PatternFinder: Symbolic Music Retrieval

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Symbolic Content-Based Music Retrieval

- **Search music by its content:** Given a musical passage, find all of its occurrences (and/or similar occurrences) in a corpus of digitized music scores.

- PatternFinder is software for symbolic music retrieval

- Python package using music21: https://github.com/ELVIS-project/patternfinder

- You can use PatternFinder's web application at https://patternfinder.elvisproject.ca

PatternFinder Web Application: https://patternfinder.elvisproject.ca

- **Query:** written in the digital music representation “**kern”
- **Search:** An algorithm to find occurrences of our musical passage
- **Filters:** to expand or narrow search results

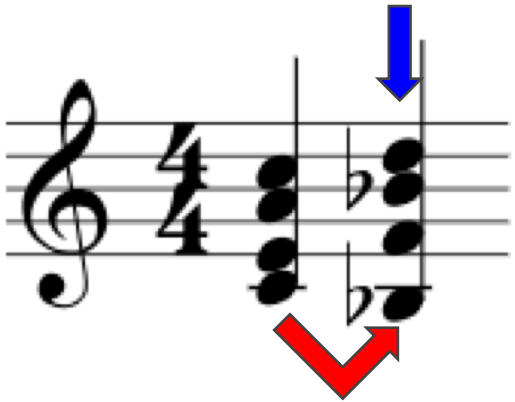
Entering Your Query

```
1  **kern
2  *clefG2
3  *k[]
4  *M4/4
5  =-
6  4c e a cc
7  4B- f b- dd
```

*clefG2 → Clef

*k[] → Key Signature

*M4/4 → Time Signature



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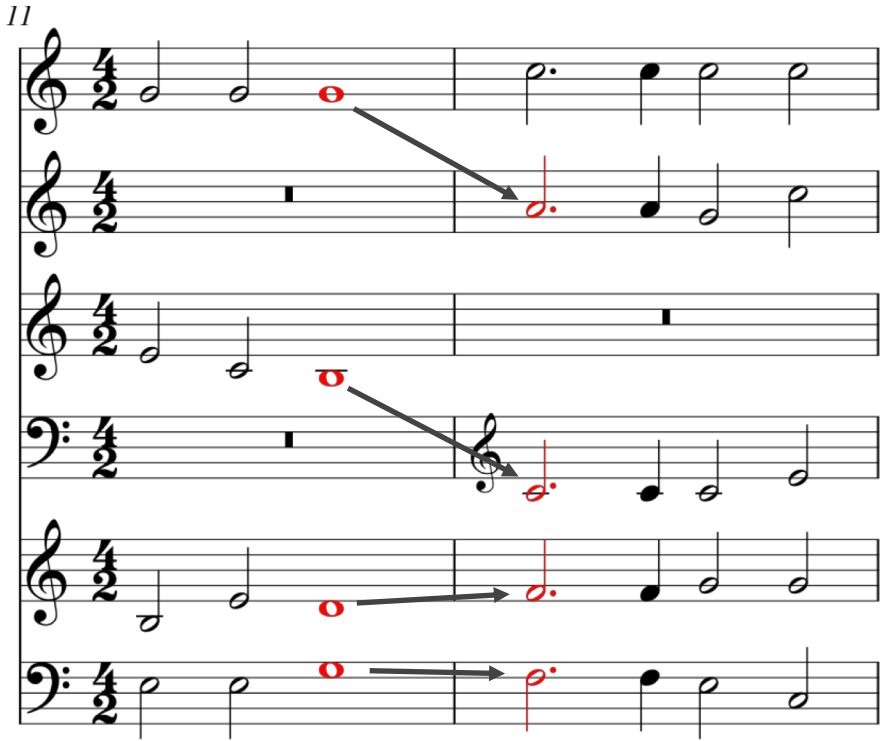
Algorithm to Find Polyphonic Occurrences

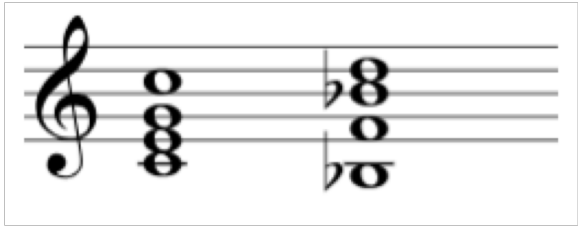
- Developed at the University of Helsinki in 2011
- Searches through polyphonic texture for exact voice leading
- Transpositions
- Partial matching
- Rhythmically altered occurrences

K. Lemström 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, 2011

Credo movement of Missa Veni creator spiritus à 6



Query:



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- **Query:** written in the digital music representation “**kern”
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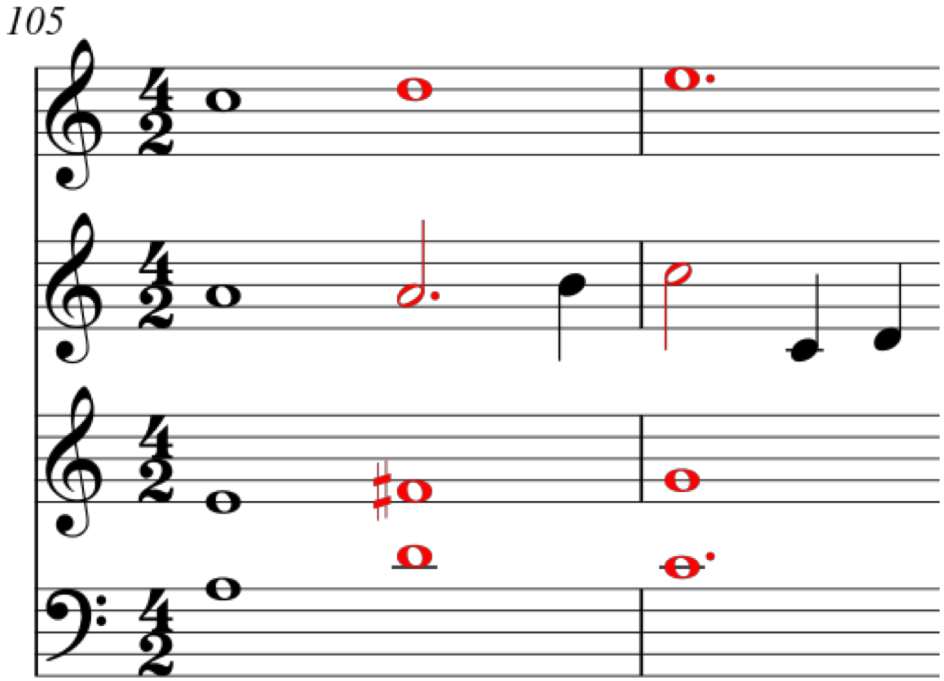
- **Filters:** to expand or narrow search results

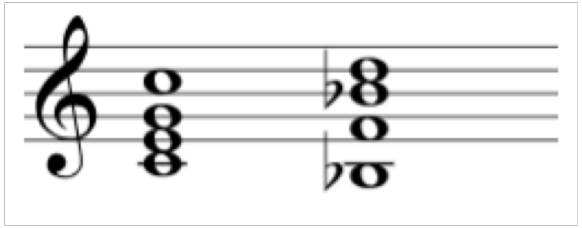
Filters

- Partial matches
- Transpositions
- Intervening notes

Gloria movement of In te domine speravi à 4: one intervening note



Query:



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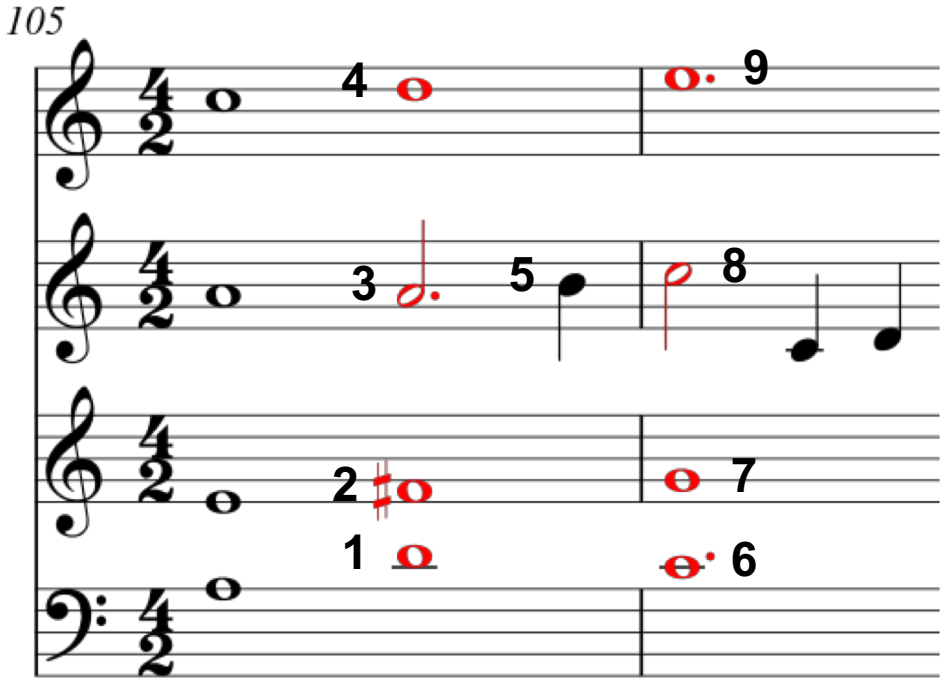
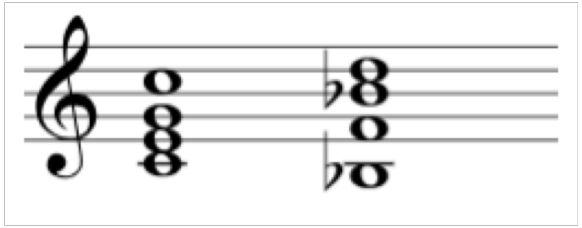
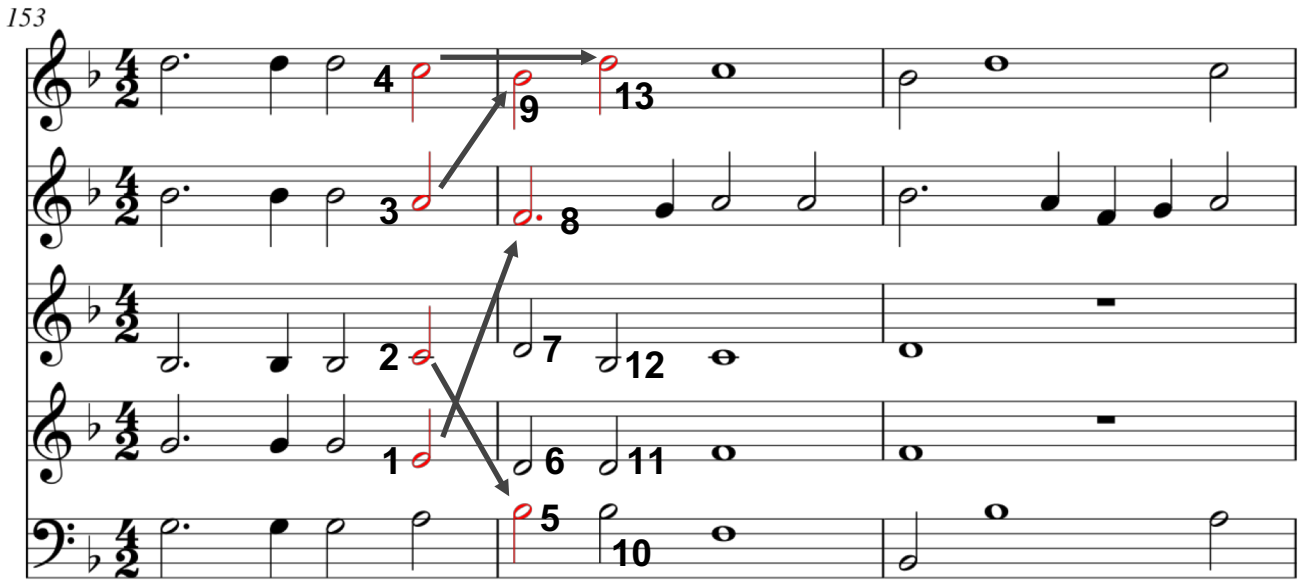


Query:



Credo Movement of Missa Memor esto à 5: three intervening notes



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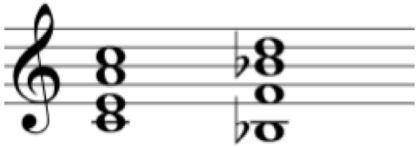
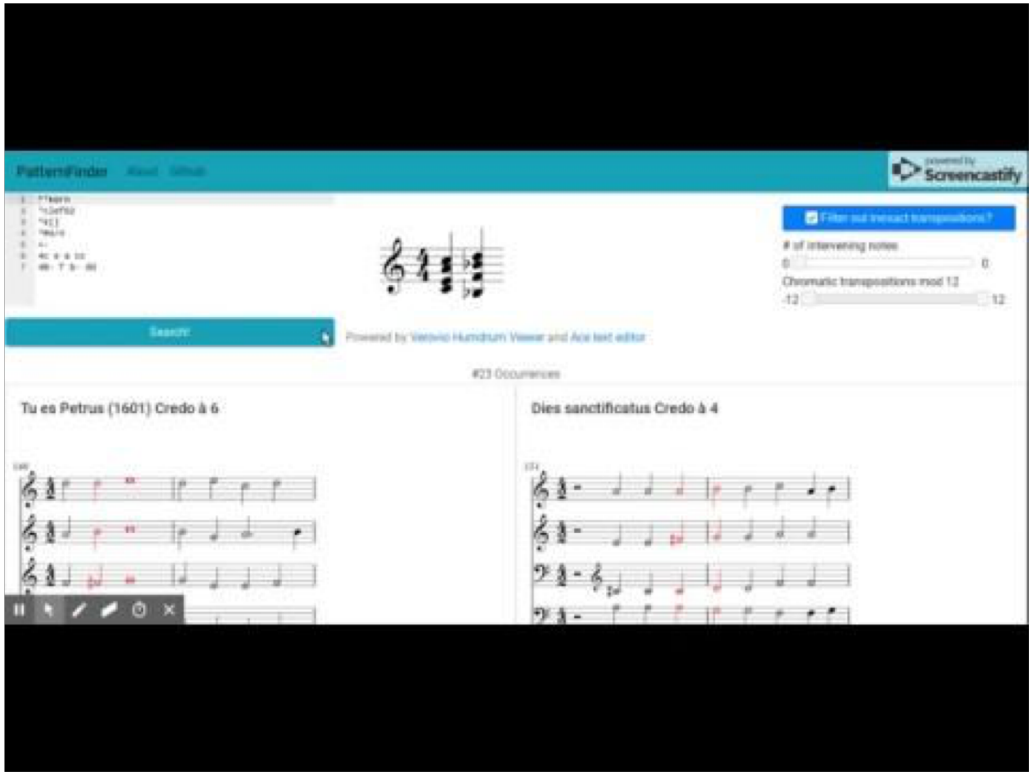


