Video Gaming for the Vision Impaired

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ABSTRACT
Mainstream video games are predominantly inaccessible to people with visual impairments (VIPs). We present ongoing research that aims to make such games go beyond accessibility, by making them engaging and enjoyable for visually impaired players. We have built a new interaction toolkit called the Responsive Spatial Audio Cloud (ReSAC), developed around spatial audio technology, to enable visually impaired players to play video games. VIPs successfully finished a simple video game integrated with ReSAC and reported enjoying the experience.

Author Keywords
Accessibility; 3D Sound; Blind gamers; Sonification.

ACM Classification Keywords
• Human-centered computing~Auditory feedback • Social and professional topics~People with disabilities

INTRODUCTION
Video gaming has become a major modern cultural phenomenon akin to movies and professional sports. However, VIPs are currently excluded from this experience. We conducted surveys with VIPs to find out their aspirations about computer gaming. They expressed their desire to play video games made for sighted gamers, and to feel included in the social conversations and excitement about gaming. The objective of this research is to enable all video games to be accessible by default. This can be achieved by making tools for game design and game play that have built-in support for accessibility. In this regard, two aspects need to be addressed. The first is the focus of our work, namely the creation of interaction techniques that enable a range of video game genres to be accessible. Secondly, metadata support needs to be standardized and built into the game development environment. The above is modeled on the success achieved by the web accessibility initiative [3], and legislation that mandates audio description of visual media [5]. Gaming involves interactions that are significantly more unstructured and dynamic than browsing web pages or watching a movie. In this work, we make a beginning in addressing the required interaction framework using a novel interaction toolkit called the Responsive Spatial Audio Cloud (ReSAC). Spatial audio, also known as 3D sound, is the computational synthesis of an immersive three-dimensional audio experience using stereo headphones [25]. We demonstrate the use of ReSAC through a simple role-playing video game. VIPs were able to complete the game's objective - to locate and reach specific objects. They reported being engaged and excited during the process.

ASSETS '18, October 22–24, 2018, Galway, Ireland

ACM ISBN 978-1-4503-5650-3/18/10.
https://doi.org/10.1145/3234695.3241025

STATE OF THE ART
Several blind gamers play mainstream video games at competitive levels and there are communities supporting such efforts [1, 7]. There is occasional help from game developers [6]. Most of efforts aimed at gaming for the blind have focused on creating audio only games [4]. There have been several projects to make exergames accessible to the blind, primarily through special purpose haptic feedback devices [8, 24] or sensing devices like the Kinect [21] or commodity devices like the Wii [19, 18]. There have been sporadic efforts at making specific video games accessible to the vision impaired [9, 23, 22, 20]. Unlike these works, we aim for an accessibility framework for all video games. Spatial audio has gained popularity among audio games (eg. Papa Sangre, Blind Legend, EarMonsters, BlindSide, etc.). There have been several research projects that utilize spatial audio for accessibility [10, 12, 13, 14, 15, 16, 17, 2]. [11] explored the use of spatial audio in making video games accessible to the blind. Our work has been informed and inspired by many of the above with the goal of creating a general spatial audio-based interaction toolkit that can be utilized by a wide range of mainstream video games to make them accessible and enjoyable to VIPs.

RESAC
Spatial audio is central to our solution. We represent all the information about the environment surrounding the gamer in the form of a spatial audio cloud (SAC). Every relevant object in the world is represented as an entity in the cloud with the following metadata parameters attached to it: a 3D spatial coordinate, object's name, succinct and/or detailed description of the object, one or more audiocons or earcons, a visibility distance that triggers inclusion depending on the distance to the player (similar to Level of Detail in graphics rendering), spatial extent of the entity, and others. ReSAC interaction tools extract and present relevant information from this cloud in response to the user (hence, ReSAC) in such a way that the user's dependence on visual information is least.

