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THE AUDIO GAME LABORATORY: BUILDING MAPS FROM GAMES

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ABSTRACT

Audio games demonstrate an emergence of interactive parameter mapping sonifications that potentially optimally display geographical information and a large number of simultaneous data variables. Our preliminary investigation of audio games is in response to a call for more research on parameter mapping sonifications, such as the best way of presenting auditory legends for representations, effectiveness of spatial audio, map comprehension techniques, and finding optimal sonic variable mappings. We also present a proposed set of auditory map interfaces observed in audio games. Commercially available interactive interfaces and audio games – that have been shaped and informally "tested" by the selection pressures of a demanding consumer market – can serve as examples of potentially effective conventions informing future work in the auditory display research community.

1. INTRODUCTION

Audio games are computer games that can be played entirely with an audio interface. These games have existed since 1972 [1] and span the spectrum from completely speech-based to being almost exclusively based on non-speech sounds. Within the context of this paper, audio games are what we refer to as a "natural laboratory" – a site of investigation where extensive iteration in culture, driven by selection pressures, has refined a set of artifacts and/or conventions to what are likely to be effective states. Elsewhere, this has been referred to as "artifact evolution" [2]. Here, we focus on audio games because they demonstrate an emergence of interactive parameter mapping sonifications with the potential to optimally display geographical information and a large number of simultaneous data variables. Our preliminary investigation of audio games is in response to a call for more research on parameter mapping sonifications, such as from Walker & Mauney [3], Krygier [4], and Flowers, Turnage, and Buhman [5]. Commercially available interactive interfaces and audio games – that have been shaped and informally "tested" by the selection pressures of a demanding consumer market – can serve as examples of potentially effective conventions that can inform future work in the auditory display research community. Past research on audio games has been limited, focusing mainly on their applicability to navigation for visually impaired users and little focus has been given to how the affordances of audio games can be applied to data representation. Through our preliminary investigation of audio games presented in this paper, examples are provided to suggest solutions to some of the more difficult problems in sonification. This exploration of audio game interfaces aims to expand the research presented in chapter 20 of the Sonification Handbook by Brazil & Fernstrom [6], and to encourage greater investigation into the potential value of audio games to the auditory display community.

2. BACKGROUND

There has been little research on utilizing audio game interfaces for data representations and mapping. For example, researchers have demonstrated that utilizing some of the techniques in audio games have enabled blind people to improve their sense of orientation and cognitive mapping ability in the physical world [7], [8], [9]. However, the existing research has not acknowledged the variety of auditory interfaces presented in audio games. Such discoveries within the audio game community may expose new opportunities, such as strategic uses of text-to-speech labels that have not been the focus of auditory display researchers. For example, developments in sonification have particularly focused on non-speech sounds [10]. However, for auditory mapping displays, the strategic use of text-to-speech is fundamental. Edler & Lamnert-Siepmann [11], who have researched the addition of an auditory dimension to cartographic maps, recommend understanding what makes current map types successful in helping to structure auditory interfaces. In visual maps, there are several purposes for using text when an image will not suffice. Titles and labels provide context, and are examples where the text is more useful than an image. Similarly, there will be instances in sonification where text, in addition to non-speech sounds, may prove useful [12].

