Hymnary.org

Melodic Similarity and Music Search

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Abstract

Hymnary.org is an online index of hymns, hymnals, and hymn-related information. While most of its data is easily accessible through text-based searching, finding a hymn tune with those same tools can be very tricky.

This goal of this project was to create a search tool for tune melodies, allowing for input in musical notation and the capability to find partial and similar matches in addition to exact ones. The major obstacles that needed to be overcome were:

• Representing music in a computer-friendly way
• Modeling similarities between tunes numerically
• Searching the information quickly and efficiently

Representing Music

Music can be defined as a collection of notes, where each note has certain properties, such as:

• Pitch
• Duration
• Loudness
• Start time ("onset")
• Tone color

Only the pitch and onset values actually affect the melodic similarity – the others are merely stylistic qualities. So, the computer can represent a melody with a series of pitch and onset pairs.

For example, this tune:

(NETTLETON, tune for "Come Thou Fount of Every Blessing")

would be represented as:

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{ (67, 0), (65, 4), (63, 8), (63, 16), (67, 24), (70,
28), (65, 32), (65, 40), (67, 48), (70, 52), (72, 56),
     (70, 64), (67, 72), (65, 76), (63, 80) }
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regardless of any changes in style:

(NETTLETON, altered)

Measuring Melodic Similarity

User-inputted melodies will often contain small changes from the actual tune in the database, so when searching, it is necessary to look for partial matches as well as exact matches.

A measurement called the "Proportional Transportation Distance" (PTD for short) is used to assign a number that describes how closely two melodies match; a distance of zero is a perfect match, with matches worsening as the distances increase.

Because melodies are often very different in length, they are broken up into melodic "segments" of four notes each before the comparison takes place.

When compared to its original, a slightly altered tune would have a small PTD (2.24, for this one):

(NETTLETON, original)

(NETTLETON, altered)

A different but similar tune would have a higher PTD (12.62, in this case):

(NETTLETON, original)

(TERRA BEATA, tune for "This is My Father's World")

Lastly, a completely different tune would have an even higher PTD (21.50, in this example):

(NETTLETON, original)

("Star Wars" Main Theme)

Searching Efficiently

Calculating a PTD for every tune in the database every time a user makes a search takes much too long to be of any real use. This is avoided by using a technique called "vantage indexing":

1. A fixed set of randomly-generated segments called "vantage segments" is created.

Sample Vantage Segments

2. The PTD is calculated between each tune in the database and each vantage object, referred to as the tune's "vantage distances".

3. Once the user searches, the PTD for each vantage is calculated against the user's search melody.

4. The database is queried for a list of tunes with similar vantage distances.

5. The resulting tunes are ordered by actual PTD values, then being displayed to the user.

The end result is that vantage distances only need to be calculated once over the life of the database, and PTD calculations are only performed on a handful of tunes, not the whole database – both of which result in a much faster search.

References

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