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

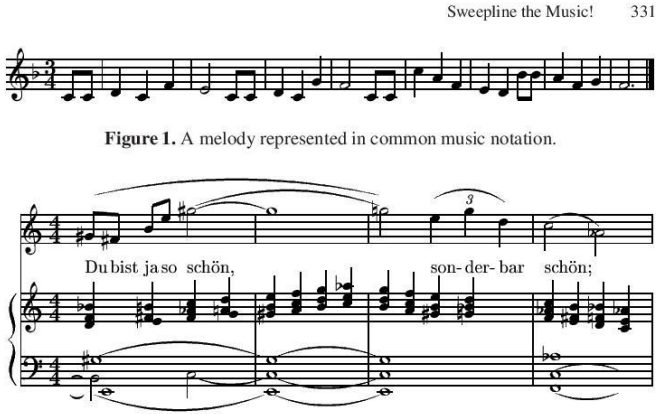


Figure 1. A melody represented in common music notation.

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

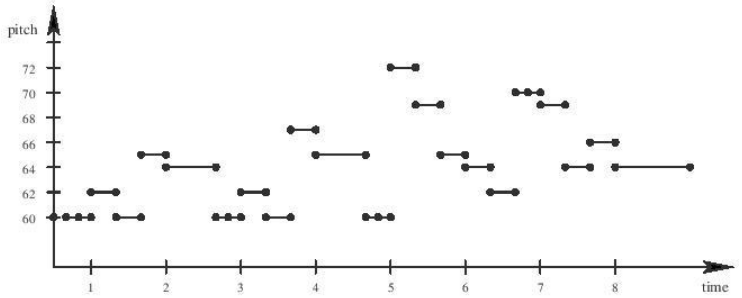
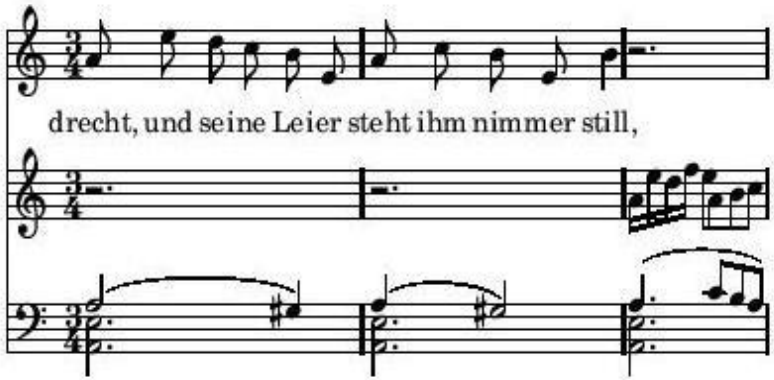


Figure 3. The example of Fig. 1 in piano-roll representation.

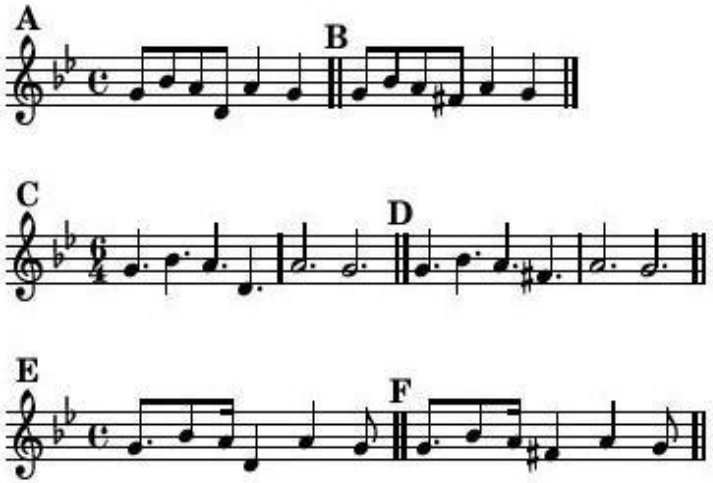
Ukkonen, E., Lemström, K., & Mäkinen, V. (2003). Sweepline the Music! *Lecture Notes in Computer Science*, *2598*, 330–342.

Source



Excerpt from Schubert's *Der Leiermann*

Queries

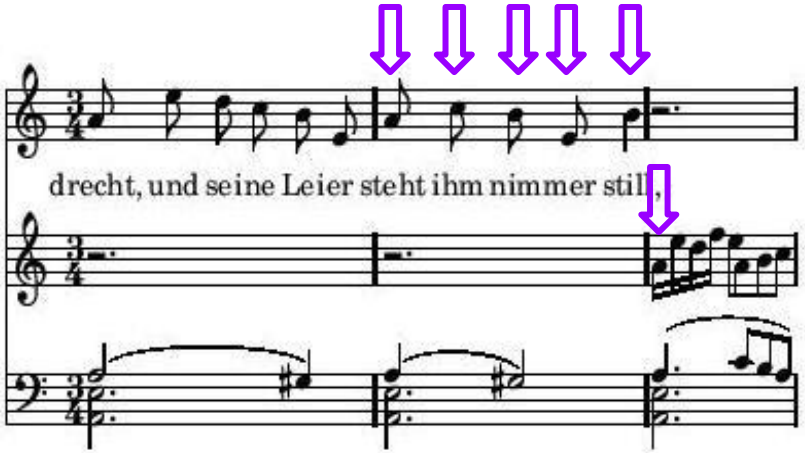


K. Lemstrom and M. Laitinen. Transposition and time-warp invariant geometric music retrieval algorithms. In Proc. ADMIRE'11, Third International Workshop on Advances in Music Information Research, Barcelona, 201

