Sounds in Space: 3D Audio Experiences through Tangible Navigation

Andrew Blakney and Sudhir Mudur

Concordia University
Montreal, Quebec

Abstract. This paper presents an experiment with 3D audio design and experience through a Tangible User Interface for 3D navigation. A generic 3D navigation metaphor, Navigational Puppetry, provides the user with a graspable viewpoint that allows them to 'reach' into the virtual world. An audio expert, specializing in relationships between 'music, place, and mobility', uses an audio-enabled prototype of this metaphor - the Navi-Teer - to populate a soundscape with graphical representations of sound elements. As navigation occurs, the audio environment yields unusual and complex 3D audio mixtures and spatial sound interactions. The experiment showcases Navigational Puppetry's subtle interactive benefits of increased spatial orientation, tactile intimacy, easy capture of complex input and support for collaboration in a task that requires navigation to complete a larger goal.

1 Introduction

The ***Navi-Teer*** interface is a Tangible User Interface (TUI) prototype for 3D navigation, which contains a superposition of egocentric and exocentric perspectives and a blending of navigational action and perception spaces. This affords an interaction that can best be described as 'navigational puppetry' - the user is a '***puppeteer***' standing over a '***stage***' containing a '***puppet***', whose perspective view is available to the ***'puppeteer'*** (see Figure 1). In the case of navigation for spatial sound, the puppet possesses the user's ears and the stage embodies the audiovisual soundscape through which the puppet-ears explore and perceive sound.

Researchers in the field of interfaces have recognized that interactions with sound are one of the most intensive interactive experiences within the known human experience [1, 2], and have experimented with this notion through the development of many diverse tangible or graspable audio interfaces [5, 7, 8]. By combining representation and control and through the blurring of input and output spaces, TUIs redefine the boundary between computer and user, allowing a broader and more intimate exchange [6], which makes them the perfect interactive vehicle for explorations into audio control and experience.

The interactive and sensory experiences of visual navigation and auditory exploration / experience of a soundscape are interestingly related and complimentary. Specifically, both require continuous temporal control over multiple, and sometimes parallel, 'degrees' or 'dimensions', while maintaining certain macro and micro conceptual orientations. Also, both could potentially benefit from increased spatial

C. Stephanidis (Ed.): Posters, Part II, HCII 2011, CCIS 174, pp. 217–221, 2011.

awareness and tactile intimacy, affordances for excessive/irregular/complex input, and minimal (or at least transparent and/or intuitive) translation from action to perceived result. Combining the graspable advantages of TUIs with the task of 3D navigation is in area that has produced interesting preliminary results [3, 4], but which could benefit from further investigation.

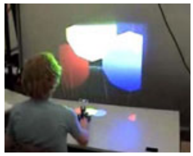

Fig. 1. 3D Audio Experiment

2 Related Work

Graphically and/or spatially enhanced approaches to 3D sound have been investigated and applied in many different domains, from game design to the creation of actual physical sound attractions. VRSonic (*http://www.vrsonic.com/*) and SoundLocus (*http://www.soundlocus.com*) are two examples of many available software packages enabling 3D audiovisual modeling that are 'navigational' in nature. There has been a vast amount of research regarding TUIs as interfaces for audio interactions [5, 7, 8] and a full review of this research is beyond the scope of this paper. However, an interesting work that highlights the potential for yielding new user experiences with tangible audio control is the ***Pendaphonics*** project [5]. This interface provides a very unique and physical way of experiencing a virtual 3D soundscape, which is linked to a physical interaction space in reality. The system consists of a large vertical display, providing the view of the soundscape to the user(s), and one or more suspended pendulums. As the pendulum is swung by one or more users through the physical interaction space, the sounds it generates change according to its relative virtual path through the soundscape. The nature of the interaction style affords very interesting explorations with sound control which are not possible without such an interface.

