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Modern Mozart

A visual analysis of musical elements

Abstract

Our group set out to create visualizations that would complement the experience of listening to music. We used previous research and existing documentation, alongside various published videos, to better understand how we can effectively visualize data from audio files. After exploring static visualizations and song (audio file) information through Python, we turned to javascript in order to create a real time 3D-model that visually reflects a corresponding piece of music. Our project resulted in us creating a body of work centered around audio data, with the primary outcome being a real time visual representation of a song.

Introduction

Music has played a pivotal role in human culture for thousands of years. Songs and the sounds they are composed of reflect current societal values, help spark emotion and joy in listeners and musicians, and create a sense of shared experience across people of varying cultures and backgrounds. In modern day, music is everywhere, and the experience of listening to music is universal. The modern music industry in the United States alone (including both the record industry and live music) generates over 20 billion dollars a year (reference2) and is fundamental to the culture and economy of the world.

Because of the prevalence of music, and the mysterious means through which it affects us individually and collectively, there is a strong desire to better understand the experience of listening. In their 2009 Paper titled “Creating Access to Music through visualization” Fourney and Fels explain that the historic listening experience is not enjoyed through sound alone. That often music is accompanied by visual stimuli, including facial expressions, body language, displays of power or force, or sexualized dancing. In modern times, music coincides with special visual effects in television or internet videos and different types of music support scenes of emotion in films. If you attend any live concert today, you will likely see large displays of LED screens, colorful lights, and even lasers that complement the sound and enhance the experience of listening. In a paper titled "Seeing what you hear: Visual feedback improves Pitch Recognition" authors Eldridge, Saltzman, and Lahav argue that sensory information, specifically visual stimuli as a redundant complement to auditory stimuli, increases learning and reinforces musically conveyed concepts and emotions.

For this project, we wanted to use the skills learned in class to create an original music visualization that would ultimately enhance the listening experience. We explored static visualizations of songs and were interested in how sound could be represented in various ways through a simple chart or graph. We considered the idea of creating an interactive visualization, in which users could interact with the music by changing points on a JS visualization (this was ultimately outside the scope of our project). Ultimately, we found a JavaScript visualization library called 3JS which allowed us to create a visual representation of an audio file in real time. Through 3JS, we were able to manipulate visuals and coordinate them with audio data, in the end creating a visualization of music that was immersive and complementary to the sound.

Related Work

Our research was centered around exploring how music can best be visualized both statically and in real time. We wanted to learn how we could create something that would provide listeners with visual stimulation while also conveying structural information of the audio file. Past research has explored a variety of mechanisms and has helped to create a plethora of tools that can be used in visualizing sound. In their article titled “Creating an Entertaining and Informative Music Visualization”, researchers Pouris and Fels describe how they used psychological models of emotion and sensory substitution to develop a complex music visualization system called “MusicViz”. While this complex system ultimately ended up outside of our scope, it served as a baseline and inspiration for what was possible in the realm of audio visualizations. A similar paper titled “Misual: a music visualization based on acoustic data” explored how features can be extracted from audio data and presented to listeners on a 3D plane.

In a different paper also written by Pouris and Fels titled “Creating access to music through visualization” the authors explore the way music visualization can provide deaf and deafened people with the information conveyed through music. Although not the goal of our project, reading about how visualization can help deaf people engage in the shared experience of music listening was informative and inspiring for our team.

In order to create an entertaining and informative visualization of music in the short time that we had, our team looked to our past experience and familiarity with javascript. We found a really cool library called 3JS that seemed to fit the bounds of our knowledge while also allowing us to create an effective and entertaining vis. We referenced published 3JS examples, and found youtube tutorials on how to sync audio files to 3JS visualizations. We used published code, youtube videos, and the 3JS documentation as resources and examples during the time we were building and experimenting with our visualizations. One particular video titled “Coding a 3D Audio Waveform Visualizer with JavaScript + Three.js” was particularly helpful in building our 3D visualization.

Statistical Analysis & Static Visualizations - Priscilla

I began the project by analyzing a large data set from music on Spotify. This inspired a large chunk of the Project Proposal; I also wrote the entire proposal and received approval from the rest of the group. I created 11 data visualizations using Seaborn and Python techniques to depict different aspects of music that the Spotify data included. These include elements such as energy, danceability, tempo, duration, key, loudness, valence, etc. Initially, I visualized the ways in which each of the elements was measured in the data set. This included a large amount of detail and components. So, I narrowed down the data set to measure and visualize six of those elements including, acousticness, danceability, energy, speechiness, liveness, and valence. For each of these graphs, I took one element and measured the additional five elements over the first element, see pages 14-19 in PDF.