Order: E, C, A, C, B, (intervening D, D), F, Bb, (intervening Bb, D, Bb), D

Demo


PatternFinder
Screencastify
Search!
#23 Occurrences
Tu es Petrus (1601) Credo à 6
Dies sanctificatus Credo à 4

Future Work

- Better indexing methods for faster search
- Experiment with ranking system
- Query interface
- Index data directly from SIMSSA DB

SIMSSA | Single Interface for Music Score Searching and Analysis

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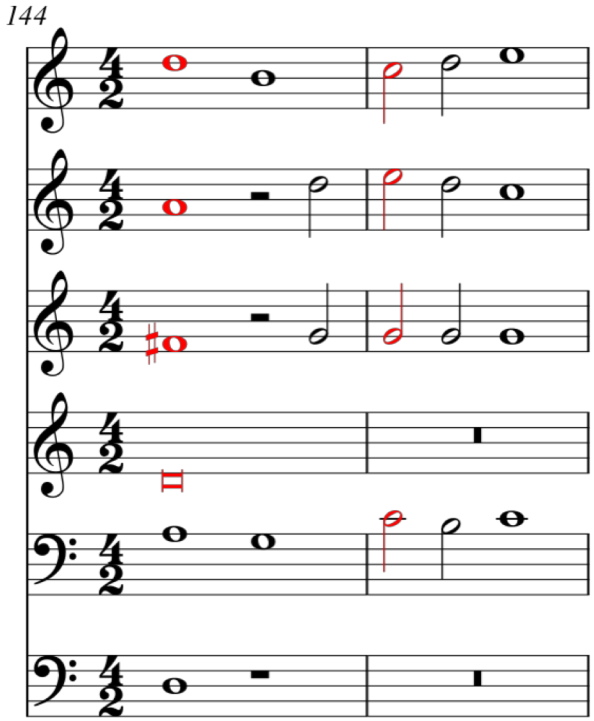
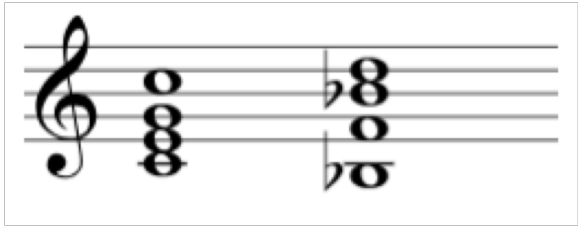
CIRMMT Centre for Interdisciplinary Research in Music Media and Technology

Fonds de recherche Société et culture Québec

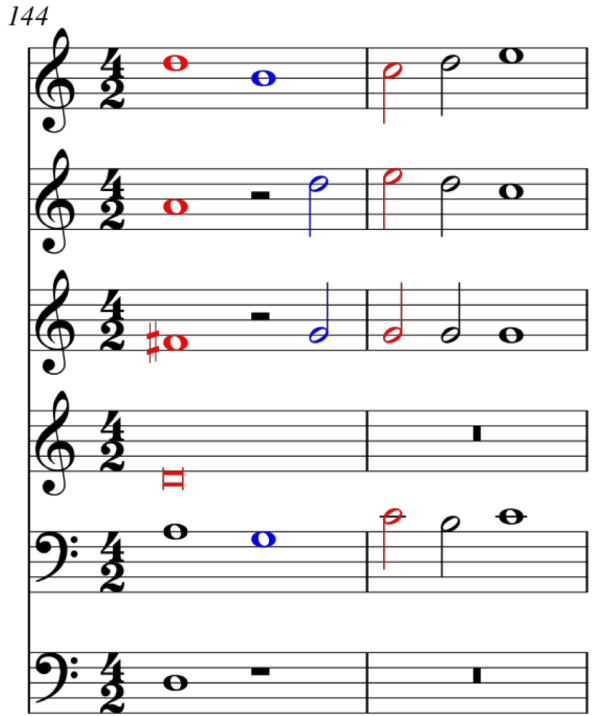
Credo Movement of Missa Tu es Petrus à 6: four intervening notes



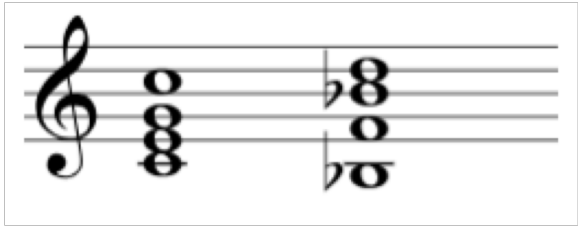
Query:



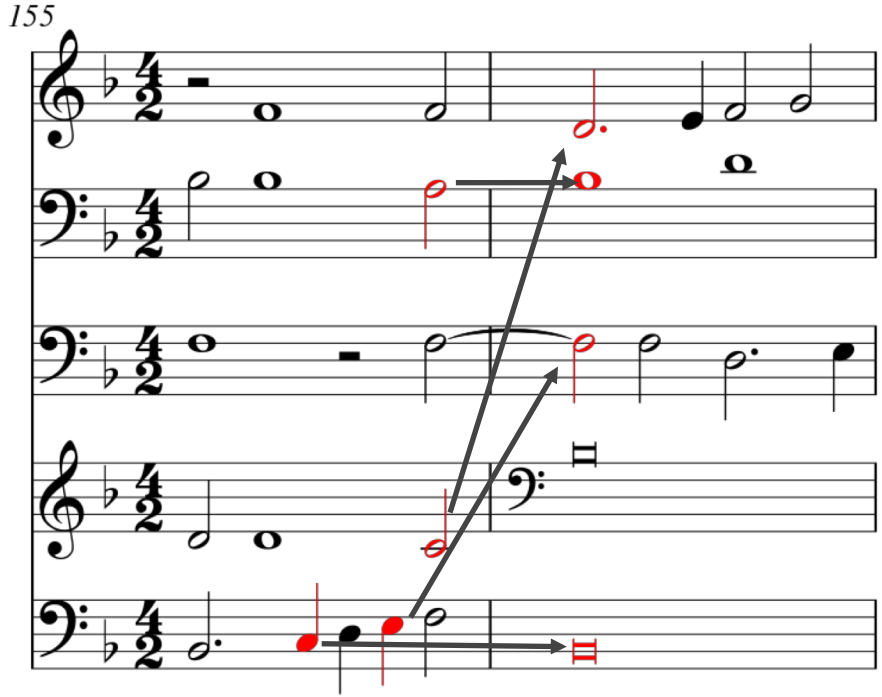
Credo Movement of Missa Tu es Petrus à 6: four intervening notes



Query:



Credo movement of In semiduplicibus majoribus à 5 (only one intervening note, but still noise)



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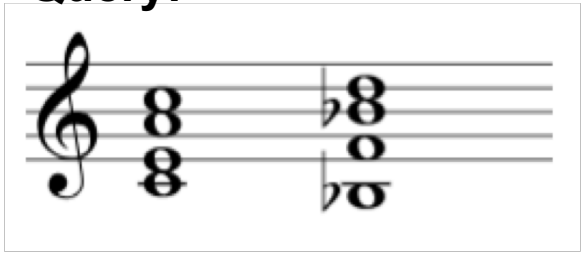