3 Navi-Teer Interface for 3D Audio

The Navi-Teer interface prototype (see Figure 1) is composed of two NEC VT491 projectors: one projecting the puppet's first person view to a large vertical rear-projection screen and one is projecting the stage-view of the VE from above down onto the horizontal table-top interaction surface. The downward projector also displays a bounding box and look-orientation-direction arrow dynamically on top of the puppet. The puppet's body is represented by a movable flat-bottomed base, containing 3 wireless function buttons, to be manually translated on a flat surface while being optically tracked in 2-DOF from above by a Quickcam Pro 4000 camera. The puppet's head is represented by a graspable sphere which is mounted on top of the puppet-body to 'look around', being sensed isotonically in 3-DOF using an Intersense InertiaCube 3 wireless 3D orientation sensor. To enable exocentric stage modifications, there is a generic tangible handle which slides around on the horizontal surface. The underlying application and VE was programmed in C++ using OpenGL (*www.opengl.org*), the ARToolkit (*www.hitl.washington.edu/artoolkit/),* and OpenAL *(www.connect.creativelabs.com/openal*).

The Navi-Teer interface is intended to be used with one or two hands on the horizontal interaction surface while the user(s) is positioned in front of the large vertical display. Basic 2-DOF translation of the viewpoint/virtual-ears, achieved by moving the puppet-body base on the horizontal surface, corresponds to a 1-1 movement of the viewpoint/virtual-ears on a horizontal plane within the soundscape. If continuous movement across a large distance is required, the puppet may deploy a *movement circle* onto the horizontal plane around itself. A movement circle is simply a projected circle surrounding the puppet-body base. When the puppet-body is moved to make its bounding box break the boundary of the surrounding circle, the viewpoint/virtual-ears *fly*, or are translated, in the direction of the break at a speed relative to how far outside of the circle the edge of the puppet-body went (ie: the greater the distance outside the circle, the greater the speed). The puppet may fly either constantly flat along the current stage plane, or look-directed flying may be enabled. At any point, the 3-DOF of orientation of the viewpoint/virtual-ears can be modified by rotating the puppet-head.

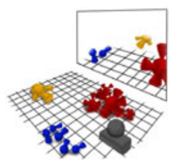

Fig. 2. The Navi-Teer 3D Audio Experience

To enable basic soundscape modeling, the Navi-Teer affords a simple ray-casting method to grab, position, and orient sound objects in 3D space. Sound objects are represented within the VE as solid colour geometric shapes - either spheres (sounds with no directional orientation) or cones (sounds with directional orientation), whose sizes are relative to their volumes (See Figure 2). These sound-spheres and sound-cones are imported into the virtual soundscape by bringing them out of a *sound-repository cube*, through ray-casting, in a predetermined order. The sound objects can be set to activate when the puppet is within certain proximities and they can also be given their own dynamic paths to move around while the puppet experiences the soundscape. Furthermore, all sounds can be simultaneously played / stopped in unison, or else each sound can be turned on/off independently by ray-selection. At any time, the path of the puppet through the soundscape can be recorded and played back to repeat a desired soundscape experience.

4 3D Audio Experiment

We enlisted an audio designer / artist, whose work focuses on the relationships between "*music, place,* and *mobility*" [9], to use the Navi-Teer interface as a final 3D mixing tool for a particular portion of a composition which contains instrument sounds from raw audio data recorded while riding a bus. He arrived with nine prepared audio .wav files, which were musical expressions of certain raw audio elements. Certain files corresponded to what would become the rhythm or percussive elements. Other sound files would become parts of the melody, such as various hums and ambient noises, which when arranged in a specific manner produced interesting melody combinations. The final composition was intended to be listened to on a personal music device while riding the same bus route.

The expert wanted to simulate the beginning of the bus ride with an approach of a specific rhythm that would then blend into another rhythm and melody combination. To accomplish this, they first positioned a sound-sphere, representing the track for the introductory rhythm, in an open space. Then they positioned five other sound-spheres ahead of the previously placed sphere. Two rhythm spheres whose auditory interaction – depending on which rhythm is panned to more than the other – form the desired rhythm to be experienced after the introductory portion is completed. These spheres were placed far from each other, on both the left side and right side relative to the previously placed sphere. The three remaining spheres, relating to another rhythm element and a basic melody, were arranged to form a triangular structure with one sphere resting above an open space between two other spheres on the horizontal plane. There was now a simple soundscape which could be experienced with the Navi-Teer interface (see Figure 1).

