SPATIALIZED AUDIO FOR MIXED REALITY THEATER: THE EGYPTIAN ORACLE

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ABSTRACT

In the Egyptian Oracle, we project a simulation of an ancient temple onto a large projection screen. (See http://publicvr.org/egypt/oracle/shortvid.html.) We create the illusion of a contiguous space by matching the scale of virtual and physical objects. In the live performance, actors in front of the screen interact with human-operated avatar actors in the virtual space. As with any dramatic production, music, sound, and dialogue are a large part of the experience. Our goal is to create a unified aural space that extends from the physical through the virtual to encompass the entire performance. We use commodity electronics to produce an elegant affordable solution, which produces an impressive dramatic effect. We also confront fundamental issues typical of performances of this type, pointing the way to more advanced auditory solutions for interactive mixed reality spaces. This project was funded by the National Endowment for the Humanities, and the code is free to the public as open source.

1. INTRODUCTION

The Egyptian Oracle performance is a live reenactment of an authentic public ceremony from Ancient Egypt's Late Period. We project our Virtual Egyptian Temple on the wall at life scale, extending the physical theater into virtual space, as shown in Figures 1 and 2. The temple is a true three-dimensional space, which the audience navigates during scene changes. The central actor depicted in Figure 1 is a high priest (right), an avatar controlled by a live human puppeteer. The sacred boat (center) is another puppet, the oracle, which reveals the will of the temple god in the drama. Audience members represent the Egyptian populace acting out brief roles in the drama. By moving the boat, the Oracle has selected the woman on the left for a great honor. In other scenes, the priest interacts directly with audience members and a costumed live actress.

This experience is very difficult to understand from description alone. We highly recommend the video posted at http://publicvr.org/html/pro_oracle.html.

In the temple, ambient music sets the mood for each space, while moments of dramatic music and sound effects highlight the action, which the movie industry calls a "stinger." We create a sense of space with simple effects such as echo and reverb., which is adjusted depending on the current "location" in the space. For example, changes in reverb would immediately allow the audience to discern the transition from a big space to a small one or from an open space to a closed one. For greater aural continuity, the voice of the puppeteer, the live actress, and the currently selected audience member, are each channeled through a separate microphone to make all the voices part of the same auditory space. A live operator mixes the sounds, providing pleasing artistic balance and preventing problems such as feedback

We implemented the virtual environment and animations with the Unity game engine (http://unity3d.com) as an application that can run on a standard Windows® laptop. The software then introduces reverb with the aid of a 32-bit sound effects processor. It provides a wide range of effects such as echo, chorus, and double slap. The amplifier output can be increased from 80 watts through 2 channels to 130 watts through a 5-channel surround system. A powered amplifier along with a separate low-frequency line out gives us more bass control. A mixer gives a human sound-system operator more control over sound and eliminates floor noise.

Figure 1: Live people and avatars interact.

The resulting system provides a basic spatialization and is simple, portable, affordable, and effective. This work is a first step toward more advanced sound spatialization systems (e.g., http://www.vrsonic.com). The overall project was funded by the National Endowment for the Humanities, and Ajayan Nambiar produced the audio design for his Master's thesis

(Nambiar, 2011). The open source is available at the project website, http://publicvr.org/html/pro_oracle.html, and can be adapted to a wide variety of dramatic productions.

Several previous dramatic productions have used a sophisticated avatar/puppet for direct viewing by an audience. Ryu (2005) and her digital puppet performed a shamanistic drama for a live audience. Andreadis and his colleagues (2010) created a live performance by avatars/puppets in a virtual Pompeii, which was projected onto a large screen for a live audience. Anstey et al (2009) staged a number of dramas with a mixture of virtual and live actors. As with a traditional play, the audience is "along for the ride." The Oracle is unusual in its attention to spatialized audio, as we describe here.

2. VIRTUAL AUDIO SPACE

The virtual audio space is created in order to extend the imagination of the user beyond the boundaries of the physical space and create a controlled, realistic, and predictable aural environment (Figure 2). Our goal is to make the theater or classroom sound like an Egyptian temple, despite differences in venue. We are pursuing a basic, simple strategy first as we develop our approach.

