Adapting Videogame Interfaces for the Visually Impaired: A Case Study of Audio Game Hub

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Abstract

Technology applications including games are generally not designed with the blind or visually impaired in mind. This is an invaluable area of research as it is this population that would benefit the most from accessible technology enabling inclusion and participation in society. "Nobody makes games for us" was a motivator for this research. This paper describes the process of creating a set of audio games for the visually impaired. The principles of audio game design are discussed and based upon these the Audio Game Hub is proposed. Audio Game Hub is currently a set of four audio games that have suitable interfaces for the visually impaired. Audio Game Hub is currently available for download on multiple platforms and has seen popularity with both visually impaired and normal sighted players, which provides an area for future research.
Keywords: audio game, user interface, visually impaired, video game.

1. Introduction

"Nobody makes games for us." [10]

Research in the area of digital technology for visually impaired has focused on web accessibility and assistive technology [4]. According to World Health Organization there are an estimated 285 million people who are visually impaired worldwide and 39 million people who are blind. A large motivation for this project stems from the lack of available video games that are accessible by those with visual disabilities, namely, those with: blindness, low vision and color

[10] Customer Testing Centre, Orange Labs. A statement expressed by one of the visually impaired testers of *1812: Heart of Winter*, an interactive audio story developed by Jarosław Beksa at Orange Labs, Polish Telecom in 2011.

blindness [2]. This is especially unfortunate as it is this group of the population that would benefit the most from accessible technology, enabling them to be an active member of society.

Games are popular because of the level of interaction they offer [3]. Although there are around 50,000 video games currently in active circulation (ugdb.com), only just over 500 of these games are accessible to the visually impaired (audiogames.net) and of these only just over 100 are audio games (audiogames.net). In order to be accessible, most of these games are text-based and rely on the use of screen reader software, often lacking the immersive depth that is integral to many traditional video games. A small portion of these, however – audio games – provide a rich counterpart to graphic-heavy interfaces by layering and manipulating sound in place of visual components.

Audio games are ones where gameplay relies on audio cues. Sound becomes the dominant interface, and the visual components are ornamental and not necessary for the game experience – audio games can be played with graphics turned off. Similar to the effect of reading a book, the user is able to fill in visual information with their imagination. It is audio games that have the potential of translating traditional video game experiences into more organic and engaging versions of blind-accessible games.

Electronic audio games first emerged as handheld devices in the late 1970s, with the release of Atari's Touch Me in 1978. Although such games were accessible to non-sighted players, they were not designed specifically for the visually impaired. During the late 70s and early 80s, there was little effort put into specifically catering to blind audiences as early video games of the time were inherently more accessible. Multi User Dungeons (MUDs) were particularly popular – text-based adventure games that relied on text commands rather than graphics for interface. However, as technology – and therefore video games – became increasingly more sophisticated, gameplay grew more dependent on visuals. Over time, the divide between sighted and non-sighted players grew exponentially, and an increasingly smaller percentage of games were accessible.

With a growing demand for accessible games, the next wave of audio games emerged in order to consciously cater games to the visually impaired. This generation of audio games was taken up by small studios, hobby game developers and amateurs, visually impaired programmers and game accessibility researchers. A number of original games were developed at the time, with a conscious effort to make them accessible for the visually impaired, including Real Sound – Kaze No Regret (1999), The Blind Eye (2000) and Terraformers (2003). In addition, there was a rise in audio games that were adapted from visual-based counterparts from across a number of genres, for example, The Last Crusade (2004) which was an adventure role playing game (RPG), Drive (2003) which was an audio-based car racing game, and The Shades of Doom (2001) which was an adaptation of the popular mainstream game Doom. Despite the momentary enthusiasm, this surge of audio games was not long-lasting as many parties discontinued development due to insufficient income generated from the games.

However, audio games have once again experienced a resurgence in recent years. This trend is caused by a number of factors that affect both the players and the developers of games. Visually impaired players are more exposed to audio games through the increasing availability of accessible operating systems as well as the proliferation of portable touchscreen devices such as smartphones and tablets, and mobile game platforms like the Apple App Store, Google Play, or Windows Store. Audio video games have also become more popular with a wider community – including both non-sighted and sighted users.

On the other hand, developers are also making more audio games, in part due to a growing awareness of accessibility needs. In general, games are increasingly easier to make due to the ready availability of game development engines such as Unit 3D and XNA, and the increase of machine computing power. Development has also been propelled by the rise of the independent ("indie") game scene, and game release has been enabled by the increasing support of crowdfunding.

