Searching musical incipits by means of sequence alignment

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Authors

- Jelmer van Nuss
  - ground truth; experiment

- Geert-Jan Giezeman
  - software development

- Frans Wiering
  - musicology and MIR context
RISM incipits

- mainly for RISM A/II (music manuscripts after 1600)
- incipits encoded in *Plaine and Easie Code* (PAEC)
- published, with other RISM products, via RISM OPAC
  - over 1 million items
RISM incipits

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Searching RISM incipits

- OPAC interface has simple provision for melody search
  - text string
  - wildcards ? and *

900.005.286-1.1.1

GxFEBCBABBAGxF
OPAC output

- classical database search
- items either match or not
- no ranking
Geometric matching

- Rainer Typke’s PhD research (2003–2007)
- Earth Mover’s Distance (EMD) and variants

idea:
- dots in 2D space
- dot ‘weight’ corresponds to duration
- the less weight has to be moved, the more similar items are
  - items are ranked
Implementation

• search engine (YahMuug!e), now defunct
  – 450,000 incipits
  – decent performance
• ground truth for 11 queries
  – used in MIREX 2005
• comparison to previous experiments
  – Roslin castle
  – deanonymisation
Sequence alignment

- inspiration: bioinformatics, DNA

- find optimum alignment, allowing of note
  - substitutions
  - insertions, deletions → there can be gaps
- create *raters* (cost functions) for each of these
- total cost → ranking
Melody sequence alignment

- Peter van Kranenburg’s PhD research (2006-2010)
- Evaluated on tune families
- Oral transmission
- Implemented in Dutch Song Database
  - [www.liederenbank.nl](http://www.liederenbank.nl)
NEW STUFF
Aligning RISM incipits

• investigate potential of alignment methods for different type of melodic material
  – written transmission, shorter, much larger collection

• MUSALIGN library (C++)
  – pairwise music alignment
  – combinations of raters
  – freely available

• Monochord search engine
  – RISM incipit search
  – mainly experimentation environment
RISM search by Utrecht University

Query type: Database query with number 1982.

Matching methods

Column M1 in table is rank of matching method 1:

1. Exact Pitch
2. Fixed duration with ima combined Exact Pitch
3. Scaled duration with ima combined Exact Pitch

<table>
<thead>
<tr>
<th>Id</th>
<th>Score</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>18</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Cristiani, Stefano 4 Cantatas</td>
</tr>
<tr>
<td>778132</td>
<td>9.4</td>
<td>2</td>
<td>48</td>
<td>55</td>
<td>Cordicelli, Giovanni L' Adrasto</td>
</tr>
<tr>
<td>900249</td>
<td>9.1</td>
<td></td>
<td></td>
<td></td>
<td>Schgraffer, Jakob Johann Anton Beata es virgo Maria</td>
</tr>
</tbody>
</table>

RISM
RISM search by Utrecht University

Details of match

Method: Exact Pitch
Result id: 778132
Score: 9.4
Pitch shift: -5

<table>
<thead>
<tr>
<th>Notes 1</th>
<th>r</th>
<th>r</th>
<th>E</th>
<th>C#</th>
<th>C#</th>
<th>B</th>
<th>C#</th>
<th>A</th>
<th>A</th>
<th>r</th>
<th>C#</th>
<th>B</th>
<th>A</th>
<th>G#</th>
<th>r</th>
<th>B</th>
<th>B</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch 1</td>
<td>0</td>
<td>0</td>
<td>215</td>
<td>204</td>
<td>198</td>
<td>204</td>
<td>192</td>
<td>192</td>
<td>0</td>
<td>204</td>
<td>198</td>
<td>192</td>
<td>187</td>
<td>0</td>
<td>198</td>
<td>198</td>
<td>198</td>
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</tr>
<tr>
<td>Score</td>
<td>0.5</td>
<td>0.5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
<td>-1</td>
<td>1</td>
<td>1</td>
<td>-0.8</td>
<td>1</td>
<td>1</td>
<td>-0.5</td>
<td></td>
</tr>
<tr>
<td>Shifted 2</td>
<td>0</td>
<td>0</td>
<td>215</td>
<td>204</td>
<td>198</td>
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<td>192</td>
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<td>204</td>
<td>198</td>
<td>192</td>
<td>187</td>
<td>198</td>
<td>198</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pitch 2</td>
<td>0</td>
<td>0</td>
<td>220</td>
<td>209</td>
<td>203</td>
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<td>197</td>
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<td>203</td>
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<td></td>
</tr>
<tr>
<td>Notes 2</td>
<td>r</td>
<td>r</td>
<td>F</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td>D</td>
<td>Bb</td>
<td>Bb</td>
<td>r</td>
<td>Bb</td>
<td>Bb</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>r</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Musical notation](image)
Query type: Database query with number 1982.

Matching methods

Column M1 in table is rank of matching method 1...