Once all the spheres were ‘singing’ properly, the expert traveled towards the triangular structure. Movements in and around that position in the soundscape achieved very interesting melody and beat interactions. During the entire interaction the expert was able to observe and grasp an interesting dual-perspective visual representation of the 3D audio mix.

After the experiment was concluded, the expert gave an extended interview on their experience with the Navi-Teer interface. They stated that the Navi-Teer’s focus on space and movement, combined with the usual temporal aspects of sound and music manipulation, changes the entire audio interactive experience. In essence, they said, there is far less distance between the individual and ‘the sounds’ due to the blurring of input and output spaces. There was a noticeable increase in the tactile immediacy of actions and responses, which is actually a more natural and realistic way to work with sound. It allowed them to experiment with many different ideas on the spot, and also to perfect certain specific movements if so desired. In addition, they also commented on how this kind of audio interface adds a certain amount of observational or performance significance to the 3D mixing task that is not present with more traditional PC interfaces.

5 Conclusion

We have presented an experiment in 3D soundscape design and experience that was afforded by an audio-enabled version of the navigational puppetry metaphor and the Navi-Teer prototype. The results outline an enhanced 3D audio interactive experience which was made possible through a graspable linking of sound, space, and time. According to feedback from our audio expert, approaching 3D soundscapes from a 'puppetry' perspective provided a more natural and intimate tactile interaction with sound and also enabled the task to have observational and / or performance significance.

Acknowledgments. This research was supported in part through grants from NSERC, Canada, ENCS Faculty, Concordia and the GRAND NCE, Canada. We also thank Mr. S. Thulin for his participation in the audio experiment.

References

1. Bischoff, J., Gold, R., Horton, J.: Music for an interactive Network of Computers. Computer Music Journal 2(3), 24–29 (1978)
2. Crevoisier, A., Polotti, P.: Tangible acoustic interfaces and their applications for the design of new musical instruments. In: Proceedings of the 2005 Conference on New Interfaces For Musical Expression, pp. 97–100. National University of Singapore (2005)
3. Fjeld, M., Ironmonger, N., Schar, S.G., Krueger, H.: Design and Evaluation of four AR Navigation Tools Using Scene and Viewpoint Handling. In: Proceedings of INTERACT 2001 8th IFIP TC.13 Conference on Human-Computer Interaction, pp. 167–174 (2001)
4. Göttel, T.: ProBoNO: Transferring Knowledge Of Virtual Environments To Real World Situations. In: Proceedings of the 6th International Conference on Interaction Design and Children, IDC 2007, pp. 81–88. ACM, New York (2007)
5. Hansen, A.S., Overholt, D., Burleson, W., Jensen, C.N.: Pendaphonics: a tangible pendulum-based sonic interaction experience. In: Proceedings of the 3rd International Conference on Tangible and Embedded Interaction, TEI 2009, pp. 153–160. ACM, New York (2009)
6. Ishii, H.: Tangible Bits: Beyond Pixels. In: Proceedings of the TEI 2008, pp. 15–25. ACM, New York (2008)
7. Jordà, S., Geiger, G., Alonso, M., Kaltenbrunner, M.: The reacTable: exploring the synergy between live music performance and tabletop tangible interfaces. In: Proceedings of the 1st International Conference on Tangible and Embedded Interaction, TEI 2007, pp. 139–146. ACM, New York (2007)
8. Pedersen, E.W., Hornbæk, K.: Mixitui: a tangible sequencer for electronic live performances. In: Proceedings of the 3rd international Conference on Tangible and Embedded Interaction, TEI 2009, pp. 223–230. ACM, New York (2009)
9. Thulin, S.: There to Hear: Placing Mobile Music. Master's Thesis. Concordia University (2009)