Most notable recent accessible development has focused on portable touchscreen devices, including titles such as Papa Sangre (2010), Sound Swallower (2011), The Nightjar (2011), Papa Sangre II (2013), Audio Defence: Zombie Arena (2014). The two Papa Sangre games as

well as Blindside (2012) also focused heavily on non-visual spatial exploration by leveraging binaural audio technology that is utilized to create 3D auditory spatial environments. Finger Dance (2007), an audio-based rhythm action game, was also notable as it was designed specifically for visually impaired players.

Many audio games are not as developed in terms of depth, diversity, multiplayer functionality and good replayability (audiogames.net). Clearly, there is a gap in the market and a need to provide visually impaired with richer gameplay than what is currently available.

2. Principles of Audio Game Interface

It is easy to say that in an ideal situation, all games would be accessible. However, this utopian intention is unrealistic in practice – what might be accessible for one user group, may completely alienate another. For example, although audio games are inclusive of visually impaired players, they do not cater to those with hearing difficulties [2]. Even when interface isn't completely ostracising, it cannot be guaranteed that every group will have fun in their experience of the game.

However, although a single game cannot simultaneously appease all parties, it is important that developers and producers make conscious and informed decisions about who they include and exclude from their work. An increase in accessible games, including audio games, would be motivated not only by producer interest and user demand, but also on game and application policy and guidelines from software and framework providers. A number of such guidelines have already been created by independent parties:

- The Game Accessibility Special Interest Group from the International Game Developers Association have formed online guidelines on accessibility of interface and game mechanics (IGDA);
- Through a collaboration between a number of game studios, specialists and academics, the well-defined Game Accessibility Guidelines were laid out, using examples from existing games (Game Accessibility Guidelines);
- John Bannick created a checklist outlining requirements for compatibility with screen readers like Jaws, Windows Eyes and Supernova [1];
- Apple and Google provide comprehensive guidelines on accessible application development (Google Inc,; Apple);

Audio-based interfaces create sonic environments through the use of three fundamental elements. Each basic element intrinsically conveys a certain type of information:

1. Speech: has the ability to carry narrative and explicitly share knowledge, information and communication between characters;
2. Music: can enrich and add depth to the soundscape, influence a scene's mood, and place emphasis on strategic moments;
3. Natural and artificial sounds: reflect interaction with the game environment or interface, indicating objects or processes, for example, sliding crates along the ground or rustling bushes [10].

It is the last category – natural and artificial sounds – that is the most crucial component to audio games. For the successful use of sounds, it is important to understand auditory design principles, and the potential of sound qualities to carry meaning in the game interface. Much like visual design principles – which focus on the significance behind shape, color and size – auditory interface design should be deliberate in its use of pitch, volume, placement in 2D space, and other sound qualities. However, in addition to the practical role of sound manipulation in interface, it is also important that the environment works as a whole and that it simply sounds good. One of the hardest challenges when producing audio games is to maintain high aesthetic standards, while still retaining functionality [6]. The layering of these sounds should be approached tactfully in order to achieve interface clarity and to establish a clean design hierarchy. A single sound environment cannot have too many elements present at once, as they will compete with one another and put strain on interface clarity. However, it is also important to include regular sound at all moments of the game to keep the user oriented [11, 9, 5].

To better understand the role of natural and artificial sounds in audio interfaces, Johnny Friberg broke them down further, into six distinct categories [6]:

1. Avatar sounds: made by an avatar when interacting with the environment or objects;
2. Object sounds: made by objects indicating presence and location;
3. Character sounds: associated with non-player characters (NPC);
4. Ornamental sounds: may add to the atmosphere of a scene, but have no direct practical significance, for example ambience and music;
5. Instructions: voice over by a narrator;
6. User interface sounds: not directly related to the game world, but indicating interface navigation, for example buttons and menu elements. Auditory icons, sound-based parallels to visual icons also fall into this category [7].

3. Audio Game Hub

Audio Game Hub (2016) is an application that combines eight original audio mini-games, specifically designed for both non-sighted and sighted users. Multiple genres of casual video games were adapted into accessible audio equivalents, each designed with unique interaction patterns and gameplay mechanics. Games were predominantly derived from cross-culturally familiar precedents from the arcade and platform genres – chosen based on concise and simple rules that would smoothly translate to an alternative interface.