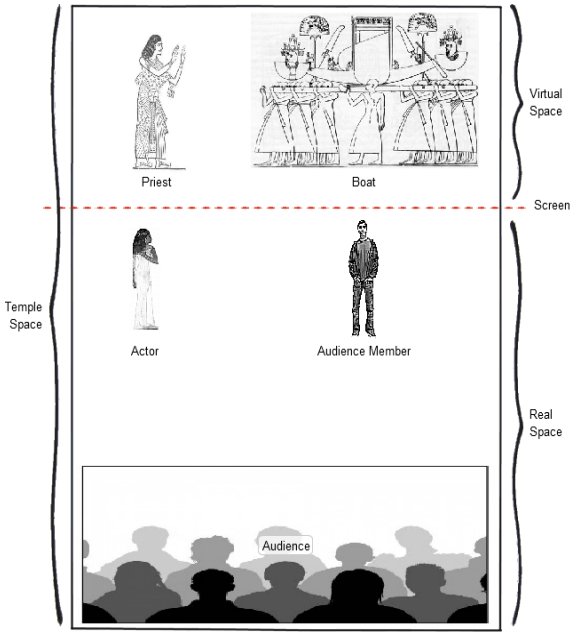

Figure 2: The unified visual and aural space, overhead view.[1]

The final audio consists of multiple layers starting from the ambient track produced within Unity3d. The next layer contains effects for realism and input from the audience. To preserve the continuity in space, the actor, puppeteer, and audience members are all provided with microphones to maintain a level field of sound. All the sounds are channeled through the mixer where the live sound-system operator can manually eliminate any interference. The mixer output goes to the amplifier to create the surround effect for the desired space.

Special sound effects help to further solidify the realism of the auditory space. Some of the effects are reverberations, echoes, Doppler effects, delays, panning, fade, and localizations. Sound effects can also help compensate for the shortcomings of the performance space. Manual control of sound effects is available in case the automatic effects fall short.

Stereo sounds lend themselves well to music but fall short when trying to simulate an environment because we perceive environments as three-dimensional, not just as left and right. We use surround sound (five speakers arrayed around the room), which helps the audience to perceive elements not actively displayed on the screen. Localization of sounds is much easier to emulate with surround sound, and our next step will be to add sound sources above and below the audience.

All of the electronic equipment for the show can be packed into the luggage shown in Figure 3. It includes a laptop computer, an Xbox 360 game controller and audio/mike headset for the puppeteer, a stereo amplifier, a mixer, two mobile microphones with their base station, 5 speakers with tripod stands, a short-throw projector, and cabling. The luggage also has room for physical props, the costume for the actress, and printed handouts. All of this is detailed in Nambiar (2011).

Figure 3: All the equipment needed for an Oracle show.

3. SONIC STRUCTURING

The goal of the Egyptian Oracle project is to provide realistic experience using a virtual space, and this paper describes the sonic/auditory dimension of that effort.

3.1. Sound Unification

The performance has multiple sources of sound input: (1) the voice of the puppeteer, (2) the voice of the live actress, (3) the voice of an audience volunteers playing small roles, (4) ambient music in the virtual temple, and (5) sound effects used to punctuate important moments in the action(stingers).

The sound inputs are fed to a high quality mixer, which requires a live operator, who balances the sounds for an artistically good effect. This is necessary because of the

[1] The image of the boat was taken from the Epigraphic Survey of Medinet Habu (1930-1940, Oriental Institute of Chicago) by the authors of http://ecuip.lib.uchicago.edu/diglib/social/ and copied into our diagram here.

unpredictability of the actors' voices and locations. For example, the volume of the speaker's voice changes, and the distance of the microphone from the actor and from the speaker varies. Also, the microphone input from the actor and puppeteer may have low-level audio hum present in the signal due to electrostatic or magnetic interference, which creates a noise floor. The noise is suppressed using the high impedance input of the mixer, producing a clean final output. Most importantly, if the actor's microphone is held at close proximity to the speaker, it results in an infinite input and output loop, which produces a high frequency sound through the speakers. The operator at the mixer can immediately drop the volume or mute the source to avert the issue. Malfunction of a device during a performance can lead to similar problems. There is no satisfactory way to automate the sound mixing, but we find the task straightforward and an opportunity for artistic judgment.

3.2. Sound Effects

The Egyptian Oracle software is built on the Unity3d game engine. Unity employs the FMOD sound engine (http://www.fmod.org/), capable of a variety of audio tasks. The Oracle incorporates triggers to handle these tasks with audio feedback. Unity's FMOD plugin can be used to regulate sound effects such as reverberations, echoes, delays, panning, fade-in, and fade-out. Since the ambient tracks are played from within the Oracle software, overlaying the desired effect helps set the conceptual space of the room in the mind of the audience. This also reduces work for the sound operator.

Finally, the sound operator can introduce variations manually by using the 32-bit effects on the mixer. The effects can apply to all sources collectively or to an individual sound channel at the discretion of the operator. For example, the actor's voice can be made to sound more emphatic, or the priest/puppeteer's voice deeper and more authoritative.