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Filters

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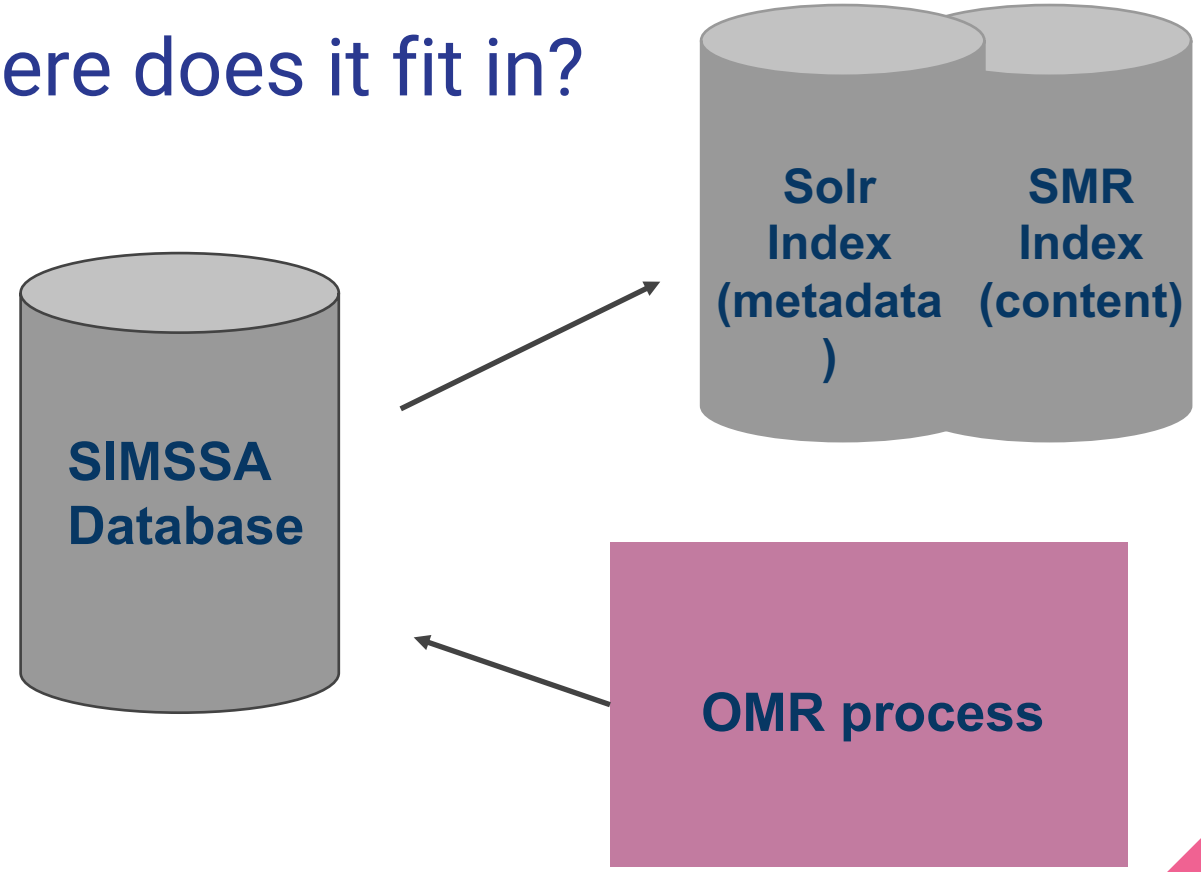
- Transpositions
- Intervening notes

Where does it fit in?



Symbolic music retrieval: desirable traits

- A music query should be found even when embedded in a larger context
  - e.g. solo cello suite melody vs bass
  - e.g. orchestral piano reduction

Symbolic music retrieval: desirable traits

- A music query should be found even when embedded in a larger context
- Notions of similarity: not just verbatim statements of the query, but also “similar” ones

Notions of similarity

- Transpositions
- Rhythmic variations
- Partial matches of a query

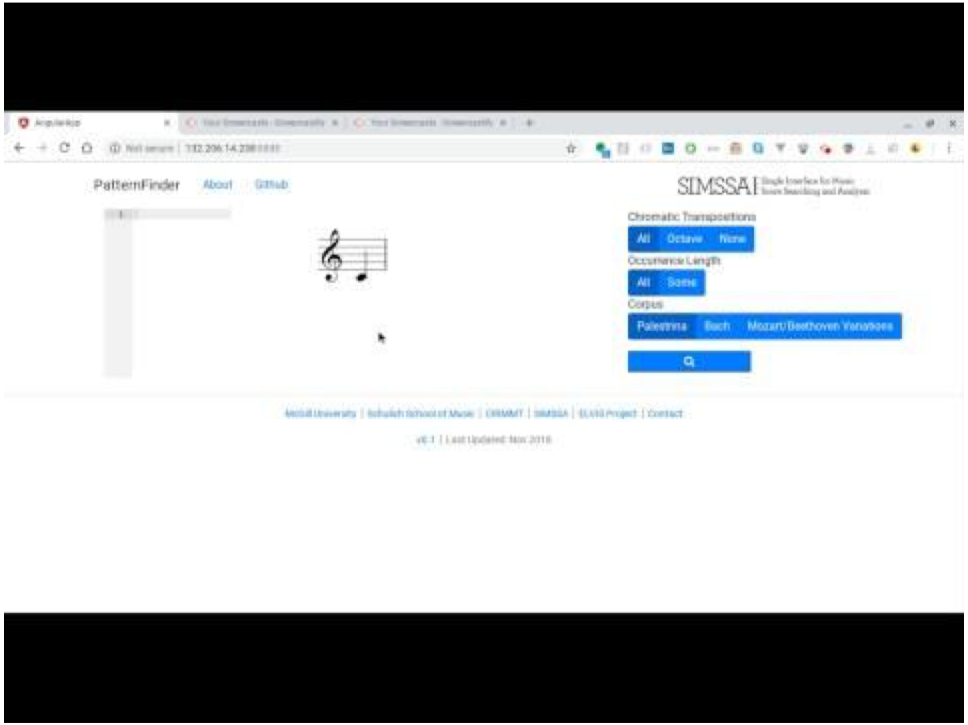
Symbolic music retrieval: desirable traits

- A music query should be found even when embedded in a larger context
- Notions of similarity: not just verbatim statements of the query, but also “similar” ones
- Ranked comparison between occurrences
- Highlighted excerpt of the content

What do we have now?