2.1. Call for research and clues from audio games

Researchers of the auditory display community have raised questions about representing complex data sets through sound that audio games may have an answer for. Here are three examples: Krygier [4] asked how one would best design a sonic legend for a map. Most audio games employ *auditory icons* – a type of representation that bears an analogical resemblance to the process or activity being represented – to reduce the need for a legend [13], [14], [8]. An example of this may be found in the audio game *Swamp* [15], in which sounds of buzzing flies represent corpses containing loot, and sounds of footsteps paired with groans represent zombies. If a map key is required, such as in *Adventure at C*, an ever-accessible tree-based menu presents a name of the different items, and a keypress, such as enter, will play a sound corresponding to the selected item [16]. The second issue identified by Krygier [4], and Flowers, Turnage & Buhman [5], called for research on the ability for users to identify objects in spatial audio. The aforementioned *Swamp* utilizes 3D audio, requiring users to center objects or creatures in their headphones through rotating their orientation, before either shooting, avoiding, or running over the object. Users have become incredibly accomplished at this task, being able to quickly navigate through complex and varied terrain while defending against dozens of enemies in the game world, all while searching for a single item [17]. A third question posed by Krygier [4] concerns whether blind people can build up maps while only being able to view a single point at a time. Balan, Moldoveanu, & Moldoveanu [8], and Sanchez et al. [9], found the highly immersive and attractive nature of audio games enables blind people to create a spatial representation of their environment that can be assigned to aid performing real-life navigation tasks. For example, strategy games such as *Tactical Battle* are precisely based around the user being able to know exactly what is happening on all parts of the map at once [18]. Flowers, Turnage & Buhman [3], Walker & Nees [19], and Walker & Mauney [5], comment that it is difficult to determine appropriate mappings between data and displays for blind audiences for several reasons, including the fact that many sonification studies are conducted with sighted participants and these studies may not account for perceptual differences due to expertise. However, given that the audio game community is mostly blind, all successful audio games have been extensively – though informally – "tested" by blind individuals [1]. Therefore, observing the data-to-display mappings in audio games can suggest generally accepted practices in the blind population. New types of experiments could perhaps be developed and deployed using games within the audio game community.

3. INTERFACES

The authors propose that audio game interfaces fit into five distinct map types: MUD style, tree-based, grid-based, side-scroller, and first-person 3D. Each of these interfaces have completely different methods of conveying the three levels of a digital interface [21]. The three levels are: physical input and output, WIMP (window, icon, menu, and pointer), and the game world itself [21]. The output interface of audio games is almost exclusively through headphones [22]. Each map type utilizes its own basic conventions, such as the mouse in first-person 3D, and typing on a keyboard in MUD-based maps [8], [23]. The WIMP interface is present in audio games, but should be changed slightly to replace "pointer" with "message" (WIMM) because audio games generally do not utilize a mouse pointer [24], [7]. The WIMM elements, which contain information about the game, stats, health, and exact location are mostly presented through speech [8]. Every aspect of the audio game experience consists of either: auditory icons, earcons, and/or speech [8]. "The game world is represented as a landscape, topography, objects, and inhabitants" [21, p.55]. Each of these game world components and their interactions are represented by one or more audio elements which could be combined to represent different levels of realism, such as varying the tambour of footsteps based on size and ground surface characteristics [25]. The most significant attribute of auditory maps is the representation of location, either as a set of coordinates or as parent-child relationships within a tree-based map structure. The five auditory maps are taken from an analysis of existing interface design literature, past studies, the author's observations through a decade of audio game play, and a growing database of annotated games. During the design process for interactive parameter mapping sonifications, the third step, after identifying the data and the message the interface should convey, is the choice of what interface to use. Almost every data set can be represented with any interface, so it is the purpose of the sonification that dictates what interface should be used.

3.1. MUD-based

MUD stands for "multi-user dungeon" or "multi-user domain" and is a completely text-based game [23]. Users interact with the world by typing commands on a keyboard, such as "north" to move north, and access system options through typing instructions such as "set exits on" [23]. MUDs are considered audio games because blind users can access their content through their screen reader which reads the output window and players will often add in custom auditory elements to represent events in the game world [26], [27]. Game world components are represented by short text descriptions such as "A black iron pot is here" after the room's description [28]. Rooms have a title attribute, such as "Shrine of St. Wiseheart" [29]. MUDs can represent any type of data that can be put into text. They enable a user to zoom in on elements through commands, such as "look pot" in the aforementioned example, to get a detailed description, and can represent a high number of variables simultaneously. A disadvantage is the high level of linguistic competency required to understand the content [8]. Interfaces where users need a strong analogical connection to the content do not work well in MUD interfaces. The content is conceptually specific, so it will say "a large dog", rather than making the sound a large dog would produce. The command line on computers is very similar to the MUD interface.