I also created four other visualizations based on different data from the original data set. The first includes a beautiful rainbow bar graph that groups 50 artists from the data set with the top danceability. The next graph is a heatmap, that grades each of the elements from the data with a color gradient; this visualization is not incredibly helpful for our project, Priscilla mainly just found this display of data really pretty and interesting to look at. Then, there is a histogram that measures liveliness. According to Priscilla, this graph was not entirely exciting enough, but still important to include as it demonstrates her progress. Lastly, the final graph displays a layered plot including graphs on each of the axes and along with a scatter plot that includes all of the data points from the data set. This graph measures loudness over the duration of each song and artist in the data set.

In addition to these visualizations and statistical analysis, I also manipulated the CSS behind two CodePen animated audio visualizations that were not included in the final project due to complications beacuase they were too difficult to incorporate into the video final product according to the rest of the group. Unfortunately, had those issues been communicated with me sooner, I would have been able to incorporate my visualizations into the final project.

Audio Visualizations & 3JS

Sphere Visualization - AJ

There was no real deep meaning behind the sphere. When first looking around for ideas to implement for a sound visualization, we stumbled across a similar example on youtube that was extremely captivating. In order to make the most of this, we took inspiration from Codepen, and downloaded 3js on our respective IDEs, as we thought it would be exciting to customize already written code, learn a bit of javascript, and ultimately improve as computer programmers. We took a lot of time to read through the documentation offered by 3js, and toyed with the code as much as we could. We toyed around with different surfaces that the sphere could embody, as well as position within its environment. A huge thing to note with this visualization is how parts of this sphere take on a tight candy corn shape. This occurs when the hi-hats are hitting within a song. This is best exemplified when house music is played with the visualization. It was extremely satisfying being able to learn a new framework, and incorporate a passion for music with it.

Plane Visualization - Trevor

When looking at the second visualization that we wanted to do, we decided to use a plane visualization. I found a repository with sample code, and decided to use some of it for the visualization. ThreeJS was chosen because it is a high level visualization library written in javascript (built on WebGL), allowing rapid prototyping while still offering flexibility. In order to do this, AJ and I had to launch a development server which allowed ThreeJS and plugins to be run together. I did this using webpack. For this visualization, Trevor used the Web Audio API native to Javascript to read the data array generated from the bin count the Web Audio API analyzer created when parsing the audio file. From there, I used the data generated to vertex mapping using a custom vertex shader, and created the rainbow effect with a fragment shader. The color choice was interesting because I wanted the otherwise bland looking visualization to look more interesting as it informed the viewer on the frequencies. From this experience, I learned a lot about how real time visualizations work, and how to use libraries like ThreeJS to quickly prototype cool visualizations.

Discussion:

Our group walked away from the project with a deeper understanding of music and the ways in which visualization can enhance the listening experience. We learned that seeing an accompanying visualization can further convey the information and emotion that music evokes. We also learned that it is *hard* to create effective visuals corresponding to songs in real time. If given more time to work on this project, it is likely we would attempt to develop a system that detects audio (maybe from a microphone) and is able to instantly convert that data to a visual stimuli. This is different from our current project as we currently use pre-existing audio files exclusively for our data input. Furthermore, it is likely that given more time, we would be able to conduct an analysis of different types of music alongside our real time visualization. It would be interesting to explore more how different genres, different frequencies, and just different sounds interact with our original visualization. Does one type of music produce a greater average amplitude from our 3d vis? Does our visualization provoke different reactions in different types of people? Is it perhaps desirable to cater different genres of music to different visualizations? These are just a few of the questions further research would allow us to explore.

Looking back, our team is deeply satisfied with how our deliverables ended up. We were pleasantly surprised that we were able to find a JS library that allowed us to create an immersive and entertaining visual experience corresponding to a piece of music. Although perhaps not as academic or insight driven as previous projects, our choice to focus on the experience of listening ultimately resulted in our team being able to create a collection of work that we are all proud of. In conclusion, this final project provided us an opportunity to combine the material learned in the class with our collective passion for music. It was a memorable experience we are extremely grateful for!