Soundscape for Immersive Audiovisual Applications

Jeremy R. Cooperstock
Associate Professor
Dept. of Electrical and Computer Engineering
McGill University

Zack Settel
4319 Esplanade, apt. 1
Montreal, QC
H2W 1T1

Abstract

1. Overview

"You are wearing a wireless microphone headset, and a head orientation and position sensor. You are singing on stage while your sound, represented as a flashlight-style beam, is casting light on to sound-sensitive objects in the projected space around you. The louder you sing, the wider the beam of light becomes. The objects instantaneously process the sound of your voice (echo, reverb, transposition etc.) when you sing in (shine in) their direction. As you rotate your head, the lighted area in front of you moves around the space accordingly, casting light (sound) directly on to other sound-sensitive objects--sometimes more than one at a time. At all times, you are controlling where your sound is going in the space, and therefore, how it is being processed".

This paper presents a rich, immersive real-time audiovisual framework that supports environments for both artistic creations, such as music, image and theatre, as well as high fidelity telepresence applications, such as distributed musical performance or collaborative engineering design. The framework provides model-based scene generation, and an audio equivalent that we call the "*Soundscape*": a modeled audio performance space consisting of sounds and sound objects (audio sources and sinks). These objects may be represented in space as graphical objects (including light sources) with computational properties for modulating audio streams. An important aspect of our integrated audiovisual framework is that both Soundscape and scene generation are integrated in the same 3D space, using the same geometry and object descriptions, and making it possible to deal with sound and light interchangeably.

We will discuss the development of interactive musical instruments, based in the concept of a spatial tablature for performance; and the production of a series of live music performance works, conceived for the framework described above, and incorporating use of these instruments. Both authors, artist Zack Settel, and McGill scientist Jeremy Cooperstock are co-developing the framework described above, with different objectives in mind: Settel is developing musical instruments, performance frameworks, and creating music for live performance, while Cooperstock is integrating immersive audio implementations in his immersive multimodal interactive environments (e.g. Shared Reality, etc.).

2. Concept

In computer-generated movies, a story is modeled; pertinent objects, characters, scenes, and even point of view (e.g. objective or subjective) are specified in the 3D model; they interact as the model is rendered from one moment to the next. In this way, the computer model is like a theatre set where action takes place. The key point in common our framework has with computer-based animation systems is the importance of the computer-based model and its ability to immersively render objects and action in space. However, unlike these systems, our model-based framework provides us with a setting (audiovisual environment) or performance space where sonic action is deeply incorporated, and where audio and musical interaction can happen—from the creator's (performer's and/or listener's) point of view.

The underlying concept is that sound may be modeled, represented and manipulated in much the same way that light can be, with intensity, direction of travel, dispersion, refraction, panning, reflection etc. We are constructing a Soundscape (framework for an audio space), where the behavior of light is used as an analog for the representation, behavior and manipulation of sound in 3D space. The same model-based graphical interfaces with lighting, that have been used so effectively for 3D computer games and computer-generated animation can be used in our framework to provide users (or performers) with unusual and effective ways to immersively work with sound.

The paper will discuss this framework, which Settel uses in music making, allowing him to realize: (1) radically new designs for musical instruments that exploit the higher dimensional audio space of the framework, (2) new performance pieces that integrate these instruments, (3) pieces incorporating position/orientation dependent (active) listening, and (4) new performance contexts/situations for these pieces to be performed in. In addition, new approaches to music score representation are likely to emerge.

3. Core

Central to this project is the development of an integrated audiovisual space where actions, objects, content streams, and users have representations and interact in real-time within a 3D modeled framework for sound and image (including modeled light). The framework lends especially well to the kind of applications we work with. These applications utilize deeply immersive environments to support artistic creation and performance for music, image and theatre, and to support high fidelity telepresence, such as distributed musical performance or collaborative engineering design.

In our framework, the 3D audio space, which we call the "*Soundscape*", and the 3D scene generation are integrated in the same 3D space. The *Soundscape*, consists of sound objects (audio sources and sinks), which may be represented in space as graphical objects (including light sources) with computational properties for modulating audio streams. Both the Soundscape and the 3D scene generation use the same geometry and object descriptions. Sound and light representations and behavior can be based on the same physical model, which describes, for example, diffusion, reflection, refraction, absorption, dissipation, etc. This makes it possible to deal with sound and light interchangeably. Additionally, the user's (or performer's) presence in 3D space is modeled. Their position and orientation is dynamically tracked as they interact with the environment; the data that is captured by movement detectors is used to update the model of the user within framework described above.

The power and appeal of using this framework is that:
(1) it yields rich and seamless user (musical instrument) interface possibilities, allowing a singer, for example, to direct their voice in a sound sensitive space, in the way that one shines a flashlight to reveal features in a dark space. Or it allows a singer to use the position of their head to direct their voice to "virtual microphones" located in the Soundscape (modeled audio space). It provides a spatial tablature for the instrumentalist.
(2) It provides alternative and efficient ways to perform audio processing. For example, recording studio engineer can perform surround-sound panning using the modeled diffusion properties of a given sound source to determine the spread pattern of the sound in the speaker field.

The paper will include a technical discussion of the Soundscape, with details on its implementation in Pure Data (PD, Miller Puckette 1995) from both a technical point of view, and from a musical point of view, discussing the ways that the Soundscape is being used in the creating and experiencing of music.