Casey Celestin

Advisors:

Scott Petersen

Konrad Kaczmarek

Senior Project Final Write-Up

This semester, I embarked on a project that would explore sound spatialization and how it can be represented in the virtual reality space. The original idea came about as a new medium for interaction with music, seeing if I could break out of the usual process just putting on headphones and pressing play. At the beginning of the semester, I had my first interaction with virtual reality and began to think of the musical application that this new space could have. Before I got carried away, I thought a semester dive into how spatialized sound works and merging that information with virtual reality visuals would be an important first step. Thus the idea of creating a room with geometric shapes to represent sound sources became the plan. This is quite basic in well established virtual reality engine like Unity, but building the audio and visual processing from the ground up would prove to be a challenge. Although because of this, I was able to retain a high amount of flexibility and customization in my program. Through this I learned of topics such as ambisonics, binaural audio, and basic graphics processing; along with this write-up, there is a more detailed document detailing the technology and tools used. In this paper, I will give an overview of my project, explain things that went well and did not, and talk about the future changes to be made.

This semester's end iteration of my senior project is a virtual reality tool for mixing and playback of song stems. It should be noted that to get the full experience of the program, it

should be used with a virtual reality headset. As of this moment, I have only tested it on a Oculus Rift, so other headsets might not produce ideal results. The user selects folders or files to be loaded into the program using the readFolder or append buttons. Once the sound sources are loaded, they are automatically placed on a representative map in the patch as well as rendered as a sphere in the virtual space that opens when the program is loaded. Using the global playback buttons in the program, the user can start and stop the audio. The location of the sources can be manipulated by clicking and dragging on the in program map or by using the virtual reality controller, using the trigger to select the source and the joystick to move it. There is basic audio visual interaction, as I have mapped intensity of input source to sphere radius.

As for the signal path, once the folder is selected, it is sent to a polybuffer~ object that loads all the samples into buffers. The polybuffer~ object then sends the names of all of the buffers it has just created to a mc.poly~ object. The mc.poly~ object creates multiple instances of the patch load_track, which initializes buffers as ambinsonic and virtual objects. load_tracks also holds all the information related to a specific source, such as position, description, color, and playback. Once playback begins, the audio is played from the buffer in the respective load_track and sent to to multichannel out of mc.poly, where is split by mc.unpack~. The individual signals are then sent hoa.2d.map~, a higher order ambisonics encoder, where it is encoded into eleventh order ambisonics B-format. From there it goes into a rotate object that rotates the soundfield based on the tracked headset position of the user. The hoa.2d.optim~ optimizes the B-format for the very center of the map. It then gets decoded into twenty-four plane waves, evenly spaced at fifteen degree increments. This is for the multiconvolve~, which loads head-related impulse

responses, which are taken at fifteen degree increments, and convolves the inputs down to binaural audio.

Overall the results are encouraging and while there are a few parts that need improvement, the program succeeds in my goal of creating a new medium in which to interact with music. The audio processing works well, with the spatialization sounding believable. Using the program is exciting while inside the virtual reality headset and creating new, spatialized mixes of songs on the fly is much easier in this tool than it would be in anything I have used to date. A few things I was disappointed by are the head tracking and rotating of the sound field. The hoa.2d.rotate~ object did a serviceable job but could not handle fast head movements, creating audible clicks when the soundfield was rotated too quickly. Another problem I encountered was creating a reliable audio connection with the headset. Working without the headset, the audio processing was fairly reliable but using the headset caused Max to crash more often than it should. With these shortcoming as well as the successes, there is a platform to continue working on, improving and adding features at each step.

As this project continues, there will be two facets of program to improve on, the current code and adding more functionality to the program. The current code can be improved by trying different ambisonics toolkits and comparing the results. As I detailed in my report on technology and tools, there are more involved ambisonics toolkits that might produce better results. Also finding a solution to my rotation problem, whether through use of a new ambisonics toolkit or physically manipulating each source position as the head rotates, will be a priority. The new features to be added will be determined by where I want to take this project. One option is to work with it as a composition tool, adding different effects and linking it with a digital audio

workstation like Ableton to promote seamless music creation. Adding to this idea, I can map physical parameters of the visual representation to sound synthesis parameters, creating a sound design element to the program. Another option is to keep exploring the program as a music interaction space. In this iteration, I would like to see increased implementation of audio visual interaction, as well as more sophisticated movement and the addition of physics to the representation. Also new exciting ways of the audience to interact with and experience the various sound sources.

Through this project, I was able to explore the basics of how we can synthesize spatialized sound and created an interesting forum to interact with and experience music. I believe this is a great beginning point that I can take in many ways going forward. With the ever evolving influence virtual reality is having on all forms of media, I am excited to see and explore its impact on music, from creation to experience. Although this technology is still quite expensive and inaccessible, I believe, as with most technology, it will only grow more accessible, more ubiquitous, and the opportunities will extend far past video games. With such exciting technology still in relative infancy, being able to apply it to the art form in which care about deeply excites me and I will be looking forward to the future and the new opportunities virtual reality and music will afford me.