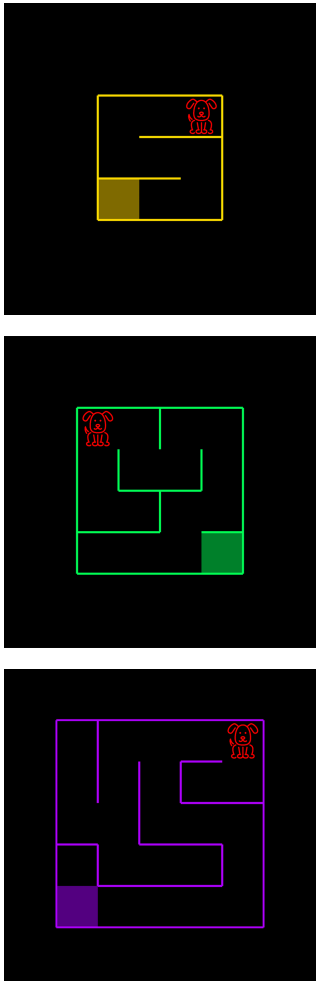

Figure 3: Maze difficulty levels. Easy (top), Medium (middle), and Hard (bottom).

(and the player's wall collision sound is played). Variables keep track of how many players have finished, which level players are on, and in which order they finished. Players are stored as objects which persist through the menus and mazes, and are destroyed when the game is restarted.

Mazes are procedurally generated within a given size. Easy is 3x3, Medium is 4x4, and Hard is 5x5, (see Figure 3). Random cells are initialized. If an initialized cell's neighbor exists, a wall is added between the two cells. If not, the neighbor is initialized and a passage is added between them. If the potential neighbor is out of the bounds of the maze, a wall is added to indicate the outside of the maze. If all of a cell's cardinal directions have not been assigned passages or walls, they will be randomly selected and checked for neighbors until all cells are initialized. With this algorithm, all cells are ultimately connected by passages, allowing for a connected maze that players can explore without the risk of blocked off sections. When the maze is initialized as a level, the goal is set to a corner of the maze, and players are placed in the opposite corner. Maze colors are randomly generated.

All mazes are visually built into a 3D representation in Unity. Using an orthographic camera placed above the built Maze, we replicate a 2D experience for the audience's enjoyment.

Gameplay Testing

After designing and building the game, we conducted a series of tests. The first test was a paper prototype. The findings of the first test were critical and provided us with insights about how we should design the game mechanisms. First, we determined that players did not initially know where they were and where the wall was when they played the game. However, when players did not receive visual feedback, they continued moving until they bumped into a wall. Second, we found that players did not know in what directions they could go, and were particularly confused by intersections in which they could move in more than one direction. Specifically, players would not check the wall at each step to determine whether or not there was an intersection.

Once the first maze was built, we tested it with our team. Considering that no members of our team are visually impaired or blind, two of our team members blindfolded themselves to properly play the game. The team tested the tutorial, the easy, and the hard levels. This test indicated missing details. First, menus needed to be read aloud so that players could know at which menu they were, and at which difficulty level their "cursor" was. Second, all the players could not join at the same time because they need to listen to their assigned character sound one by one. Therefore, they could not identify which player each of them was. Additionally, since it is a multiplayer game using one PC, Player One controls the level selection and moves onto the next step. Hence, player order affects all the players.

The game has not yet been tested with individuals with visual impairment, and we acknowledge this as a design limitation. However, we would like to have input from individuals who are blind or visually impaired in the future.

Conclusions and Future Work

Lost in Spaze addresses the lack of accessible digital games that are available to individuals with visual impairment. This game defies the traditional mode of visual feedback present in modern video games by utilizing an entirely audio dependent gameplay system. Players must use audio feedback to make their way through the game to escape the generated mazes. Therefore, Lost in Spaze offers a potential opportunity for individuals of any visual ability to play a digital game together. We hope that this audio-based party game will ex-

pand the landscape of accessible video games and inspire more accessible video game design in the future.

Lost in Spaze is still in early development. In the future, we will recruit individuals with blindness and visual impairment for testing. Additional future features may also add to the enjoyment and challenge of the game:

Player Interaction Enabling players to be able to interact with each other will add to players' enjoyment of the game. When players reach a specific point in the maze or hit a specific wall, they may receive items which can be used to slow other players, accelerate themselves, or even cross walls for a short time.

Sound Navigation More advanced sound navigation techniques could make it easier for players to get through the mazes. These techniques could give more specific indications on distances to objects in the maze, or let players know if they have returned to a place they have been before.

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