Audio Game Hub is an ongoing practice-driven research project first started at the Gamification Lab, Centre for Digital Cultures in Leuphana University Lüneburg, Germany and is now being continued at the Auckland University of Technology, New Zealand. Development of the games was completed at the time of writing, and user tests were being undertaken. The application is designed for use with touch screen devices, touchpads, keyboards and computer mice, and is compatible with both mobile (iOS, Android, Windows Phone) and desktop (Windows, OSX) platforms.

Navigation Interface

In order to provide accessibility for the visually impaired, Audio Game Hub focuses its interface primarily on audio output combined with gesture input from the players. Minimal graphics are also used, however, they are not necessary for game functionality. Instead, they exist as "visual aids" for those new to audio games and can be turned on or off at any screen.

Audio

As the application puts heavy emphasis on audio, particular attention was paid to a number of different categories of sound in the audio interface [6].

Game engagement is key to the project, and each game world features layers of unique background music, ambient sound and voice over characters. Many of the sounds were also synthesised in 3D binaural technique to amplify player immersion as "when such stimuli are presented over headphones, there is a perception of auditory space [...]" [12].

In addition to experiential value, audio is also critical for navigation and orientation within and between games. Each action from the user triggers a sound, confirming their input, and therefore creates feedback loops between the application and the user. In the mindset of audio icons, the same actions and events cause the same sounds, regardless of what screen the user is on, which assists in clarifying interface for users as it "[...] establishes an expectation that we will hear the same sound as a reaction to the same action" [5].

Gesture and Input

The gesture-based input (touch screens) and mouse or keyboard input (desktop) for the games is specifically designed for the visually impaired, using simple actions to navigate menus and trigger game mechanics. Controls are limited to up, down, left, right, single and double taps or clicks, and can be performed across most of the screen – avoiding the necessity for precision

that often accompanies visual-based games. A single tap or click allows the user to orient themselves, and the action triggers the current in-focus element to be announced. User interface elements (options in the main menu, as well as the corner buttons) are activated with a double-tap gesture (touchscreen devices), double-click or enter keyboard key (desktop).

Graphics

The bold minimalist graphic interface mirrors the broad gestures that are used to interact with the game. Elements are high-contrast and clearly-defined, and were designed with accessible graphic guidelines in mind. The graphics are also responsive and scale according to the device's screen size. Although these visual elements are not necessary for gameplay, they aim to make the experience of audio games more palatable for sighted or partially-sighted players. The intention is for Audio Game Hub to be accessible and enjoyable for both sighted and non-sighted players, and to create an inclusive community where they can play together.

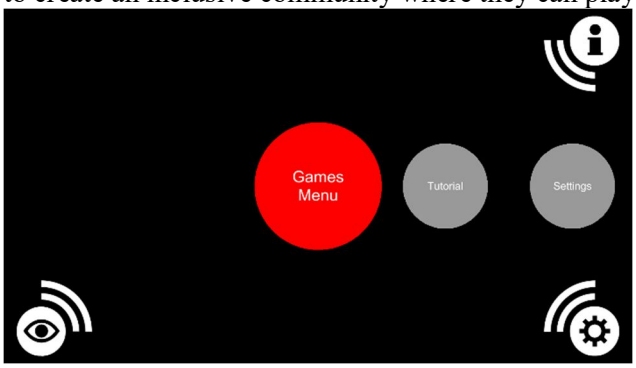

Fig. 1. Audio Game Hub main menu.

Logic: Main Menu

The main menu is the first interaction a user has after opening the application, and shows high-level options including "games menu", Audio Game Hub "tutorial", "credits", and "settings". To guide new users and familiarise them with the interface, a general tutorial is played upon the first launch of the application. A user can navigate the menu options by swiping left or right (touch screen), dragging mouse left or right, or using the left or right arrow keys (desktop). The options within each menu are placed equidistant in stereo panorama, giving the user an understanding of how many options there are in total and where the current focus is – all through spatial audio perception. To facilitate user orientation, the current menu position is announced whenever a new element or menu is shifted into focus, and can also be re-prompted by tapping or clicking once on the screen.

Logic: Corner Buttons

A number of functions were necessary to include throughout the games and menus, and were therefore implemented in the corners of every screen of the application. Like other elements, they shift dynamically in response to device size, and sit directly in the corners of the active screen or window. This makes locating them without visual aid much easier, as position is relative to the physical device and not to each other. This also makes them as far away from the centre of the screen as possible, therefore leaving more room for in-game and main menu gestures. The four corner buttons are as follows:

- Upper left: Return, to go back to previous menu;
- Upper right: Information, to hear a tutorial about your current screen (either game or menu);
- Lower left: Visual Mode, to toggle graphics on or off (for sighted players);
- Lower right: Settings, to custom-adjust the volume levels of audio layers. The user is able to control voice, sound effects, ambience, and music volumes.