- Experimental search service at patternfinder.elvisproject.ca
  - Three corpora: Palestrina masses, Bach fugues, Mozart/Beethoven Themes & Variations
- Simple ranked comparison between occurrences
  - Size of partial matching
- Highlighted excerpt of the content
  - Api for serving excerpts
- Similarity:
  - Transpositions, rhythmic variation

Patternfinder demo



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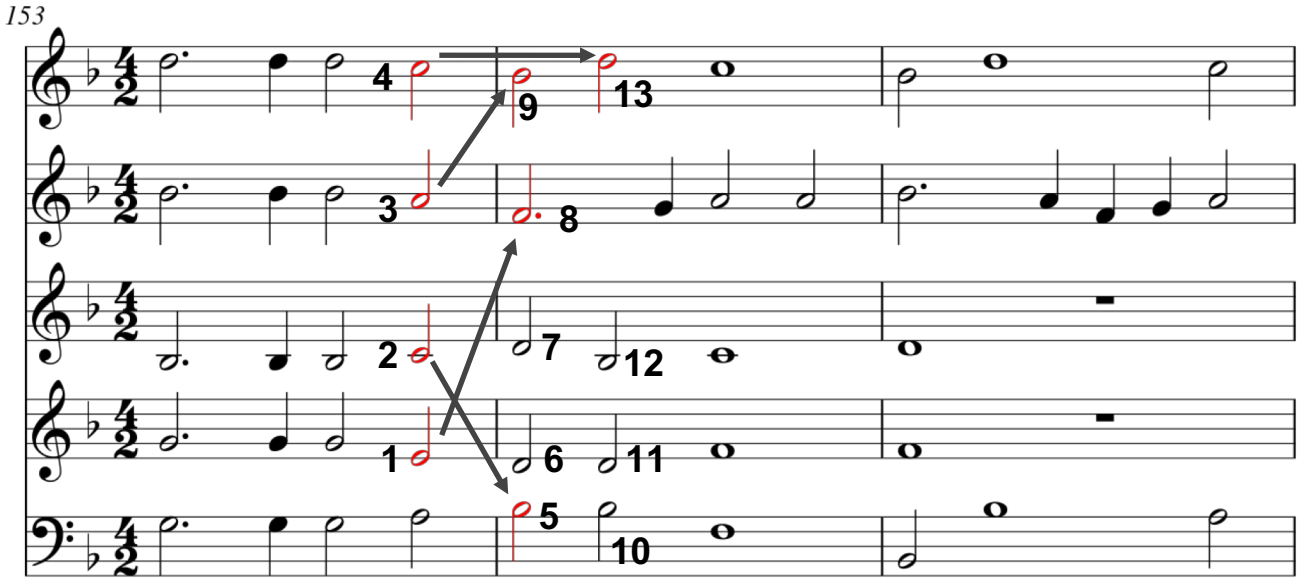
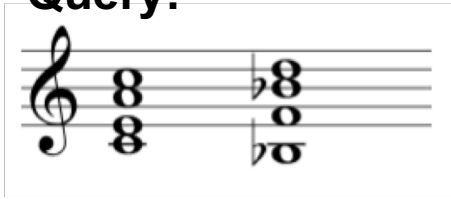
Embedded in a larger context

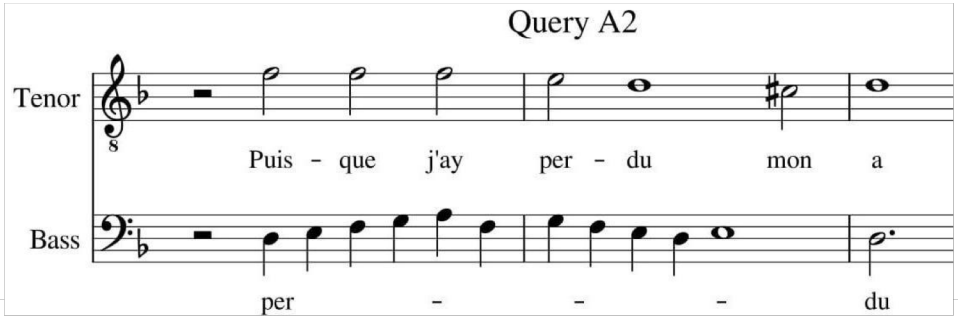


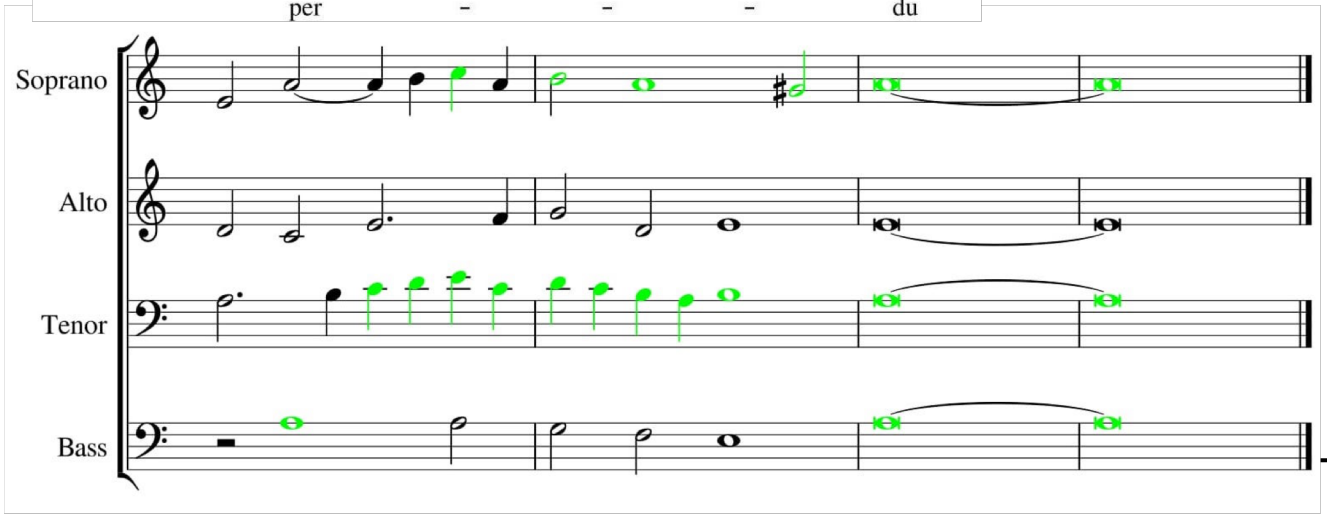
Query:



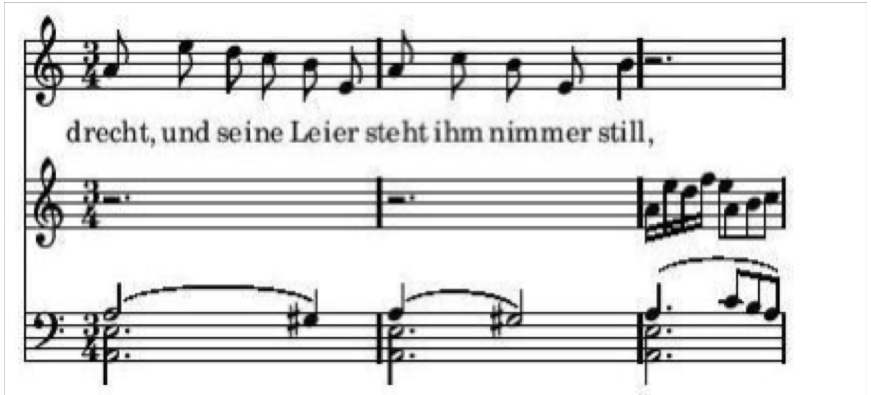
Order: E, C, A, C, B, (intervening D, D), F, Bb, (intervening Bb, D, Bb), D