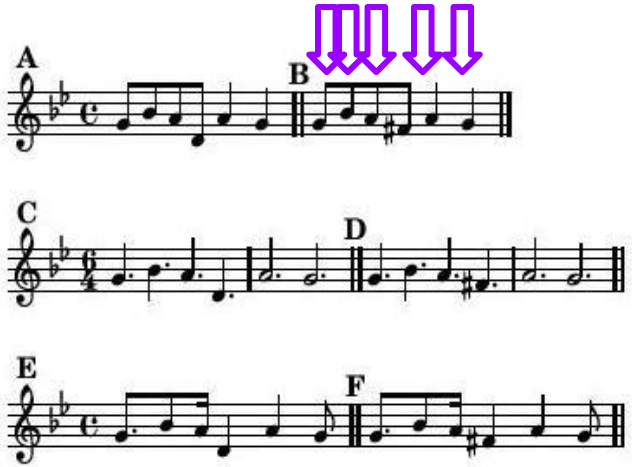
Threshold

- 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



Excerpt from Schubert's *Der Leiermann*



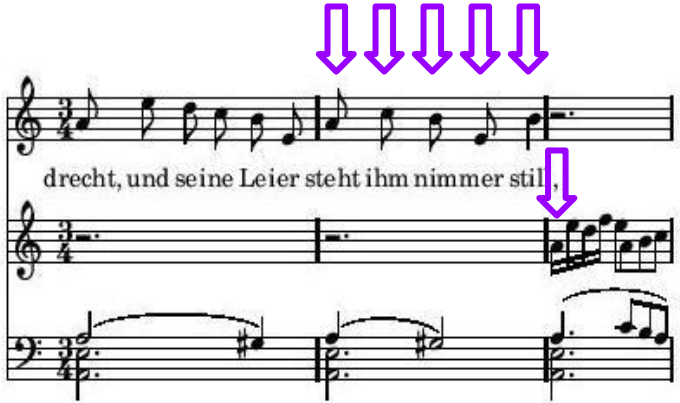
Queries B, D, and F require a threshold of at least 5 (or 85%)

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



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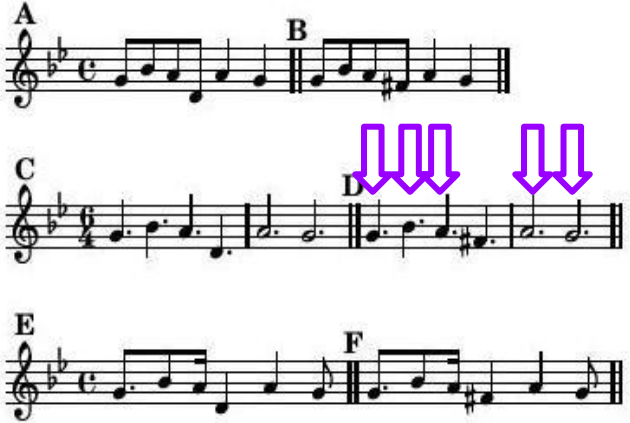


Queries A and B require a scale of 1

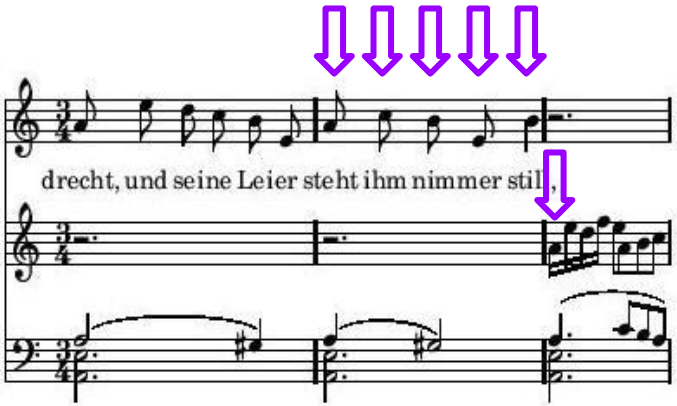
Queries C and D require a scale of 3/2

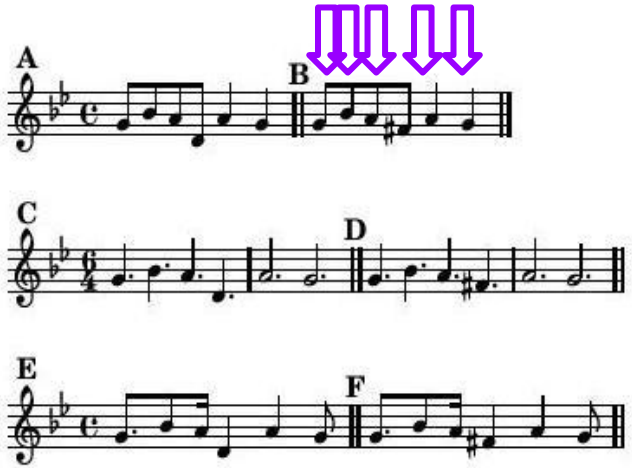
Queries E and F require 'warped'

Window

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

Window





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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References

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

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

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.

Laaksonen, A. (2013). Efficient and Simple Algorithms for Time-Scaled and Time-Warped Music Search. In *Proceedings of the 10th International Symposium on Computer Music Multidisciplinary Research* (pp. 621–630). Marseille, France: Laboratoire de Mécanique et d'Acoustique.