3.2. Tree-based

Tree-based maps are a set of parent-child relationships that show hierarchical structure [30]. The input to tree-based maps is generally comprised of four parts: move forward, move backward, move up a level, and move down a level. The only analogical relationship is hierarchical; every other representation is conceptually specific. Browser-based games and list-based games such as *Sryth* and *Crafting Kingdom* are organized as tree structures [31], [32]. Game world components are represented as nodes, either pages or menu items, and often with accompanying speech and auditory icons that play when the user selects an object. Almost every game utilizes a tree-based menu structure to allow the user access to actions such as start, exit, and save [25], [33]. One advantage of tree-based maps is that users do not need to remember all the data points in a set; they simply need to remember the location of the data they are looking for. Menus allow users to explore data without needing to remember order to navigate through the interface. However, trees do not represent distances between two nodes very well. They also tend to have a steep learning curve, and as the size of the tree structure increases, browsing through it becomes impractical [34]. Representations showing groups of data and lists of points are best shown with tree maps. File explorers and most websites are tree-based interfaces.

3.3. Grid-based

Grid-based maps are based on a set of coordinates representing squares placed together in a column–row relationship [35]. The most common example of a grid interface is the spreadsheet. The user navigates through a rectangular array of tiles or cells, and components are placed in different cells around the rectangular array to represent the map content. The input interface generally utilizes the arrow keys to allow moving between cells, and keystroke combinations, such as Ctrl+Up arrow to jump upward through the tiles [33]. Game messages are frequently accessed through menus and by pressing letter keys on different tiles. Each game world component is situated in a tile and the user can move around the squares and view component locations in relationship to one another. Auditory elements of a tile's components play when the user enters a new tile. Strategy games (such as *Tactical Battle*), where showing an overview of a map is important, employ grid-based maps [18]. Zhao et al. [7] found that grid-based maps allow blind users to easily explore unfamiliar geographical data and quickly understand adjacent relationships. Grids are ideally suited to allowing the user to get an overview of the data being represented [34]. Grids, however, do not show irregular shapes; users do not like the number of keystrokes it takes to move through the map; and it takes a while for users to understand everything that the map has to offer [7]. Many data sets, in comma-separated values (CSV) format, can be represented using text in a grid-based spreadsheet. However, adding non-linguistic sonic cues and brief speech messages allow multiple variables to be represented in a single cell.

3.4. Side-scroller

Side-scroller maps utilize a side view of the map where the user primarily moves left and right and analogical object sounds are represented using stereo panning [36], [37]. Games such as *Adventure at C* utilize a side-scroller map. Users mostly use the arrow keys to move through the map and access conceptually specific status information through menus and letter key presses, such as "h" for health [33]. Oren performed a study designing a complex side-scroller game with multiple levels and different heights of objects [37]. He demonstrated that three variables – height, position, and type – could be effectively represented simultaneously using pitch, stereo panning, and texture respectively. The conclusion was that side-scroller interfaces allow for quick recognition of several variables at once, and complexity beyond that leads to confusion. The interface is optimal for quick navigation through a high level of analogical detail.

3.5. First-person 3D

First-person 3D maps are characterized by the use of 3D audio and are the most studied of the audio game map types [8], [38], [25], [39], [9], [40]. The input interface to first-person 3D maps span the range of input devices, from "keyboard only" (as in *Top Speed 3*), to gyroscope as seen in *Swamp* with the "see monkey", to GPS location as presented by Rober & Masuch [39], [41], [15]. WIMM elements are both inside and outside the game world. The game world is incredibly detailed and tries to mirror reality [38]. The analogical game world components are positioned around the user and use short looping sound samples to let the user know where they are [25], [39]. Terrain and topological features are represented by audible thuds as the user hits impassible obstacles, and changes in footstep tambour or tone quality as the user moves over different surfaces [25], [15]. First-person 3D provides the most detailed and analogical interface out of the five map types, and can allow for many different variables to be represented at once. This makes first-person 3D perfect for data sets with many variables. The disadvantages of first-person 3D are the easy disorientation of the users and the length it takes to explore an interface.

4. CONCLUSION

Audio games provide a large set of potentially effective sonic interfaces that can be used in designing data sonifications. Researchers can shape their hypotheses based off what seems to work in audio games. If one has access to the data in an audio game, it would be possible to perform empirical studies on user tendencies. Currently most sighted users have had no experience with these interfaces and it may require some training before they become proficient. This means that there may be factors other than good design that may lead to a successful interface and there may be interfaces beyond what has been mentioned that may be employed in audio games. Designing data sonifications using the framework set forth by Jørgensen will allow a more dynamic and intuitive interface and expand the capabilities of existing sonification practices, such as those presented in Brazil & Fernstrom [21], [6]. The use of auditory elements, such as auditory icons, earcons, and speech should be ubiquitous in most sonic interfaces. Future research needs to validate and clarify the systematic application of the five audio game map interfaces to data sonifications. A larger set of audio games also needs to be evaluated to insure validity.