Query A2 in *Spem in alium*

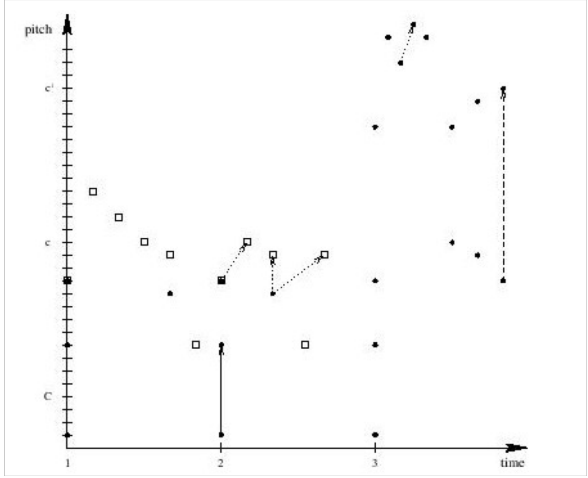




Point-set Representation



Excerpt from Schubert's *Der Leiermann*



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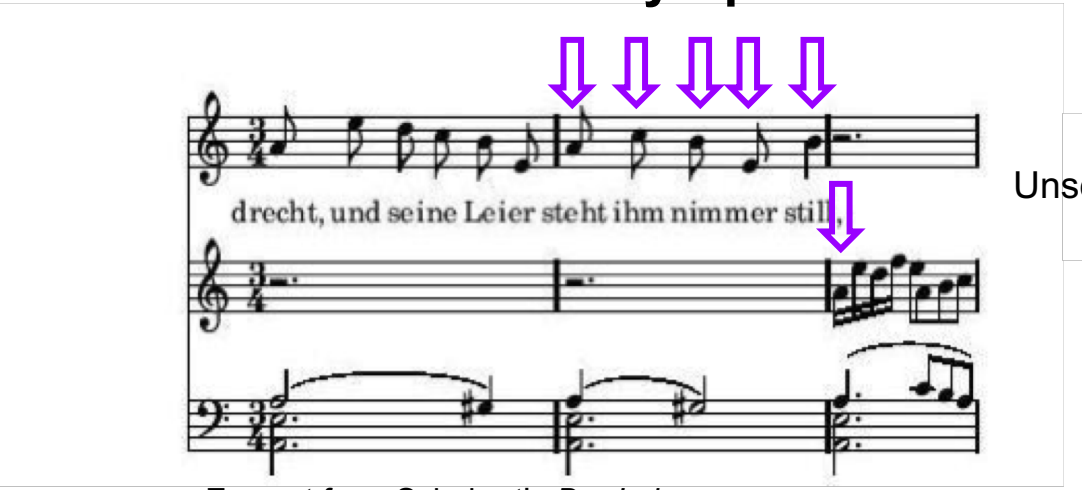
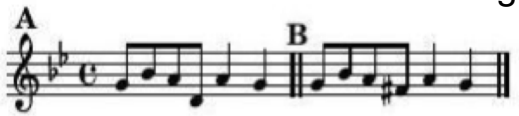
Unscaled similarity: queries A and B



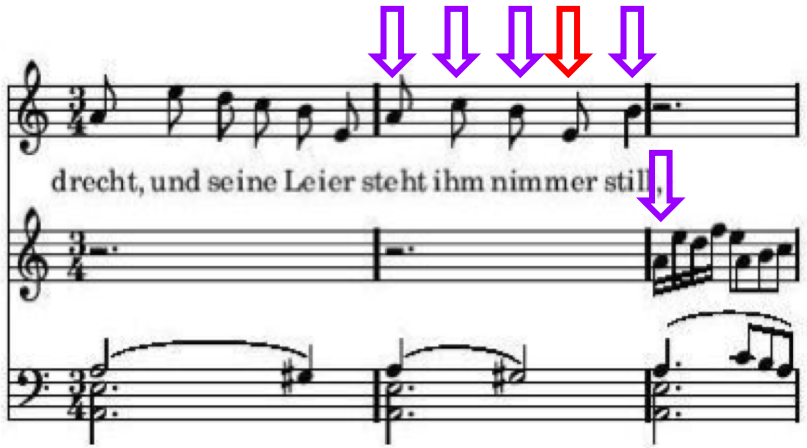
Excerpt from Schubert's *Der Leiermann*

All notes One missing

Unscaled 

- Transposition invariance : the results of our query should not change based on the key of our query

Unscaled similarity: queries A and B



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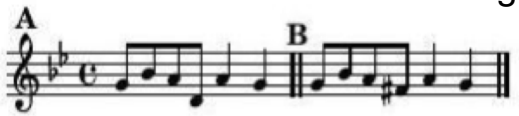
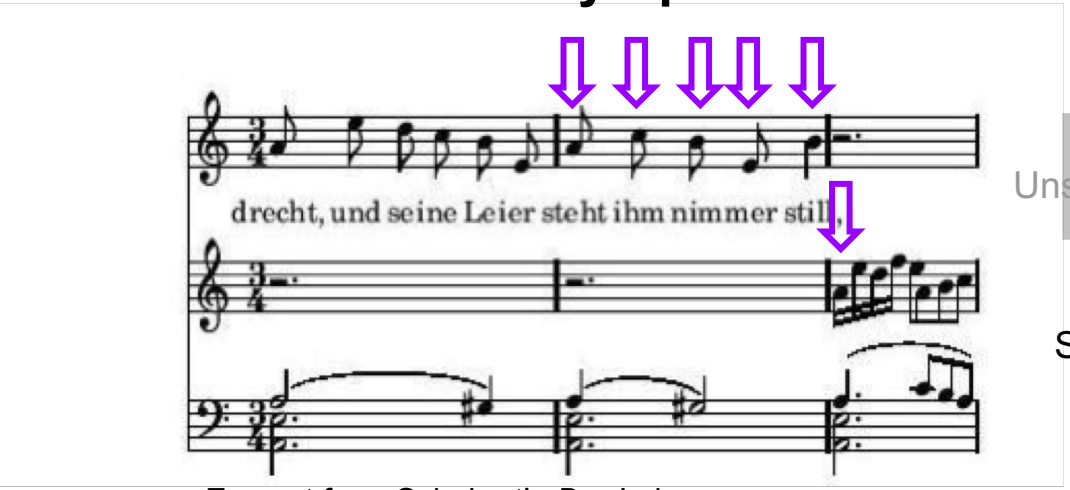
Unscaled 

P5 --------> m3

- Transposition invariance : the results of our query should not change based on the key of our query

