CSC 497 – DESIGN REQUIREMENTS: BINAURAL AUDIO

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ABSTRACT

Binaural audio allows the listener to hear sounds as if they were in the room with their source, creating a more immersive experience than the standard 2-channel stereo audio [1]. This project seeks to explore and explain the principles behind binaural audio and binaural synthesis, first starting with the basics of panning and finishing with an understanding of how to synthesize a binaural soundscape with the use of Head-Related Transfer Functions (HRTFs). This design specifications document begins by presenting my introduction, followed by my goals, implementation plan, and initial work on the project.

1. INTRODUCTION

This project is a pedagogical approach to binaural audio using Jupyter Notebook[2] and Google Collab[3]. It will explain what binaural audio is, explore the principles behind binaural audio, and provide interactive examples and comparisons to aid in understanding.

The initial motivation for this project came from a previous interest in binaural audio specifically in relation to virtual and augmented reality. I had done research into the applications of binaural audio in relation to virtual reality, learned the high-level concepts of how binaural audio is recorded or synthesized, and what problems come with applying it to new media and the solutions others have come up with to solve those problems. Though binaural audio itself is not new, the ways that we are applying it are just beginning as we explore its use as an immersive tool.

2. GOALS

For this project to succeed I have defined the following goals:

2.1 Concrete understanding of binaural audio

The project should give the reader a clear understanding of what binaural audio is and what techniques they can use to synthesize it using HRTFs. The reader should not need any prior knowledge about binaural audio to understand the concepts at a high level and a reader with a background in computer science or acoustics should understand the concepts at a low level.

2.2 Explore and compare HRTFs

The reader should understand what HRTFs are. In addition, there will be examples of multiple HRTFs that the reader can then listen to and compare against each other.

2.3 Interpolation

Some basic information about interpolation will be included in the project and how it can be used in binaural audio to create movement or placements that HRTFs were not measured for.

2.4 Implementation of binaural soundscape

Part of this project is to create a binaural soundscape using the techniques taught in this project. The binaural soundscape will be synthesized using mono sounds filtered with HRTFs.

3. IMPLEMENTATION PLAN

The following are the milestones I would like to achieve as I work on this project:

3.1 Sprint 1

For this sprint, I will have finished the Design Requirements document, started my Jupyter Notebook by explaining the basics of panning laws, started the Google Collab notebook containing a sound that is panned, and started my GitHub repository for this project.

Originally due June 7th but was moved to June 14th.

3.2 Sprint 2

For this sprint, I will have completed my Progress Report document and finished the basic explanation of HRTFs as well as begun implementing examples in Jupyter Notebook and Google Collab. In addition, I will have started my work on the binaural soundscape.

Due June 30th.

3.3 Sprint 3

For this sprint, I will have completed the examples of HRTFs as well as begun the explanation about the basics of interpolation in Jupyter Notebook and Google Collab. Additionally, I will have progressed further into my work on the binaural soundscape.

Due July 13th.

3.4 Sprint 4

For this sprint, I will have completed the Final Report document and finished the explanation about interpolation in the Jupyter Notebook and Google Collab. Additionally, I will have finished my binaural soundscape.

I will also have completed my preparation for the presentation of my project, including Powerpoint slides with explanations and examples of the project.

Due July 27th.

3.5 Sprint 5

For this sprint, I will have finalized both my Jupyter Notebook and my binaural soundscape and will turn in the final product in.

Due August 10th.

4. INITIAL WORK

I have met twice with my supervisor, George Tzanetakis, to discuss the project and start defining it. In our first meeting, we contemplated the different angles we could come from in exploring the topic of binaural audio, narrowed down the scope, determined the outline for the course itself, and shared some helpful resources. Afterwards, I looked at books and papers which explored topics from methods of recording binaural audio [4] to research in selecting HRTFs for a given listener from a database [5]. Through this, I determined I wanted to take a pedagogical approach. At the second meeting, we discussed where I should start with the project. He advised me to start with a simple Jupyter Notebook that played a single sound and showed examples of simple stereo panning using different panning laws. He shared the paper *Loudness Concepts & Pan Laws* [7] and told me to implement the examples they discuss in the Pan Laws section. From there I can then move on to using HRTFs to filter and place the audio. We also discussed the Design Requirements document and the use of both a GitHub repository and Google Collab in the project as a way to share my progress.

I have since finished a first draft of the initial explanation of what binaural audio is, a high-level description of the techniques to record and synthesize binaural audio, and the explanation of stereo panning laws. I was initially unsure how to create two-channel audio in Python using techniques we learned

in CSC 475 but quickly realized that I just had to put the two arrays into a 2D array to get stereo sound. I have had trouble inserting the images that explain the different panning laws, as only one of them can be inserted for some reason, but I will be replacing them with ones generated by code in the Notebook itself in my next draft of these sections.

5. REFERENCES

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