The current approach of *SIMILE*

- Represent monophonic melodies as sequence of tuples <pitch, onset>
- Transform sequences into musically meaningful (but rather low-level) representations:

Musical Dimension	**Transformation**
Pitch	a) none, b)intervals, c) step/leap, d) Parsons Code
Rhythm	a) Durations 5 classes, b) 'Gaussification'
Contour	a) Interpolation of pitch values between melodic turning points, b) Fourier Transform of pitch ranks
Implicit harmonic content	Tonality calculation (Krumhansl-Schmuckler)
Micro-motives	n-gram chains

The current approach of *SIMILE*

- Apply various comparison techniques to transformed melodies:
  - Edit Distance
  - n-grams Comparisons
  - Correlation Measures
  - Difference Measures
- Compare computed similarities to expert judgements from psychological experiments
- Pick best individual similarity measures (algorithmic chains) and combine them in hybrid measures

Result: The *SIMILE* algorithms

Implemented algorithmic chains (1)

VPN_MEAN	Mean of human subjects‘ ratings	FOURR	Fourier (ranks)
Qbh	Fraunhofer qbh-measure (June 2003)	FOURRST	Fourier (ranks), weighted, 0-1
RAWED	Raw pitch edit distance	FOURRW	Fourier (ranks), weighted
RAWEDW	Raw pitch edit distance weighted	FOURRWST	Fourier (ranks), weighted, 0-1
RAWPC	Raw pitch Pears. Brav. correlation	FOURRI	Fourier (ranks, intervals)
RAWPCST	Raw pitch P-B. corr, weighted, 0-1	DIFFED	Intervals (Edit distance)
RAWPCW	Raw pitch Pears. Brav. Corr. Weighted	DIFF	Intervals (Mean difference)
RAWPCWST	Raw pitch P-B. Corr. weighted, 0-1	DIFFEXP	Intervals (Mean difference, exp.)
RAWCC	Raw pitch crosscorrelation	DIFFFUZ	Intervals (fuzzy), Edit Distance
RAWCCW	Raw pitch crosscorrelation weighted	DIFFFUZC	Intervals (fuzzy contour)
CONSED	Contour (Steinbeck) edit distance		
CONSPC	Contour (Steinbeck), P-B. correlation		
CONSPCST	Contour (Steinbeck), P-B. corr., 0-1		
CONSCC	Contour (Steinbeck), Crosscorrelation		
CONED	Contour, Edit distance		
CONPC	Contour, Pearson-Bravais correlation		
CONPCST	Contour, Pearson-Bravais corr., 0-1		
CONCC	Contour, Crosscorrelation		

Result: The *SIMILE* algorithms

Implemented algorithmic chains (2)

NGRSUMCO	n-grams Sum Common (intervals)	RHYTGAUS	Rhythm (gaussified onset points)
NGRUKKON	n-grams Ukkonnen (intervals)	RHYTFUZZ	Rhythm (fuzzy, Edit distance)
NGRCOORD	n-grans Coordinate Matching (intervals)	ESFMAX	Selfridge-Field (max.)
NGRSUMCR	n-grams Sum Common (interval dir.)	ESFMOD	Selfridge-Field (modus I)
NGRUKKOR	n-grams Ukkonnen (interval dir.)	ESFMODK	Selfridge-Field (modus II)
NGRCOORR	n-grams Coord. Match. (interval dir.)	ESFSIGN	Selfridge-Field (signs)
NGRSUMCF	n-grams Sum Common (fuzzy int.)	HARMCORR	Harmonic correlation (type I)
NGRUKKOF	n-grams Ukkonnen (fuzzy int.)	HARMCORK	Harmonic correlation (type II)
NGRCOORF	n-grams Count distinct (fuzzy int.)	HARMCORE	Harmonic correlation (Edit distance)
NGRSUMFR	n-grams sum common (fuzzy rhythm)	HARMCORC	Harmonic correlation (circle)
NGRUKKFR	n-grams Ukkonnen (fuzzy rhythm)	JOINT52	Accent similarity measure
NGRCOOFR	n-grams Coord. Match. (fuzzy rhythm)		

Result: Optimised measures

- Measure for variations of same melody:

$$\textbf{opti1} = 3.355 \cdot \texttt{rawEdw} + 2.852 \cdot \texttt{nGrCoord}$$

- Measure for finding similar melodies from general melody collection:

$$\textbf{opti3} = 3.027 \cdot \texttt{ngrUkkon} + 2.502 \cdot \texttt{rhythFuzz} + 1.439 \cdot \texttt{harmCorE}$$