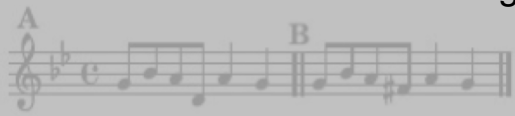
Scaled similarity: queries C and D



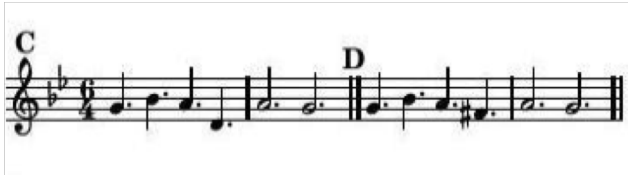
Excerpt from Schubert's *Der Leiermann*

All notes One missing

Unscaled

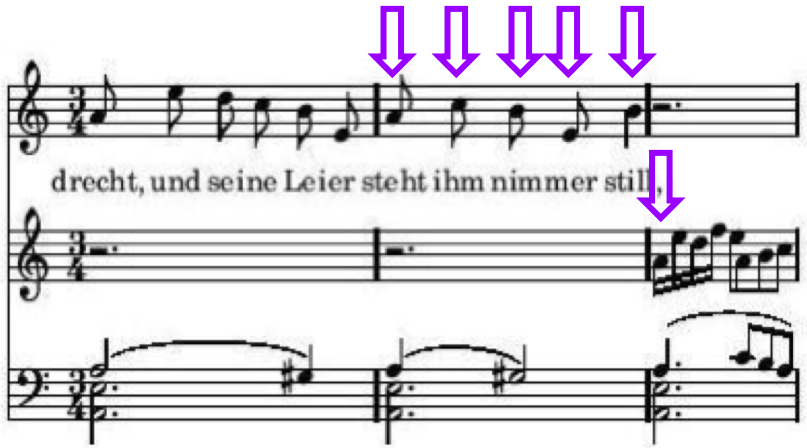


Scaled

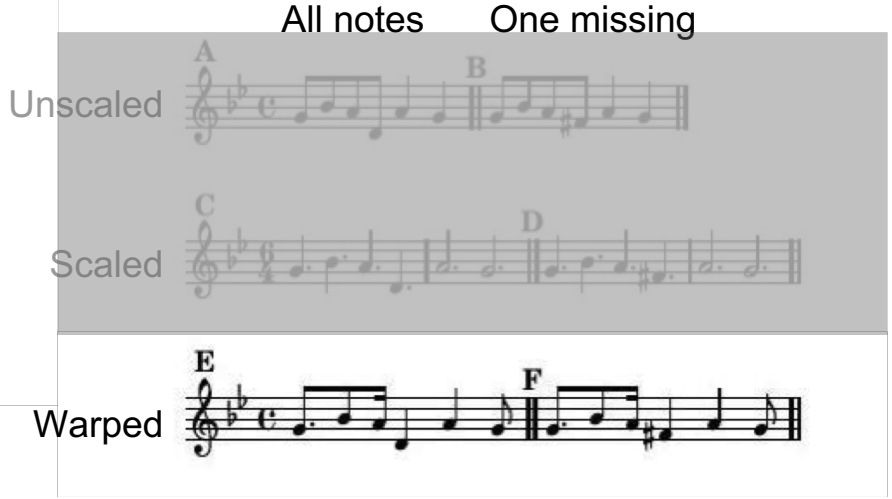


- Transposition invariance : the results of our query should not change based on the key of our query
- Time-scaling invariance: augmentation and diminution

Warped similarity: queries E and F

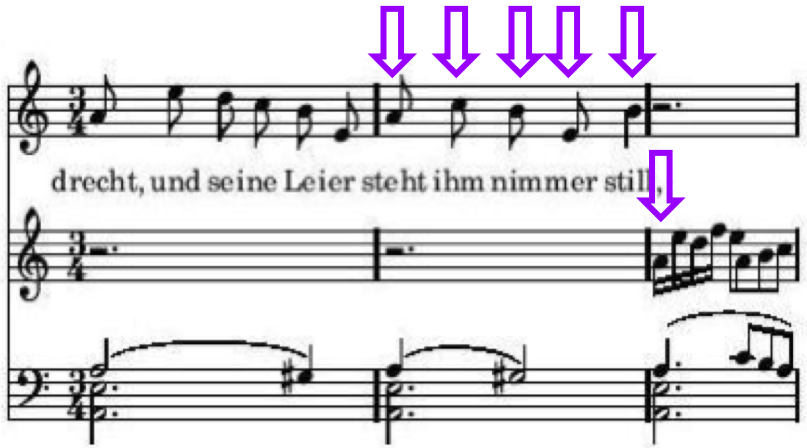


Excerpt from Schubert's *Der Leiermann*



- Transposition invariance : the results of our query should not change based on the key of our query
- Time-scaling invariance: augmentation and diminution
- Time-warping invariance: arbitrary rhythmic warping of individual notes

Warped similarity: queries E and F



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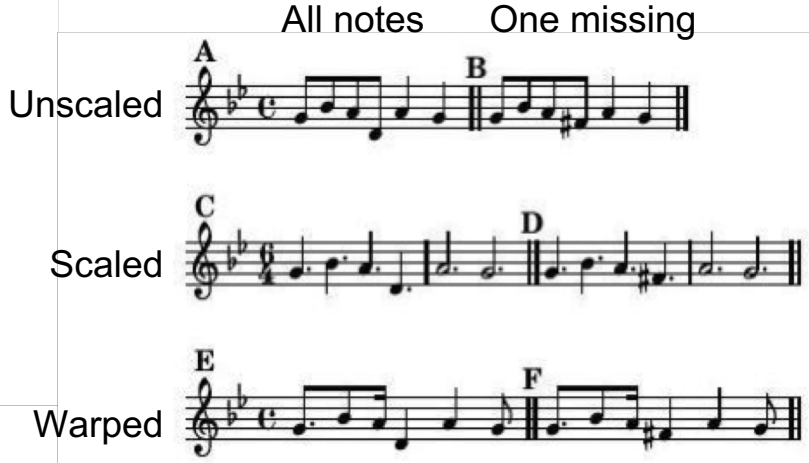

- Transposition invariance : the results of our query should not change based on the key of our query
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Piano-roll Representation

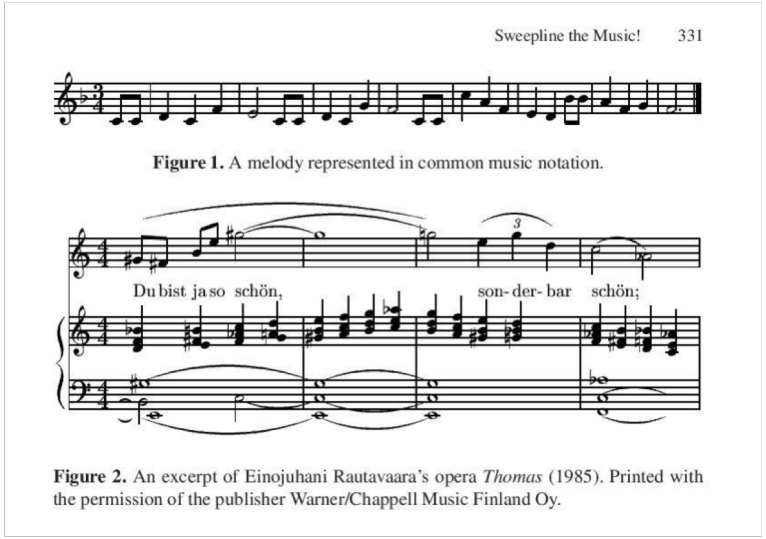


Figure 1. A melody represented in common music notation.

