Detection of Harmonical Changes

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Abstract

We develop a graph-theoretic AI agent, augmented by modern tonal music theory, to detect harmonic changes in Baroque musical scores, such as major mode Fugues and Preludes from J.S. Bach's Well-Tempered Clavier, Book I. In this approach, we seek a middle-ground between Graph Theoretic AI and Modern Tonal Theory to convert scores into computer-accessible data, in order to implement the algorithms for logical and intuitive reasoning necessary to identify harmonic changes throughout a given score. In further detail: We developed an artificially-intelligent, weighted multigraph agent which represents and navigates common chord progressions of scores, usually following the Tonal "Circle of Fifths", with the root node as the either the tonic chord or starting musical key. With such a graph-based agent, we incorporate graph-traversal algorithms, where navigation between vertices represent chord progressions in a score.

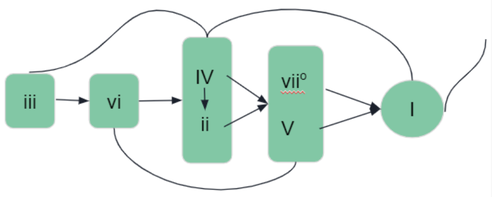
Objectives

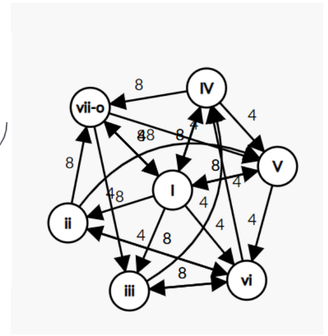
- To create a traversable graph based on Diatonic Harmonic Sequences.
- To view musical scores as data.
- To implement an Artificially Intelligent Agent that can recognize harmonical sequences, using logical reasoning.
- To use Scalar Vector Graphics to represent view scores differently.
- To create a serialized problem that can later be parallelized.

Methods

Creating the Modern Tonal Harmonic Graph

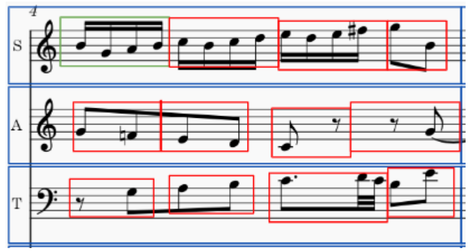
Since we were working with Baroque era, we used the 'Circle of Fifths to be able to create a handmade graph, and recreate it using Python Dictionaries





Where each Roman numerals correspond to a diatonic triad in each key signature. We define triads as a set of three notes.

We teach the computer how to read music, in a structured way, divided by subdivisions, where each subdivision is each of the colored boxes.



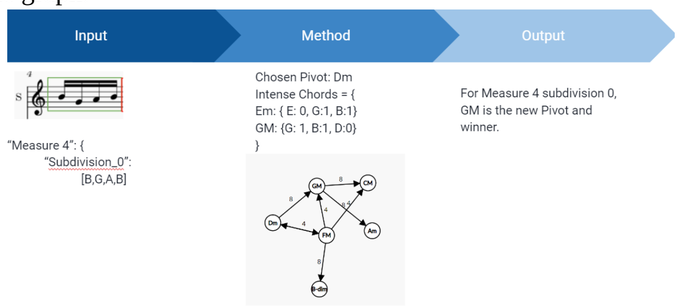

```
"Measure_4": {

"subdivision_0":[B,G,A,B] ,
"subdivision_1":[C,B,C,D] ,
….
}
…
"Measure_n":{ … }
```

Later, we run the harmonic detection algorithm. It starts with a pivot in the graph, I for first iteration. Then, for each measure it calculates the most intense triad for each of its subdivision.
Chord intensity is defined as:

$$I = \sum_{n=3}^{i} (s_i + p_i)$$

where *i* is each note of a chord, s is the number of times the note is played, and p is the presence of the note.

Then, for each intense chord we check if it is connected to the pivot in the graph.



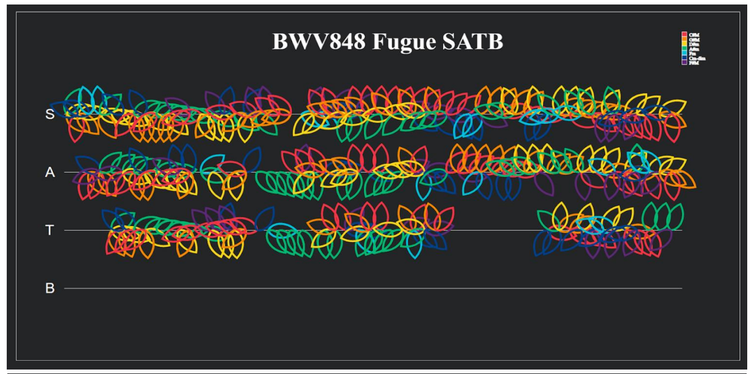
If the chord there isn't any intense chord connected, we check for the adjacent vertices and see if the intense chords are connected from there, and if there is a clear transition.

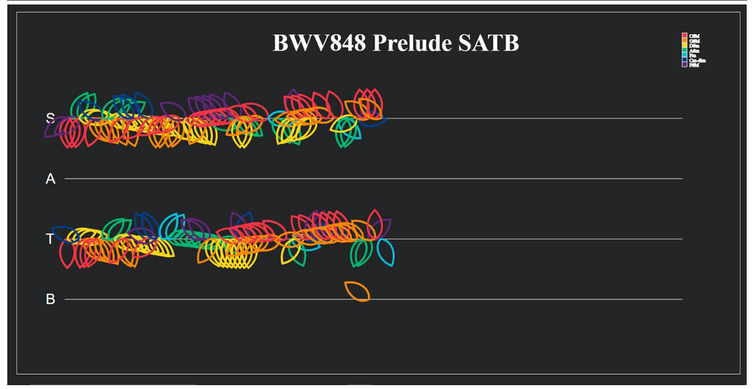
If it is not connected either, we apply the same algorithm for the second most intense chords. If there aren't any other chords, we label them as "UNIDENTIFIED", which means it can be a real sequence instead, something our agent does not know, or understand yet.

Results

Knowing that our agent only reads SATB scores, we used petal-shaped Bezier curves to represent the harmonic sequences of each of the scores analyzed by our agent. The following images were created by using Scalar Vector Graphics (SVG).

Bach Prelude and Fugue in C# major





Where each color is a different chord detected, empty spaces are unidentified chords. The petal transformations are based of the measure they are being played, and rotations are based on which chord at what measure.

Conclusion

Although the graph-theoretic AI agent was shown only primitive chord progressions, it could still encapsulate what fugues and preludes were about in Baroque era. Fugues, much like in the image, are usually going in a variety of chord progressions to add different colors in a score, whereas preludes are a more soothing way of transitioning through each chord progression, in an ordered manner. By teaching the agent about harmonic sequences, it chooses chord progressions logically, with the knowledge it has as an AI musician, much like we as musicians analyze classical scores. We are conscious about inaccuracy in chord progressions, due to the lack of knowledge out agent has, but with real sequences added, extending our graph, and teaching it to use all the voices at once to detect chord progressions, the accuracy will increase.

References

- S. M. Kostka and D. Payne, *Tonal harmony, with an introduction to twentieth-century music*. Boston: Mcgraw-Hill, 2004.

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