Games: Hunt

The Hunt is a shooting game, where user has to hit moving targets – forest animals. With each level of difficulty the targets move faster.

The aiming system in The Hunt (see figure 2) is based on a 2D soundscape represented by stereo panorama (the "x" axis) and pitch (the "y" axis). There are two sound sources placed within the 2D game world and available to the player:

- The target board (A)
- The aiming point (B)

In each round the target sound (A) is placed along the "x" axis (heard to the left or to the right), and along the "y" axis (heard in a higher pitch when placed up, and in a lower pitch when down). The aiming point sound (B) corresponds to the finger position. When the finger moves closer to the target, the corresponding targeting sound is played more frequently (z – distance between the target and the aiming point).

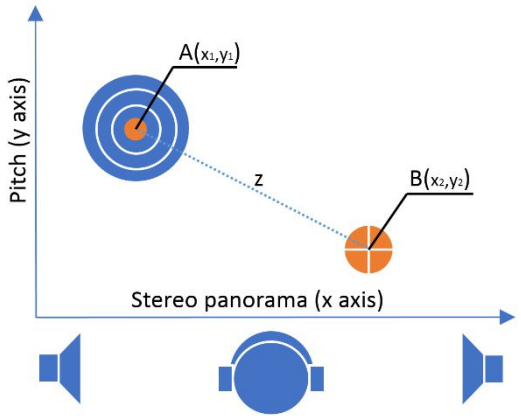

Fig. 2. Game mechanics in The Hunt.

Games: Animal Farm (Memory)

The first example is a digital audio adaptation of Memory, an analogue card party game, also known as *Match Match* or *Pairs*, amongst others. The player's task is to find matching pairs of farm animals stored in boxes. To locate the boxes, the player moves their finger on the screen (searching for a wooden box sound). Each box is opened by a double tap gesture, which triggers the sound of a selected animal. Matching pairs of animals are removed until there are no boxes left and the game is solved.

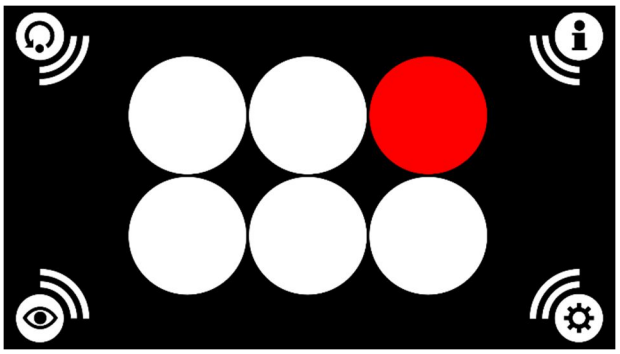

Fig. 3. Animal Farm game screen.

Games: Samurai

Samurai is a reflex based game for up to four players. The screen is divided into four equal parts corresponding to the game space occupied by each of the players. The goal of the game is to beat other opponents by touching the screen faster than other players after hearing the trigger time. The game also supports one and two player modes.

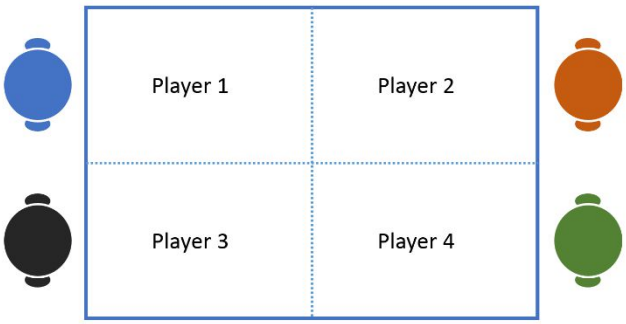

Fig. 4. Samurai user interface scheme.

Games: Labyrinth

Labyrinth is a classic arcade maze. The player's goal is to find the exit by following the "guiding" sound. When getting closer to the exit, the guiding sound becomes louder. The game consists of randomly generated rooms, whose borders are drawn by sounds signifying the player bumping into a wall.

