Prospectus: Visualizing Musical Structures

Lo, Wesley

1 Introduction

The association between mathematical patterns and music is frequented. From the wave functions that can describe audio information to the placement and varied recurrence of melodic sequences, patterns are both foundational and utile in the field of music.

While there are specific concepts such as common chord progressions, harmonies, etc., there are many free-form musical ideas which are often connoted via vague qualitative descriptors. For instance, melodies may be described as "somber," "dancing," "melodic," etc. I think it would be interesting to develop a tool that can help provide a concrete organizational structure for some of these ideas. For instance, using pattern analysis on midi data for Christmas music and comparing it with Hip Hop. By identifying the set of labels associated with different characteristic properties of a given genre, it may be possible to find similarities between them. In jazz theory for instance, there are different chord progressions that are more standard than others. Ideally, this program would be able to extract a set of these principles in some visual way. This many benefit musicians interested in better understanding their own compositional process, understand other people's music, and yield insights into what differentiates different genres and their respective properties.

2 One-sentence description

This is a program that analyzes musical information and visually represents embedded patterns and structural information which can help inform the user about musical compositions and genres.

3 Project Type

Application / Visualization / Data Analysis

4 Audience

This project is intended to help people who write music, play music, or are interested in music theory.

5 Approach

5.1 Details

To keep it straightforwards, the analysis will be just on piano compositions. There are three main components to this project: (1) processing the data (2) analyzing + extracting embedded information from the data (3) displaying the information in some visual form that can actually be used as a tool. The general approach is to identify python's capabilities for processing different types of music data. Then port live to html if possible. If live is not an option, then uploading data to the tool could also work as well and provide similar insights. Once the pipeline is setup, experimenting with different data processing and analysis methods is the next step. Finally, reading up on how to best visualize musical information would allow the tool to most effectively benefit the user.

5.2 Evidence for Success

Going down the aforementioned list of main components of this project, most of the resources necessary for the project are flexible:

1. Midi data and audio data are quite accessible online.
2. Python is extremely flexible with any kind of data, so I don't anticipate this to be limiting.
3. The ideas I have for the visualization are very straightforward to implement and I don't expect to extend much further beyond how I've used D3 in the past.

Given how the circle of fifths and different scales are discussed in countless music theory videos, I anticipate that there is a large scope to explore this project. Seeing as said concepts are fundamental to music theory instructions, I anticipate that there exists similar results that can help in composing music.

6 Best-case Impact Statement

In the best case, the visualization can provide meaningful/novel insights into how different harmonic ideas, chords, melodies, etc. relate to each other and also work as a compositional aide to help the user come up with melodies.

7 Major Milestones

These milestones are in no particular order, as the different components are somewhat independent of one another (with respect to any one having another as a prerequisite)

- Python to port to html
- See how capable mido is at processing midi data
- Process time series music data into analyzable format
- Download many songs from each genre
- Figure out how to subdivide different song segments automatically
- Figure out how to identify a melody
- Figure out how to identify rhythms
- Test out on live music data
- Create baseline visualization
- Read up on what makes a successful visualization that maps to audio information
- Read up on any relevant math theoretic concepts towards music analysis
- Find and implement time series clustering on music data
- Find and implement cluster analysis
- Create visualization
- Create final visualization

8 Obstacles

8.1 Major obstacles

Music is open ended enough that there are multiple approaches that could work for this project as backup plans. If live data is not accessible to work with, working on existing midi file data is a fallback. I would anticipate limitations in the midi library as far as how interactive the tool can be to be the greatest limitations

8.2 Minor obstacles

It may be that the form of the midi data makes it difficult to analyze in a consistent way. In this case, finding other data may be the approach or limiting the analysis tools.

9 Resources Needed

There are numerous online databases of midi and audio data, and also analysis libraries in Python to explore. Mido is the most flexible midi tool I've found for Python.

10 5 Related Publications

A, Moreno, *On group-theoretical methods applied to music: some compositional and implementational aspects*: Starting point for a mathematical framework to apply.

W, David, (2009) *Mathematics and music*: More on the relationship between math and music

D, James, (2015) *Dynamic Time Warping for Music Retrieval Using Time Series Modeling of Musical Emotions*: Algorithms for analyzing time sequence music data. Also a resource for analyzing emotional information as another dimension.

K, Dongmoon, (2007) *A music recommendation system with a dynamic k-means clustering algorithm*: Clustering algorithm could be similarly applied towards an unsupervised learning model

G, Sergio, (2018) *Automatic assessment of violin performance using dynamic time warping classification*: Potential ideas for performance analysis of compositional data.

11 Define Success

At minimum, if I can generate results from this tool and have a comparison of before and after, there will be enough to publish a paper.