1. Exact Pitch
2. Fixed duration with ima combined Exact Pitch
3. Scaled duration with ima combined Exact Pitch

Results

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<td></td>
<td></td>
<td></td>
<td></td>
<td>L' Adrasto</td>
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<tr>
<td>900249</td>
<td>9.1</td>
<td>3</td>
<td>X</td>
<td>X</td>
<td>Schräßter, Jakob Johann Anton</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Beata es virgo Maria</td>
</tr>
</tbody>
</table>
Cristiani, Stefano

4 Cantatas

Werkinformation

Besetzungshinweis: S, pf
Text: Metastasio, Pietro
Sprache: Italienisch
Schlagwort: Kantaten

Quellenbeschreibung

Originaler Titel: [title page] Cantate del Metastasio | Poste in Musica dal Sig.r | Stefano Cristiani
Material: • short score (piano score): 32-33lf.
Abschrift; 20,5 x 28 cm
Schreiber: Cheucci, Giovanni

Musikincipits

1.1.1 S, c [f.32v-33r] oh Dio Fileno comincia il prato; G

Oh Dio Fileno
Alignment experiment

- evaluate raters
- relate to previous work, esp. Typke (2003, 2005)
  - case studies
  - deanonymisation not discussed here
- performance comparison difficult
  - larger dataset \(\rightarrow\) revised ground truth
  - geometric search unavailable
Raters and methods

- 3 pitch raters
  - exact pitch
  - 2 raters using interval size (Zigzag and Kranenburg pitch)
- 3 duration raters
  - none
  - 2 raters using duration (notated and scaled)
- 3 metric raters
  - none
  - 2 raters using Inner Metric Analysis (raw and normalised)

- $3 \times 3 \times 3 = 27$ alignment methods
- evaluation: Precision/Recall graphs
- Mean Average Precision (= Area Under Curve)

Typical P/R graph: black=best
Results

- best combinations
  - exact pitch, notated duration, raw IMA (0.42)
  - exact pitch, notated duration, normalised IMA (0.41)
  - exact pitch, notated duration, no IMA (0.41)

- for comparison
  - exact pitch only (0.30)
<table>
<thead>
<tr>
<th>method</th>
<th>retrieved items</th>
<th>comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorting DARMS code</td>
<td>6</td>
<td>Howard 1998; 13 known items</td>
</tr>
<tr>
<td>Earth Movers Distance</td>
<td>12</td>
<td>Typke et al. 2003; 17 known items</td>
</tr>
<tr>
<td>Proportional Transportation Distance</td>
<td>16</td>
<td>Typke et al. 2003, combining 3 different queries; 17 known items</td>
</tr>
<tr>
<td>RISM OPAC</td>
<td>17</td>
<td>key signature added</td>
</tr>
<tr>
<td>alignment (pi2mw0dur0)</td>
<td>23</td>
<td>exact pitch, no IMA, no duration; top-50 results only for all alignments</td>
</tr>
<tr>
<td>alignment (pi2mw2dur1)</td>
<td>24</td>
<td>exact pitch, normalised IMA, fixed duration (overall best rater combination)</td>
</tr>
<tr>
<td>alignment (pi2mw0dur1)</td>
<td>25</td>
<td>exact pitch, no IMA, fixed duration</td>
</tr>
<tr>
<td>alignment (pi2mw1dur1)</td>
<td>25</td>
<td>exact pitch, raw IMA, fixed duration</td>
</tr>
<tr>
<td>alignment (pi2mw2dur2)</td>
<td>26</td>
<td>exact pitch, normalised IMA, scaled duration</td>
</tr>
<tr>
<td>alignment (pi2mw0dur2)</td>
<td>27</td>
<td>exact pitch, no IMA, scaled duration</td>
</tr>
<tr>
<td>alignment (pi2mw1dur2)</td>
<td>27</td>
<td>exact pitch, raw IMA, scaled duration</td>
</tr>
</tbody>
</table>

29 relevant items known from RISM OPAC
Additional results

RISM OPAC query (transposition seems not to work)

Monochord results not in RISM (transpositions excluded)
Query: Anonymus. Andante Es-Dur

W.A. Mozart, Variations

A.F.J. Eberl, Variations

L. Jansa, Variations

I. Umlauf, Das Irrlicht, Excerpts

J.L. Böhner, Variations

F. Schubert. Harmonien rauschen im Hain
Other methods, new results

J.C.H. Rinck. Variations

J.L. Böhner, Variations

J.P.S. Schmidt. Ehre sei Gott in der Höhe (???)
Conclusions

- alignment performs better than string matching
  - more relevant items
  - interesting non-identical matches
  - less need for query adaptation

- suggestion: integrate some combinations in RISM OPAC
  - exact pitch + fixed duration
  - exact pitch + scaled duration
  - other combinations?

- test utility in practice
  - what musicological insight do the non-identical matches provide?

- use MUSALIGN in other kinds of (MEI?) software
THANK YOU