

VAmbiR - Ambisonics in VR

Music 222: Sound in Space

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1 Concept

Audio in virtual reality to date has been a largely individual experience, understandably so in pursuit of its primary goal: seeking to heighten immersion for a single user. An audio experience confined to headphones presents the most commonly accessible solution to the problem of creating an immersive listening environment for the individual. However, when more advanced sound spatialization facilities are available, for example large performance spaces capable of faithfully presenting material encoded with higher-order ambisonics, new possibilities for controlling live spatialization of sound leveraging the advantages of virtual reality as a three-dimensional workspace start to emerge. With the proper tools, virtual reality can serve as an artistic medium through which musicians gain unprecedented real-time control over spatialization as well as other aspects of composition, creating an entirely new purpose for audio in virtual reality, namely creating an external experience for an audience of many instead of an internal experience for a single individual.

Current tools for controlling the position and motion of sound sources in three-dimensional space are limited by the constraints of working on a two-dimensional screen, either restricting realtime control to two dimensions or employing awkward and unintuitive interfaces to allow additional degrees of control in realtime. Virtual reality provides an ideal environment for manipulating sounds in three dimensions, free of the limitations of a 2-D workspace.

VAmbiR is a Unity-based VR application design to communicate and work with the SPAT package in Max/MSP. It allows one to control multiple sound sources within a virtual space, including real-time position, trajectory and path creation and manipulation, source grouping / parenting, level control, and simple reverb control.

Sounds can be assigned one of several different movement control modes:

- 1: Free Motion - unconstrained motion within a settable spherical volume, grab and release sources to manipulate, variable source drag allows sources to follow adjustable physics.
- 2: Orbit - sources revolve around a movable center position, with a settable level of 'gravity'/attraction to the center. Orbit centers can be assigned their own movement mode or can be other sound sources.
- 3: Blink - sources move immediately from one position to another. Time at each position is variable. Any number of positions can be assigned to a source; that source can cycle through positions randomly or sequentially, with options to loop back to the first or reverse direction through the list when the last position is reached. Each position has a settable volume level, and sources have a fade time that controls how quickly the volume ramps between levels at each position.
- 4: Set Path - similar to Blink but sources travel smoothly along paths between positions. Time at each position instead corresponds to time taken to reach the next position (travel speed), or source velocity can be set to constant.
- 5: Draw Path - source paths can be free-hand drawn in 3D space. Sources follow paths at the same rate at which they are drawn. One-time, loop, or backtrack options are the same as Set Path and Blink modes.

One can also control global ambisonic variables, including pitch, yaw, and roll of the entire ambisonic field, as well as translation of the center (listener) position and overall space scale/size.

VAmbiR additionally includes a rudimentary (for now) 3-D level meter that simultaneously visualizes different ambisonic channels in 3-D space.

2 Reflections

Additional features to implement:

Transport / Global Timeline: A global time clock against which all sources measure their position and behavior, to allow creation of complete pieces with precise control over every aspect in a persistent, repeatable, savable format; with similarities to conventional DAW formats.

Trigger Volumes / Conditions: 3-D based rules governing the re-triggering of sounds, such as having a sound play whenever it collides with a settable space, or adjust its volume with proximity to other objects or sound sources.

Non-spherical playing spaces: Using cubic or other shapes to constrain the movement of sources in Free Motion mode.

Compositional space: A mode for composing musical material that translates spatial manipulation of objects to temporal and pitch information for a single sound object that can then be manipulated as a sound source in spatialization mode.

I intend to have a piece prepared that showcases the capabilities of VAmbiR for live performance. As of this Milestone writing, some elements of the piece have begun to come together, but a significant number of features remain to be implemented in VAmbiR itself. I believe it to be quite possible to have these features in place to complete the piece in time for the Bing concert. Assuming this happens, I would be running Max/MSP on my Mac Pro, outputting 16 3rd order ambisonic channels, requiring ambisonic decoding. I would be running Unity with a VR headset on a separate machine (all of which I will also provide), which would have to communicate OSC to and from Max over a network. While the intention of the piece would not require visualization of the virtual space for the audience, having a screen display a window into the virtual workspace might be a worthwhile consideration for the sake of performance if it could be easily facilitated.

3 References

In addition to resources listed as readings for class,

Martin Naef, Oliver Staadt, and Markus Gross. 2002. Spatialized audio rendering for immersive virtual environments. In *Proceedings of the ACM symposium on Virtual reality software and technology (VRST '02)*. ACM, New York, NY, USA, 65-72. DOI=<http://dx.doi.org/10.1145/585740.585752>

Cook, Perry. 1998. N»2: Multi-speaker display systems for virtual reality and spatial audio projection. *Proceedings of the 5th International Conference on Auditory Display (ICAD1998)*, Glasgow, UK, November 1-4, 1998. Ed.: S. Brewster. International Community for Auditory Display, 1998.

Bates, Enda; Boland, Francis. *Spatial Music, Virtual Reality, and 360 Media*. 2016 AES International Conference on Audio for Virtual and Augmented Reality (September 2016). <http://www.aes.org/e-lib/browse.cfm?elib=18496>

Pike, Chris; Taylor, Richard; Parnell, Tom; Melchior, Frank. *Object-Based 3D Audio Production for Virtual Reality Using the Audio Definition Model*. 2016 AES International Conference on Audio for Virtual and Augmented Reality (September 2016). <http://www.aes.org/e-lib/browse.cfm?elib=18498>

Shivappa, Shankar; Morrell, Martin; Sen, Deep; Peters, Nils; Salehin, S. M. Akramus. *Efficient, Compelling, and Immersive VR Audio Experience Using Scene Based Audio/Higher Order Ambisonics*. 2016 AES International Conference on Audio for Virtual and Augmented Reality (September 2016). <http://www.aes.org/e-lib/browse.cfm?elib=18493>

Graham, Richard; Cluett, Seth. The Soundfield as Sound Object: Virtual Reality Environments as a Three-Dimensional Canvas for Music Composition. 2016 AES International Conference on Audio for Virtual and Augmented Reality (September 2016). <http://www.aes.org/e-lib/browse.cfm?elib=18510>

Additional Resources forthcoming re: ambisonic channel / spherical harmonic visualization / rendering.