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

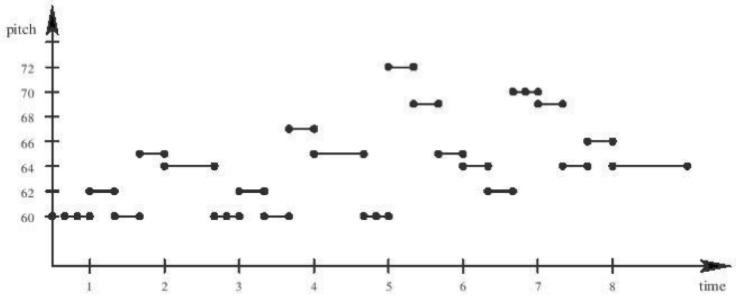
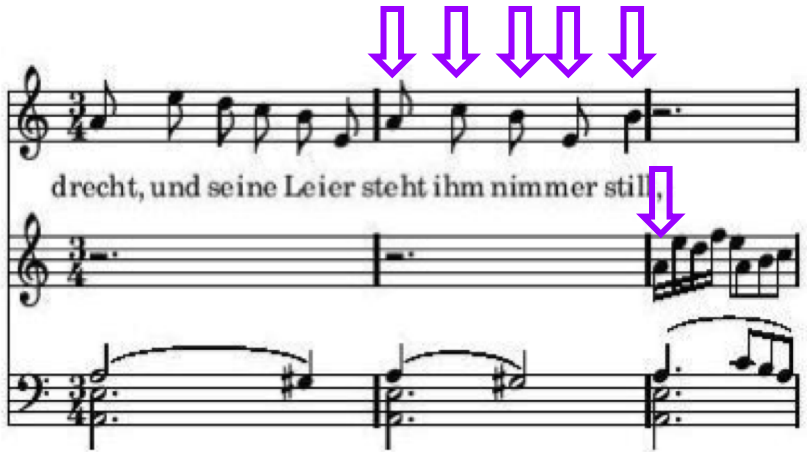


Figure 3. The example of Fig. 1 in piano-roll representation.

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

Threshold



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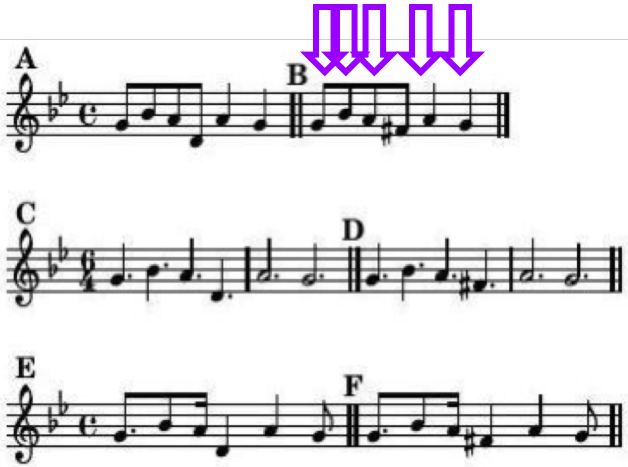


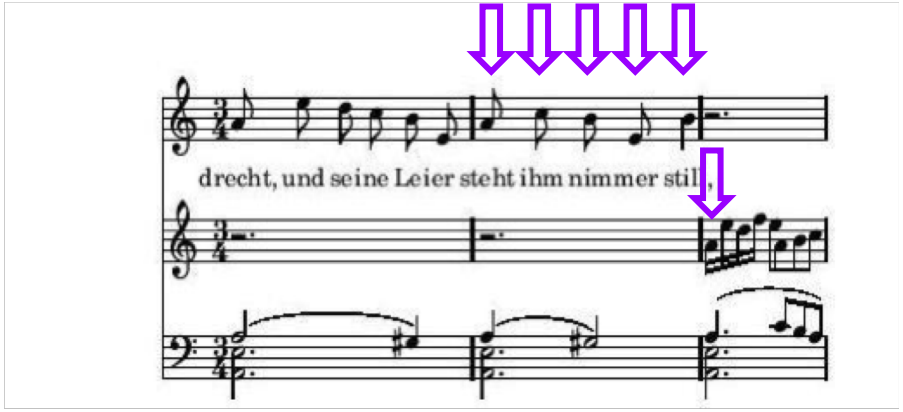
Queries B, D, and F require a threshold of at least 5 (or 85%)

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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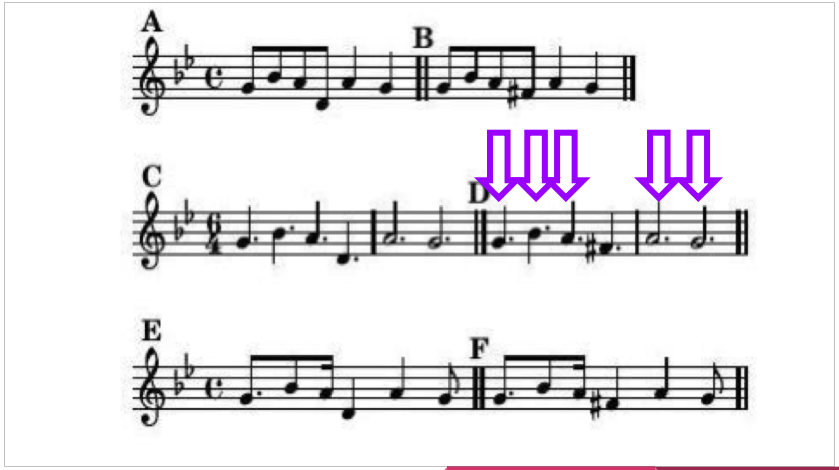
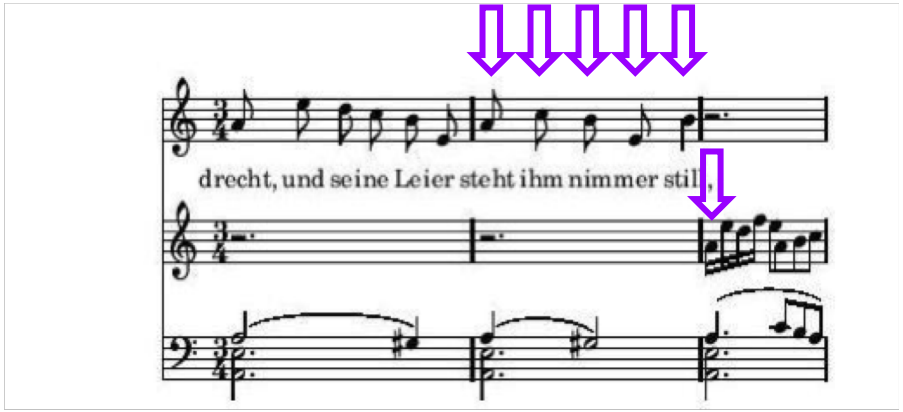


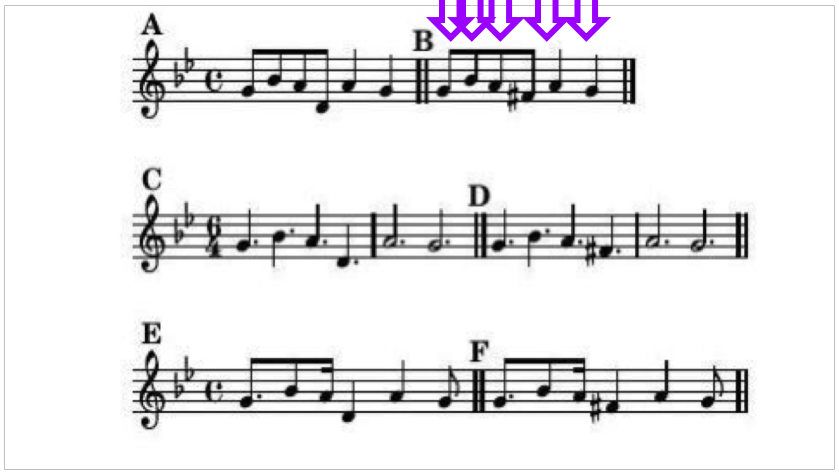
Queries A and B require a scale of 1
Queries C and D require a scale of 3/2
Queries E and F require 'warped'

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