Applications for optimised measures

- Folksong research:
  - Find duplicates and variants of melody
  - Group melodic phrases
- Measure accuracy of melodic memory (in psychological experiment)
- Detect cases of melodic plagiarism
- Retrieve classical themes from database (MIREX 2005, 2006)

New ideas for SIMILE

High-level Transformations

- Melodic accents
- Implication-Realization descriptors (Namour, Schellenberg, Grachten)
- F-motifs (Boroda)
- Melody fingerprints
- Allow for arbitrary, user-defined combinations of melodic-rhythmic transformations

New ideas for SIMILE

Comparison techniques

- Weighted edit distances
- Feature-based similarity (Jaccard, Dice…)
- Phrase-based similarity
- TF-IDF measures
- Generalized n-grams

New ideas for SIMILE

Evaluation

- Try other optimisation techniques
- Optimise on other datasets
- Conduct more experiments
- Tackle non-expert similarity

New ideas for SIMILE

Software

- Make it truly modular
- Include scripting possibilities
- Graphical User Interfaces
- Webservice
- Fusion with *MELFEATURE*, strictly based on the concept of melodic transformations (similarity as feature of melody pairs…)

New ideas for SIMILE

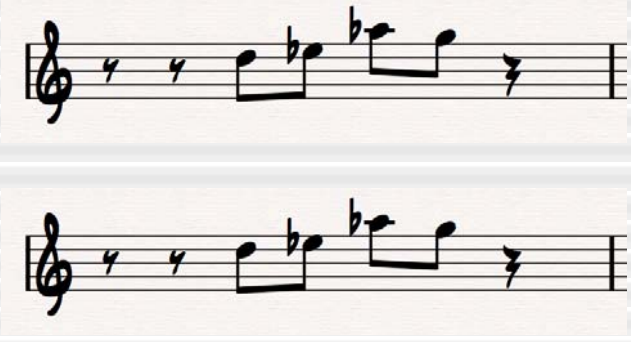
Distribution

- Licensing model
- Open source?
- Integration within greater infrastructures (e.g. AMuSE, M^{4}S project, WITCHCRAFT, Melex)
- Propose MIREX contest with our ground truth data?

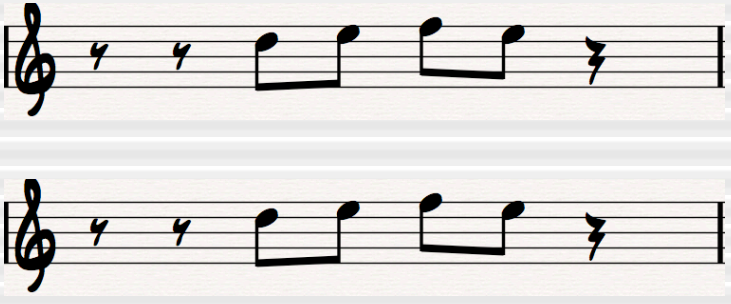
Example:TF-IDF measure as comparison technique

Idea: Take frequency of melodic feature / formula into account when comparing melodies for feature => Model melodic knowledge

Example: TF-IDF measure for n-grams (interval representation)



More decisive, if present in two melodies
(f = 7.1 ·10^{-5} in ca. 8000 pop songs)



Less decisive, if present in two melodies
(f = 4.9 ·10^{-3} in ca. 8000 pop songs)

Example:TF-IDF measure as comparison technique

TF-IDF similarity for melodies *s, t from corpus C:*

$$\sigma_{C;n}(s,t) = \frac{\sum_{\tau \in s_n \cap t_n} IDF_C(\tau)(TF_s(\tau) + TF_t(\tau))}{2\sum_{\tau \in s_n \cap t_n} IDF_C(\tau)}$$

with Term-Frequency for term τ in melody *m* with m_n different terms:

$$TF_{(m,\tau)} = \frac{f_m(\tau)}{\sum_{m_n} f_m(m_n)}$$

and Inverted Document Frequency for term τ in corpus C with |*C*| melodies:

$$IDF_C(\tau) = \begin{cases} \log \frac{|C|}{|m:\tau \in m|} & \exists m \in C : \tau \in m \\ \log \frac{|C+2|}{2} & else \end{cases}$$

Example: Generalised n-gram measures as comparison technique

- Well-known n-gram measures are based on counting of common n-grams or not different n-grams
- Ideas: Soften the notion of *identity* to *similarity* of n-grams (“fuzzy identity”)
- Straight-forward generalisation leads then to new (huge) classes of n-gram similarity measures.

Melodic similarity: The big picture and some new ideas

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