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6. REFERENCES

[1] J. Swarts, "A look at audio games, video games for the blind," March 2016. [Online]. Available: https: //inverse.com/article/13331.

[2] D. Kirsh, "Explaining artifact evolution," in *The cognitive life of things: recasting the boundaries of the mind*,
L. Malafouris and C. Renfrew, Eds. Cambridge, UK: Mc-Donald Institute for Archaeological Research, 2009.

[3] B. N. Walker and L. M. Mauney, "Universal design of audi- tory graphs: A comparison of sonification mappings for

vi- sually impaired and sighted listeners," *ACM Transactions on Accessible Computing*, vol. 2, no. 3, pp. 12:1–12:16, March 2010.

[4] J. Krygier, "Sound and geographic visualization," in *Visualization in modern cartography*, 1994. [Online]. Available: https://makingmaps.net/2008/03/25/making-maps- with-sound/.

[5] J. H. Flowers, K. D. Turnage, and D. C. Buhman, "Desktop data sonification: Comments on Flowers et al., ICAD 1996," *ACM Transactions on Applied Perception*, vol. 2, pp. 473– 476, 2005.

[6] E. Brazil and M. Fernstrom, "Navigation of data," in *The Sonification Handbook*, T. Hermann, A. Hunt, and J. G. Neuhoff, Eds. Berlin, Germany: Logos, 2011, pp. 509–523. [Online]. Available: http://sonification.de/handbook/.

[7] Zhao, C. Plaisant, B. Shneiderman, and J. Lazar, "Data sonification for users with visual impairment: A case study with georeferenced data," *ACM Transactions on Computer-Human Interaction*, vol. 15, pp. 1–28, 2008.

[8] O. Balan, A. Moldoveanu, and F. Moldoveanu, "Navigational audio games: An effective approach toward improving spatial contextual learning for blind people," *International Journal on Disability and Human Development*, vol. 14, pp. 109–118, 2015.

[9] J. Sánchez, M. Espinoza, M. de Borba Campos, and L. B. Merabet, "Enhancing orientation and mobility skills in learners who are blind through video gaming," in *Proceedings of the 9th ACM Conference on Creativity & Cognition*, 2013, pp. 353–356.

[10] T. Hermann and A. Hunt, "Guest editors' introduction: An introduction to interactive sonification," *IEEE Multimedia*, vol. 12, no. 2, pp. 20–24, 2005.

[11] D. Edler and N. Lammert-Siepmann, "Approaching the acoustic dimension in cartographic theory and practice: An example of mapping Estonia(n)," *Meta-Carto-Semiotics*, vol. 3, no. 1, pp. 1–15, 2010.

[12] B. N. Walker, J. Lindsay, A. Nance, Y. Nakano, D. K. Palladino, T. Dingler, and M. Jeon, "Spearcons (speech-based earcons) improve navigation performance in advanced auditory menus," *Human Factors*, vol. 55, pp. 157–182, 2013.

[13] C. Peirce, "Logic as semiotic: The theory of signs," in *Philosophical Writings*. Dover, 1902. [Online]. Available: http://theory.theasintheas.org/wp-content/uploads/2013/02/Peirce-C-S-Logic-Semiotic.pdf.

[14] W. W. Gaver, "Auditory icons: Using sound in computer interfaces," *Human-Computer Interaction*, vol. 2, no. 2, p. 167–177, 1986.

[15] J. Kaldobsky. Swamp. [Online]. Available: http://www.kaldobsky.com/audiogames/.

[16] VGStorm. Adventure at C. [Online]. Available: http://www.vgstorm.com/aac/about.php.

[17] Hannibal, "Pattern for the strip mall," in *Black Screen Gaming*. [Online]. Available: http://www.blackscreengaming.com/swamp/warehouses/strip mall/pattern/index.php

[18] I. Reed, "Tactical Battle," 2013.

