Experimental Analysis of Spatial Sound for Storytelling in Virtual Reality

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Abstract. Spatial sound is useful in enhancing immersion and presence of the user in a virtual world. The spatial audio design allows the game designer to place audio cues that appropriately match with the visual cues in a virtual game environment. These localized audio cues placed in a story based game environment also help to evoke an emotional response from the user and construct the narrative of the game by directing the user's attention towards the guiding action events in the game. Our paper explores the usefulness of spatial sound for improving the performance and experience of a user in a virtual game environment. Additionally, with the help of the relevant subjective and objective inferences collected from a user study conducted on three different test cases, the paper also analyzes and establishes the potential of spatial sound as a powerful storytelling tool in a virtual game environment designed for Virtual Reality.

Keywords: Spatial Sound, Storytelling, Virtual Reality.

1 Introduction

Virtual Reality (VR) is a powerful platform for conveying narratives through games and films. In a story based virtual environment, badly designed environment may cause confusion and break the flow of the experience to negatively affect immersion. In a well-designed environment, appropriate visual and audio cues may be embedded in the game space to evoke emotional response, construct the underlying narrative, and contribute to presence and immersion while still preserving game interactivity [4]. The current discussions in game design posit that VR sound design should mimic real sound environments by employing fully spatialized sound so that spatial immersion and presence are supported by the audio components [2]. However, it is an ongoing debate on the usefulness of spatial sound in achieving total immersion [7]. Furthermore, although the idea of using visuals and audio as a storytelling tool in a game environment has been suggested, little has been discussed about spatial sound as an influence in convey-

ing narrative [3]. This is a preliminary study that contributes to the field of spatial storytelling by studying the influence of audio cues on player experience. The goals of this study are to 1.) Evaluate the impact of spatial sound on a user in a virtual environment and its contribution to immersion; and 2.) Analyze the significance of spatial sound as a storytelling tool in a virtual game environment.

2 Background and Related Work

The guidelines for interactivity and narrative in a virtual game environment are often conflicting [6]. Henry Jenkins established a relationship between games and stories by introducing a spatial aspect to merge narrative and interactivity into game design. Besides visual cues [3], spatial sound cues embedded in the space can also evoke an emotional response and construct the narrative. The influence of spatial audio on immersion has been implied in a general context but the parameters of incorporating spatial audio in a virtual environment remain unclear. On the face of it, employing spatial audio, with its higher fidelity to the natural world, seems an obvious choice. However, spatial audio is vulnerable to creating the "Uncanny Aural Valley" in VR, an audio equivalent of "Uncanny Valley" [7]. Also, sound, like graphical components, demand processing resources which can result in competition for allocation of resources between audio and video at run-time [5]. These insights lead to questioning the need of sonic realism for VR storytelling thereby, offering a designer an audio-related choice for the development of immersive worlds [7].

3 Experimental Design and Implementation

Charlotte, is a VR door puzzle set in a haunted mansion where in the narrative is to pass through multiple rooms via doors that can be operated with the help of switches [1]. Each door has a spatial sound cue that indicates the opening or closing action accordingly**.** *Charlotte* was modified to rid the game of all narrative game object interactions and enrich the soundscape exclusively. Three sound cue categories were introduced which were moderated as required. *Door sounds* are the sound cues for the doors in the puzzle. *In-place triggers* activate the sound cue at the player's location when the player overlaps the location within the radius of the trigger. These are intended to evoke fear in the player in form of a jump scare. *Far-place Triggers* activate the sound cue at a distant location when the player overlaps the location within the radius of the trigger. These are intended to influence the player's direction by capturing his attention towards the direction of the next room.

4 User Study

Three separate test cases which differ only with respect to the soundscape were introduced. A no-sound test case was setup for one participant at the end of the study as a control. For the Spatial Audio test case, door sounds, in-place triggers and far-place

triggers were rendered spatial. For the Ambient Audio test case, door sounds, in-place triggers and far-place triggers were rendered ambient. For the Mixed Audio test case, door sounds, in-place triggers and far-place triggers were moderated depending on how each sound category would potentially impact the gameplay. The user-study was conducted with 34 participants wherein equal number of participants were assigned a single soundscape test case. The user-study was conducted individually, starting with a pre-experiment questionnaire, participating in an introductory test environment, participating in the VR puzzle and then the post-experiment questionnaire. The time to finish the complete experiment was estimated to be around 45 minutes. The main measures in this experiment is the time to solve the puzzle and the subjective experience measured by the 24 questions in the post-experiment questionnaire.

