
PatternFinder: Content-based music retrieval with music21

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Symbolic Content-Based Music Retrieval (CBMR)

Goal: Given a query (pattern) of symbolic music, find all of the similar occurrences of this query within a database (source)

Why: Computer-aided musicology of symbolic music scores

Challenges:

- Application-dependent task
- Polyphonic music searching

PatternFinder

- Python package built on top of music21
- We started by implementing seven CBMR algorithms developed at the University of Helsinki (Kjell Lemström, Antti Laaksonen, Esko Ukkonen, Mika Laitinen)
- These algorithms find music similarity by trying to intersect sets of two-dimensional points

Piano-roll Example

Sweepline the Music! 331



Figure 1. A melody represented in common music notation.



Figure 2. An excerpt of Einojuhani Rautavaara's opera *Thomas* (1985). Printed with the permission of the publisher Warner/Chappell Music Finland Oy.

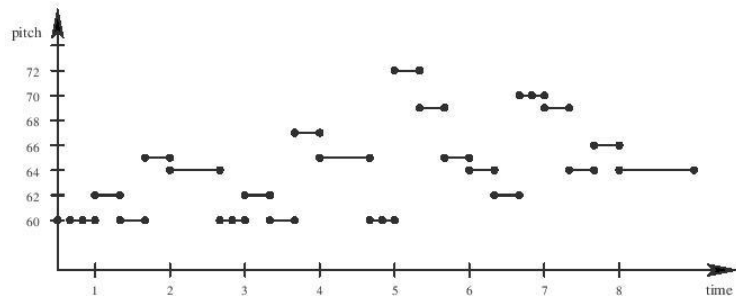


Figure 3. The example of Fig. 1 in piano-roll representation.

Ukkonen, E., Lemström, K., & Mäkinen, V. (2003). Sweepline the Music! *Lecture Notes in Computer Science*, 2598, 330–342.

Source

The image shows a musical score for Schubert's 'Der Leiermann'. It consists of three staves. The top staff is the vocal line in 3/4 time, with the lyrics 'dreht, und seine Leier steht ihm nimmer still,'. The middle staff is the right-hand piano accompaniment, and the bottom staff is the left-hand piano accompaniment. The key signature has one flat (B-flat).

Excerpt from Schubert's *Der Leiermann*

Queries

The image shows six musical queries, labeled A through F, arranged vertically. Each query is a single staff of music in 3/4 time with a key signature of one flat. Query A is a melodic fragment. Query B is a melodic fragment with a sharp sign on the final note. Query C is a melodic fragment. Query D is a melodic fragment with a sharp sign on the final note. Query E is a melodic fragment. Query F is a melodic fragment with a sharp sign on the final note.

K. Lemstrom and M. Laitinen. Transposition and time-warp invariant geometric music retrieval algorithms. In Proc. ADMIRE'11, Third International Workshop on Advances in Music Information Research, Barcelona, 201

Threshold

- Minimum number of notes in the pattern which get mapped somewhere in the database
- Exact (every note is matched) or approximate (at least x pattern notes are matched)
- Or one can specify 'mismatches', meaning at most x pattern notes are missed

Threshold

drecht, und seine Leier steht ihm nimmer stil.

The image shows a musical score for Schubert's 'Der Leiermann'. It consists of three staves: a vocal line in 3/4 time, a piano accompaniment in 3/4 time, and a bass line in 3/4 time. The lyrics are 'drecht, und seine Leier steht ihm nimmer stil.'. Five purple arrows point to specific notes in the vocal line: the first arrow points to the first note of the second measure, and the other four arrows point to the four notes of the third measure. A single purple arrow points to the first note of the piano accompaniment in the third measure.

Excerpt from Schubert's *Der Leiermann*

The image shows six musical queries labeled A through F, extracted from the score. Each query is a single line of music in 3/4 time. Query A is the first measure of the vocal line. Query B is the second measure of the vocal line. Query C is the first measure of the piano accompaniment. Query D is the second measure of the piano accompaniment. Query E is the first measure of the bass line. Query F is the second measure of the bass line. Purple arrows highlight specific notes in each query: Query A has one arrow pointing to the first note; Query B has five arrows pointing to all five notes; Query C has one arrow pointing to the first note; Query D has one arrow pointing to the first note; Query E has one arrow pointing to the first note; Query F has one arrow pointing to the first note.

Queries B, D, and F require a threshold of at least 5 (or 85%)

Queries A, C, and E require a threshold of at least 6 (or 100%)

Scale

- Time-scaling liberties taken by the algorithm to find a match
- *Pure*: rhythmically identical occurrences
- *Scaled*: finds augmentation and diminution
- *Warped*: rhythmic values are ignored

Scale

The image shows a musical score for Schubert's 'Der Leiermann' in 3/4 time. It consists of three staves: a vocal line, a piano accompaniment line, and a bass line. The vocal line has the lyrics 'dreht, und seine Leier steht ihm nimmer stil,'. Five purple arrows point to the notes G4, A4, B4, C5, and D5 in the vocal line. A sixth purple arrow points to the G4 note in the piano accompaniment line.

Excerpt from Schubert's *Der Leiermann*

The image shows six musical queries labeled A through F, each on a single staff in 3/4 time. Query A is a scale from G4 to D5. Query B is a scale from G4 to D5 with a sharp sign on the D5 note. Query C is a scale from G4 to D5 with a sharp sign on the D5 note. Query D is a scale from G4 to D5 with a sharp sign on the D5 note. Query E is a scale from G4 to D5. Query F is a scale from G4 to D5 with a sharp sign on the D5 note. Purple arrows point to the notes G4, A4, B4, C5, and D5 in queries A, B, C, D, E, and F.

Queries A and B require a scale of 1

Queries C and D require a scale of 3/2

Queries E and F require 'warped'

Window

- Number of intervening notes allowed between two matched notes
- Pattern window
- Source window

Window

drecht, und seine Leier steht ihm nimmer stil,

The image shows a musical score with three staves. The top staff is a vocal line in 3/4 time, with the lyrics "drecht, und seine Leier steht ihm nimmer stil,". Five purple arrows point to the notes: the first arrow points to the first note (G4), the second to the second note (A4), the third to the third note (B4), the fourth to the fourth note (A4), and the fifth to the fifth note (G4). A sixth purple arrow points to the eighth note (G4) in the same staff.

A B C D E F

The image shows a musical score with three staves. The top staff is a vocal line in 3/4 time, with the lyrics "drecht, und seine Leier steht ihm nimmer stil,". Six purple arrows point to the notes: the first arrow points to the first note (G4), the second to the second note (A4), the third to the third note (B4), the fourth to the fourth note (A4), the fifth to the fifth note (G4), and the sixth to the sixth note (F#4). The notes are labeled A through F.

All queries would require a source window of 4
Queries B, D, F need a pattern window of at least 2

Limitations and Future Work

- Ranking system
- Implementation of popular monophonic search methods (which are comparatively more effective than polyphonic-capable algorithms in their domains)
- Implement index and filtering methods for scalable database queries

SIMSSA | Single Interface for Music | Score Searching and Analysis



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- Lemström, K. (2010). Towards More Robust Geometric Content-Based Music Retrieval. In J. S. Downie & R. C. Veltkamp (Eds.), *Proceedings of the 11th International Society for Music Information Retrieval Conference* (pp. 577–582). Utrecht, Netherlands.
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