[19] B. N. Walker and M. A. Nees, "Theory of sonification," in *The Sonification Handbook*, T. Hermann, A. Hunt, and J. G. Neuhoff, Eds. Berlin, Germany: Logos, 2011, pp. 9–39. [Online]. Available: http://sonification.de/handbook/.

[20] F. Grond and J. Berger, "Parameter mapping sonification," in *The Sonification Handbook*, T. Hermann, A. Hunt, and J. G. Neuhoff, Eds. Berlin, Germany: Logos, 2011, p. 363–397. [Online]. Available: http://sonification.de/handbook/.

[21] K. Jørgensen, *Gameworld interfaces*. Cambridge: MIT Press, 2013. [Online]. Available: https://ebookcentral.proquest.com/lib/oculocad-ebooks/detail.action?docID=3339717.

[22] audiogames.net. Audiogames, your resource for audiogames, games for the blind, games for the visually impaired! [Online]. Available: http://audiogames.net/

[23] The Mud Connector. Getting started: Welcome to your first MUD adventure. [Online]. Available: http://www.mudconnect.com/mud intro.html.

[24] P. Christensson. WIMP definition. [Online]. Available: https://techterms.com/definition/wimp.

[25] F J. Friberg and D. Gärdenfors, "Audio games: New perspectives on game audio," in *Proceedings of the 2004 ACM SIGCHI ACE*, 2004, pp. 148–154.

[26] CX2. VIP MUD. [Online]. Available: https://audiogames. net/db.php?id=VIP+MUD.

[27] I. Williams. (2016, Sep) How blind players made a text-only RPG more accessible. [Online]. Available: https://waypoint.vice.com/enus/article/kwz77n/how-blind-players-made-a-text-only-rpg-more-accessible

[28] Rumble. The builder's tutorial. [Online]. Available: https: //www.tbamud.com/getting-started-menu.

[29] Materia Magica. A world of text adventure is waiting for you. [Online]. Available: https://www.materiamagica.com/.

[30] E. W. Weisstein, "Tree," in *MathWorld*. [Online]. Available: http://mathworld.wolfram.com/Tree.html.

[31] M. H. Yarrows. Sryth the age of Igtheon. [Online]. Available: http://www.sryth.com/.

[32] MetalPop LLC. Crafting Kingdom. [Online]. Available: http://metalpopgames.com/forum/index.php?/forum/ 11-crafting-kingdom/.

[33] I. Reed. (2013) User guide for Tactical Battle. [Online]. Available: https://blindgamers.com/Home/IanReedsGames.

[34] J. Tidwell, *Designing Interfaces*, 2nd ed. Sebastopol, CA: O'Reilly Media, 2010.

[35] M. Soegaard. The grid system: Building a solid design layout. [Online]. Avail- able: https://www.interaction-design.org/literature/article/ the-grid-system-building-a-solid-design-layout.

[36] "What is a side scroller?" in *Techopedia*. [Online]. Available: https://www.techopedia.com/definition/27153/side-scroller.

[37] M. A. Oren, "Speed sonic across the span: Building a plat- form audio game," in *Proceeding CHI EA '07 CHI '07 Extended Abstracts on Human Factors in Computing Systems*, 2007, pp. 2231–2236.

[38] I. Podkosova, M. Urbanek, and H. Kaufmann, "A hybrid sound model for 3D audio games with real walking," in *Proceedings of the 29th International Conference on Computer Animation and Social Agents*. ACM, 2016.

[39] N. Rober and M. Masuch, "Leaving the screen: New perspectives in audio-only gaming," in *Proceedings of International Conference on Auditory Display, 2005*, 2005. [Online]. Available: http://hdl.handle.net/1853/50168.

[40] E. Klein and O. G. Staadt, "Sonification of three-dimensional vector fields," in *Proceedings of the SCS High Performance Computing Symposium*, vol. 8, 2004.

[41] L. de Ruijter, P. de Ruijter, B. Duvigneau, and D. Loots, "Top Speed 3," in *Playing in the dark*. [Online]. Available: http://www.playinginthedark.net/topspeed3

e.php.