3.3. Spatialization

The Oracle software uses the game engine Unity, the sound library FMOD, and the sound system described to create a sense of space to help the audience feel as if they are inside the temple. To achieve true surround sound, the laptop being used must have an HDMI out or an optical out (SPDIF) port. The panoramic sound system allows us to localize sound sources within the soundscape. For example, the voice of the puppeteer appears to come from the side of the stage where the priest avatar is standing.

In this way, we employ spatialization to surround and enclose the audience, actor, and puppeteer within a single conceptual space, the Virtual Egyptian Temple. It blurs the line between the virtual and real worlds, including the audience within the performance.

4. MUSIC COMPOSITION

The pre-produced audio in the Oracle presentation consists of an ambient introduction, an ambient loop played in the background throughout the performance, and 14 tracks of "stingers" (short musical pieces to complement an action) and "traveling music" (music playing while the "camera" moves throughout the virtual space). Jon Hawkins wrote and produced the music and special effects in Logic Pro. See http://www.hawkinssounds.com and http://www.apple.com/logicpro/.

The ambient tracks consist of almost-static synthesizer drones and sounds, small chirps of birds, and slight wind (when the location is outside the temple). The deep synth drones provide a relaxing backtrack throughout the performance and reinforce the illusion of aural space in the virtual model. The "stingers" provide dramatic effect during actions at key moments in the drama. The "traveling music" provides a pleasant aural experience while the camera travels from one part of the temple to another during scene changes. The music tracks are designed to fit over the ambient backtracks or work as independent pieces as needed. They are also timed so that when they are triggered by an action in virtual space (i.e., the boat choosing an audience member), the stingers are synchronized with the animations.

Nobody knows what Egyptian music really sounded liked, because Egyptians had no musical notation. Many interpretations are possible, based on their surviving musical instruments and ethnographic evidence. Coptic Christian liturgy, for example, has elements that were bound to have come from Pharonic times. For this composition, however, we experiment with Hellenic elements and style because the Greeks, and later Rome, ruled Egypt for much of its Late Period, the setting for this drama.

When we secure the funding, we will record live performances of reconstructed ancient instruments. For now, we are using electronic simulations consisting of samples, filter effects, EQ, and harmonic manipulators to imitate the sounds of popular ancient instruments: the kithara (an ancient harp/lyre), pan flute (a wooden multi-chambered flute), and a variety of percussive instruments (drums, bells, finger cymbals, and shakers).

We developed the sounds by feel, using our artistic judgment. We tested and refined it in a variety the venues of different sizes and acoustic properties, and find that it works well. The next step will be to use more advanced software to simulate the acoustic properties of the virtual temple as they might have been in real life.

5. APPLICATIONS

The Egyptian Oracle performance has a dual purpose – to demonstrate the potential of mixed reality theater and to educate the public on a key aspect of ancient Egyptian culture that the public is not likely to have seen elsewhere. Religious performance and ritual permeated ancient Egyptian culture, and it is related to much of the ceremony in the Abrahamic religions (Judaism, Christianity, and Islam). The current version of the Egyptian Oracle performance was originally designed for children 10 to13 years old and for family audiences, but it has been well received by adult audiences as well. The performance is currently well suited to special showings at community theaters, K-12 schools, and science museums. As we develop it further, we will add depth to the narrative and refine the artwork. Our goal is to distribute the Egyptian Oracle to museums in the humanities in the form of a documentary film and online as a distributed virtual world. The spatialized audio described in this paper is a first step to harnessing higher

fidelity audio displays, primarily for audiences in museums and large dome (planetarium) venues. Obviously, the technology and approach could be used for educational theater on a wide range of topics.

6. CONCLUSION

The Egyptian Oracle sound spatialization project began with a purely software-based solution in mind. But performances at different venues revealed that a purely software-based solution was incapable of handling all the demands of live sound. In response, we devised a hardware solution based on a live sound system operator working with the mixer. While a live operator working alone can exercise more judgment and far greater flexibility than any automated system, the cost is greater than that of a turnkey solution. In the end, our solution provides a real and elevated sound experience for an excellent visual depiction of the Egyptian Oracle.

7. REFERENCES

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8. FINAL NOTE ON ICAD 2012

This short paper will be presented during the poster session at the International Conference on Auditory Display in Atlanta, June, 2012. We will demonstrate the software and a stereo version of the sound (using headphones) for passersby. In the future, we would like to stage the full performance, but that is not possible at this time.