5 Results

All the participants are equally Engaged with the environment irrespective of the sound condition. There are slight differences between the Engrossment levels, however, consistently, spatial and mixed case results have no significant differences. The same applies to both the Participation and Immersion levels, where in there is a significant difference between spatial case and ambient case, and mixed case and ambient case, but no significant difference between the spatial and mixed tests case results. *Therefore, we conclude by saying that both spatial and mixed audio helped to achieve total immersion and provided the best experience*. The inferences from the experience results for spatial audio test case gave us evidence that spatial audio helped the participants to construct the narrative in the environment. The participants agreed that the spatial sound cues helped them understand the genre of the game and also conveyed the emotion of the environment. *To conclude, since spatial audio was successful in constructing the narrative and evoking fear, it could potentially be a powerful storytelling tool.*

6 Discussion

Finding 1: The results do not statistically prove that spatial audio helped to improve the player performance. Ambient sound performed better than spatial and mixed audio. In our opinion, in the ambient sound test case, the player learned the spatial map of the environment instead of relying on sound cues. In the spatial audio test case, the player most likely followed the direction of the sound and overlooked the spatial mapping of the environment. However, in the mixed sound test case, it is unclear whether the participants were following the sound or learning the spatial map, therefore, the average time taken to solve the puzzle lay between the average time taken for ambient audio and spatial audio. Additionally, in the no sound test case condition, the participant solved the puzzle in the average time. This gave us evidence that, in the absence of sound, the participant relied on the spatial map of the environment. Due to the small area of the environment, it was easy to memorize the spatial map. This served as evidence that learning the spatial map in the absence of persuasive sound helped the par-

ticipants to solve the puzzle faster. Alongside varying participant knowledge and familiarity with VR games, another reason for not having significant performance time differences between the test cases could be the genre and nature of the game itself. Many participants mentioned that fear dominated their sense of direction while some stated that they were too focused on the task to notice the sounds.

Finding 2: Ambient sound evoked more fear with respect to spatial sound. Ambient sounds were more jarring to the participants thereby startling them and triggering the "fear of unknown" phenomenon due to the absence of directional audio information.

Finding 3: Environment exploration pattern varied with test case. In the ambient sound scenario, we assume that on the first non-directional door sound, the participants knew that they had to rely on visuals and memory to locate the door. The sound gave away the occurrence of the event but not the location. Therefore, the participant was observed to explore the environment piece by piece in search of the door. Since there were multiple sound triggers placed in different parts of the room, the ambient sound scenario participant was successful in activating almost all the triggers in the environment. Conversely, in the spatial audio scenario, we assume that the first door sound hinted to the player that they had to follow the sound. Therefore, on our visual observation, we found that their movement initially was very quick and focused towards the sound of the door. We also observed that since the participant did not try to explore the environment thoroughly, the triggers that were located away from the doors were not activated.

7 Conclusion

The results indicate that spatial audio did not help to improve the performance of the player. This could have been due to the failure of the spatial sound cues, thereby, allowing memorization of the spatial map of environment to aid in solving the task. Nevertheless, spatial audio did positively affect the immersion and experience of the player. However, the mixed sound test case performed almost on par with the spatial audio test case. The equivalent performance of both indicates that the sound in the environment can be optimized by rendering some parts as ambient and some as spatial, thereby making the environment relatively computationally inexpensive. Therefore, sonic realism although desired, can be compensated by appropriately designing the sound cues. When creating narrative rich VR environments, the results indicate that designers should consider what is needed, story wise, from the sound. Ambient sound was interpreted by the players, the lack of directional information did not break immersion but rather supported the thematic aspects of the environment. Ambient sound also did not hinder player performance, rather players employed different strategies to progress. The strategy employed for the ambient scenario encouraged exploration and slower pacing. On the other hand, the spatial sound scenario encouraged focus on task and quicker pacing.

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