ReSAC Interaction Tools

ReSAC interaction tools include the Narrator (equivalent of a screen reader for games), Viewdio (a generalization of audio description for video games), Anchor (a selected object that serves as an anchor to help in orientation), NorthHorn (a unique tone played always from the North direction), BodyScan and a variant called VisorScan, and Select and Reach. Footsteps of the player and spatialized sonifiation of names of objects that the user bumps into are the other cues.

BodyScan

On selection of BodyScan, the player gets spatialized audio playout of all objects that intersect a virtual frustum emanating outwards from the player's body. Every object that intersects this frustum is sonified with spatial audio, either using text to speech of the object's name (or description) or by the playback of an earcon (for example, a whir of a fan).

Select and Reach

When BodyScan enumerates objects in the view in spatial order, the user can activate the Select and Reach tool to select one of the objects being listed. On selection, a spatialized siren guides the gamer to reach the selected object. This siren is modulated in volume and pitch to better guide the player.

GAME IMPLEMENTATION

We prototyped our solution in Unity by building a first-person adventure game to understand and evaluate the ReSAC tools. A key implementation challenge is rendering the SAC at every instance alongside graphics rendering. Relevant information must be extracted at run-time from the objects in the scene. Since video games focus on the quality of the rendering of each frame, they are optimized at the level of triangles and pixels, without any need for semantics of triangles. In BodyScan for example, we need the set of visible objects in the view frustum, not an exhaustive list of all the visible triangles and their textures (a challenge identified by [20] and [23]). In our Unity implementation, we introduce a metadata container script for every game object, which is otherwise just an aggregate of polygons and textures. When a player collides with an object, the name of the object is picked up from the metadata container and passed to the TTS engine for sonification. This interaction is similar to a VIP's exploration using a cane or hands in the real world.

USER STUDIES

We built a much simpler first-person 3D video game for conducting preliminary user studies with 6 VIPs: this is a room of size 84x36 sq. ft which has many typical workplace objects. Participants' data is specified in Table 1. The task was to reach 4 specific objects (chair, flowerpot, books, and cupboard) in the room. Users wore stereo headphones and used an Xbox controller to play the game on a PC. Each player was assisted by a researcher to explore and understand the game and interaction tools for about 20 min before playing the game. None of the participants had used a game controller before, and only one participant (P4) had experience with playing audio games.

All participants were able to find and reach objects in the testing phase and were excited about being able to navigate a virtual game room. P1: "*I don't play (PC/mobile) games because I have a prejudice that games are largely inaccessible. But this game has changed my perception*". P4: "*I could feel myself inside the room. I heard the voice exactly from the objects' location, so it helped me to know where I should move and take turns. I am imagining, and I am playing*." One gamer (P4) deduced that some objects are located behind bigger objects and that he has to go around to reach the destination object. Participants quickly overcame difficulties using the controller and asked for increased game complexity. One conspicuous drawback was the difficulty faced by the participants in orientation and sensemaking. This might be due to many factors: the short duration of play, absence of proprioception, or limitations of the current ReSAC toolset. We intend to explore these in the future.

ID	**Age**	**Gender**	**Extent of Vis. Impairment**	**Task Time (min:s)**
P1	37	M	fully blind	14:11
P2	21	F	fully blind	36:52
P3	34	M	fully blind	12:23
P4	22	M	residual sensitivity	23:49
P5	22	M	fully blind	16:59
P6	28	M	fully blind	17:53

Table 1. Participants' Data from User Studies

CONCLUSION AND FUTURE WORK

We are excited about the response from VIPs to a simple game built using the ReSAC toolkit. We are continuing to work with them while expanding game complexity and understanding their implications for the support needed from game engines like Unity. The preliminary user studies conducted were to gauge VIPs' response to ReSAC. We plan to conduct more systematic user studies with structured data analysis in the future. We anticipate the design of ReSAC to evolve significantly with the genre, especially for First Person Shooters, Real-Time Strategy games and multiplayer games. The larger challenge, that we do not address here, is the evolution of game engines like Unity and 3D modeling platforms like Blender and Maya to provide support for accessibility metadata creation. This is essential to minimize the load on game developers so that all mainstream games are eventually built to be accessible.

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