Near-neighbour search in acoustic feature spaces

A case study in contrafactum and parody

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Friday 4th September 2015

Introduction
Transforming Musicology

Project participants:

- Goldsmiths, Queen Mary, Oxford, Lancaster, Utrecht
- Musicologists, Computer Scientists, Psychologists

Research strands:

- 16th-century music
- Wagner leitmotifs
- Social media
- Semantic publishing

Introduction
Parody and contrafacta

The 'remixes' and 'cover songs' of the Renaissance
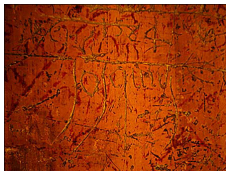[musical examples]

Introduction
Josquin des Prez

Josquin des Prez (c.1450–1521?)

- contemporary reputation: greatest composer of the age

Introduction
Nicolas Gombert

Nicolas Gombert (c.1495–c.1560)

- transition figure between Josquin and Palestrina

Introduction
The Je prens congies complex

- *Je prens congies* chanson
- *Tu sola es* and *Tulerunt Dominum* motets
- *Lugebat David Absalon* motet
- *Credo a 8* mass fragment
- *J'ay mis mon cueur* chanson

Introduction
Attribution

Attribution shift over almost a century

- 19th century (Otto Kade)
    - *Tulerunt* authentic Josquin
    - *Lugebat David Absalon* doubtful

- Josquin Edition (Albert Smijers, 1921–)
    - neither *Tulerunt* nor *Lugebat*

- Das Chorwerk (Blume, 1933)
    - *Tulerunt* attributed to Josquin

- Early Venetian Motets (Norbert Böker-Heil, 1969)
    - Identification of *Je prens congies* as source material

Introduction
Attribution
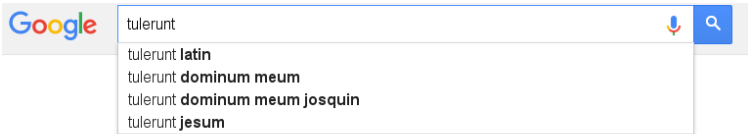
Similarity
Audio Features: Non-Negative Least Squares Chroma

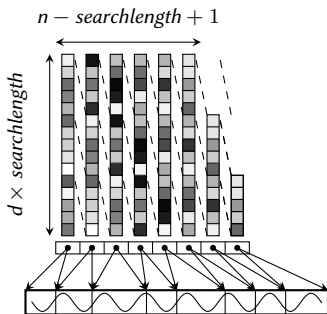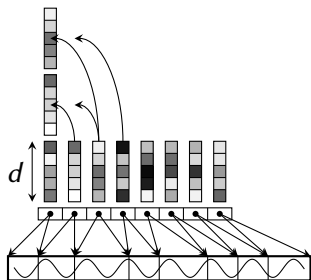- log-frequency short-time Fourier Transform $\mathbf{Y}_{k,m}$
- note dictionary $\mathbf{E}_{k,n}$
- find note activations $x_{n,\cdot}$ to minimize $||Y_{k,\cdot} - E_{k,n}x_{n,\cdot}||_2$
  - subject to $x_{n,m} \geq 0$

Matthias Mauch and Simon Dixon, *Approximate Note Transcription for the Improved Identification of Difficult Chords*, Proc. ISMIR, 2010

Similarity
Audio similarity: sequences

In this investigation:

- frames: 1s granularity;
- feature dimensionality d: 12;
- sequences: *searchlength* 10-30 frames.

Similarity
Audio similarity

Fragment to fragment:

$$d_L(f_m^i, f_n^j)$$

- metric distance (maybe?)
- non-negative (maybe?)
- bounded above (maybe?)