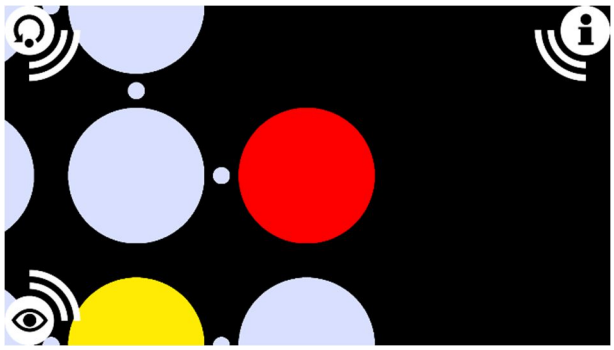

Fig. 5. Labyrinth game screen.

4. Conclusions

In the footsteps of earlier audio games, Audio Game Hub provides four mini games that can be used for reinterpreting popular video games for the visually impaired. Despite careful study, the potential of audio games however, depends on a large number of outside variables, unrelated to the gameplay itself.

There is increasing interest around audio games both from the side of developers as well as from users. In general, contemporary visually impaired players experience a lower usability barrier than ever before, thanks to a conscious push in accessibility efforts for digital technologies and devices. Sighted consumers are also increasingly interested in audio games, not only due to the rise in experimental games, but also because of the popularity of portable narrative audio, such as audiobooks and podcasts [8].

Audio Game Hub has completed the development stage and is currently available for download on most popular mobile platforms and PC Windows (www.audiogamehub.com). The current emphasis is on obtaining qualitative data through focus groups and usability studies in New Zealand, using participants from the following three groups: blind; visually impaired; sighted. These tests will be completed and data will be analysed in time to present results at the conference. Results that have already been obtained emphasise the significance of this research.

"I wanted to write this email to express not only my thanks and gratitude but also my complete amazement of your Audio games hub app. I am partially sighted and my wife is fully sighted and to be able to play games with her is just fantastic. You made possible something I thought I wouldn't ever see. It's about the games yes certainly, but the experiences, the laughs and fun we can have because both sighted and visually impaired people can play these set of excellent games together. So for the fun we have had so far and the fun we will have in the

future I can't thank you enough. I hope more games will be on the way, at the moment Android doesn't have allot of high quality audio games but yours is certainly one of the best. Thank you and take care." [11]

Exposure to a wider audience will allow for further research focusing on quantitative data, based on user behaviour that will be tracked using analytics tools. Audio Game Hub continues to be an ongoing project and future additions and adjustments will be made, according to qualitative and quantitative feedback.

References

1. Bannick, J. "Guidelines for Building Blind-Accessible Computer Games". Retrieved from http://www.blindcomputergames.com/guidelines/guidelines.html.
2. Bateman, C. 2009. "Beyond Game Design: Nine Steps Towards Creating Better Video games".
3. Bei, Y. & Folmer, E., "Blind Hero:enabling guitar hero for the visually impaired." Proceedings of the 10th International ACM SIGACCESS conference on Computers and Accessibility.
4. Bigham, J., Cavender, J., Brudvik, J., Wobborck, O. and Lander, R., "Webinsitu: a comparative analysis of blind and sighted browsing behaviour. Assests '07: Proceedings of the 9th international ACM SIGACCESS conference on Computers and accessibility, New York, USA.
5. Collins, K. 2013. "Playing with sound: a theory of interacting with sound and music in video games". The MIT Press.
6. Friberg, J., & Gärdenfors, D. 2004. "Audio games: New perspectives on game audio". Advances in Computer Entertainment Technology '04, Singapore.
7. Hermann, T., Hunt, A., Neuhoff, J. G. 2011. "The Sonification Handbook". Logos Publishing House, Berlin, Germany.
8. Kozlowski, M. 2014. "Global Audiobook Trends for 2015.Retrieved from http://goodereader.com/blog/audiobooks/global-audiobook-trends-for-2015.
9. Mynatt, E. D. 1997. "Transforming graphical interfaces into auditory interfaces for blind users". Human Computer Interaction, 12, 7-45.
10. Röber, N., & Masuch, M. (2004). Interaction with sound – An interaction paradigm for virtual auditory worlds. Proceedings of the 2004 International Conference on Auditory Display, Sidney, Australia.
11. Röber, N., & Masuch, M. 2005. "Playing audio-only games – a compendium of interacting with virtual auditory worlds". Proceedings of DiGRA 2005 Conference.
12. Wenzel, E.M., Arruda, M., Kistler, D. J. & Wightman, F. L. 1993. "Localization using nonindividualized head-related transfer functions." J. Acoust. Soc. Am. 111-123.

[11] Email from one of Audio Game Hub users received on 29.04.2016