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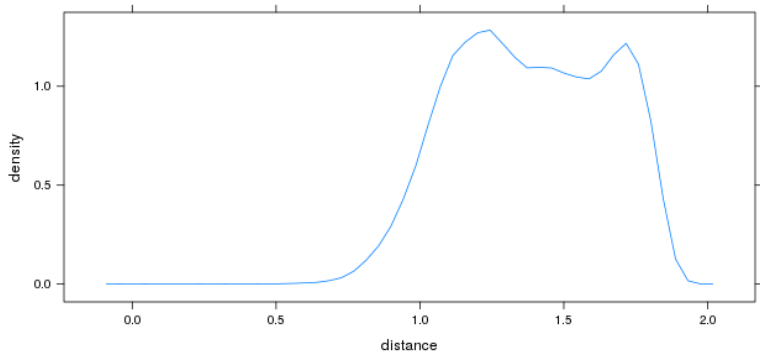
$$d_L(f_m^i, t^j) = \min_n \left(d_L(f_m^i, f_n^j) \right)$$

Track to track:

$$d_L(t^i, t^j) = \min_m \left(d_L(f_m^i, t^j) \right)$$
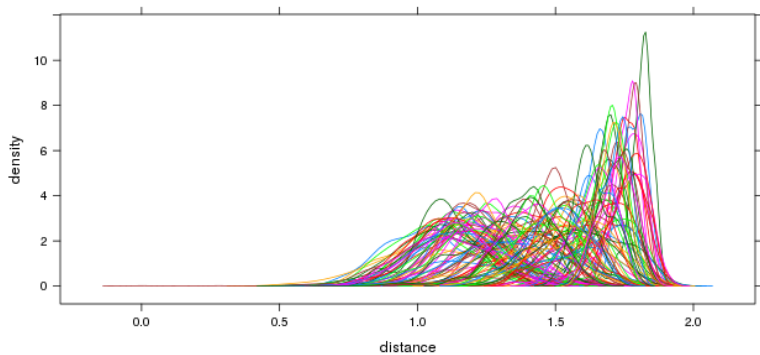
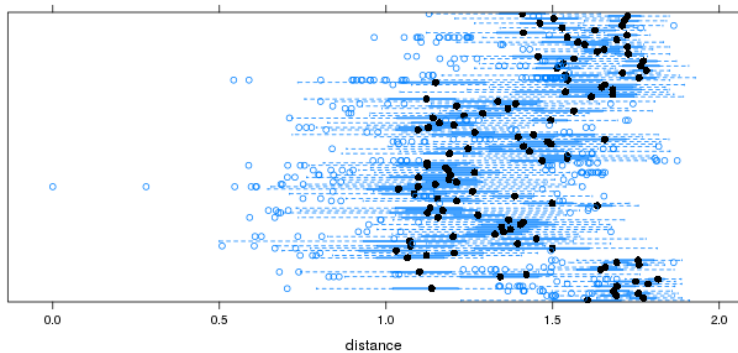# Similarity
Outlier analysis

Similarity
Outlier analysis

Similarity
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Results
Josquin attribution

With some care: can find all of the recordings in the *Je prens congies* complex as low-distance retrievals:

- aggregate over many fragments of source tracks;
- chroma rotation.

Results
Reproducibility

Gave (broadly) this investigation to students at Oxford Digital
Humanities Summer School:

- no prior programming assumed;
- audio features precomputed.

Student feedback for five-day "Digital Musicology": 92% "met" or
"exceeded" expectations

Conclusions

- audio similarity can be used to guide attribution...
- ...if recordings are available
- (mechanically-generated recordings would be better for this task)
- similarity outliers can help increase understanding

Conclusions
Further work

- query language (Hendrik Blokeel "Declarative Data Analysis")
- hierarchical indexing (Fionn Murtagh "High Dimensional Data Scaling")
- shrink-wrap software
- new interfaces for exploring collections of music

Questions

Investigation materials:

- audioDB software:
  `https://github.com/TransformingMusicology/audioDB`
- linked from
  `http://www.doc.gold.ac.uk/~mas01cr/papers/`:
  - iPython notebook
  - numeric feature data

Questions or comments to:

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- `@TMusicology`
- `#ecda2015`