

# Melodic accents as a good transformation for similarity measures

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# Idea

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- Some notes of a given melody are perceived to be more important than others
- Reduction to structurally important notes makes melody representation robust to ornamentation, motivic variation, and changes in particular musical dimension
- Idea related to Schenkerian analysis

# Exemplifying the idea

„Cold Cold Heart“ by *Wet Wet Wet*





# Background

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- Empirical studies on melodic accent perception:  
e.g. Thomassen (1982), Monahan & Carterette (1985), Povel & Essens (1985), Boltz & Jones (1986), Jones (1987), Monahan et al. (1987), Jones (1993), Huron & Royal (1996), Jones & Pfodresher (1997), Boltz (1999), Pfodresher (2003), Pfeleiderer, Müllensiefen, & Frieler (2007)
- Shortcomings:
  - Definition of accent rules not precise enough for analysis
  - No comprehensive taxonomy of accents rules from all possible sources
  - No explicit model formulation (additive, conditional etc.)
  - No exact weighting of relative rule importance

# Approach Pfeiderer, Müllensiefen, & Frieler (2007)

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1. Define all (meaningful) accent rules from literature including possible variants
2. Determine all possible accents algorithmically for all notes in a set of melodies
3. Determine accent strength values empirically in listener experiment with pop melodies (Pfeiderer & Müllensiefen, 2006)
4. Fit data from algorithmic accent rules to empirical accent values using
  - Linear regression and regression tree (3 accent values)
  - Logistic regression and classification tree (2 accent values)
5. Evaluate best accent models on data test set

# Definition of accent rules (1)

40 rules in 6 different categories: Pitch Interval, Pitch Contour, Interonset Interval, Position in Phrase, Meter and Syncopation, Harmony

RULE NAME	Description
	<b>Pitch Interval</b>
JMPAFT[3,4,5]	Accent on note after a jump of at least 3, 4 or 5 semitones
JMPBEF[3,4,5]	Accent on note before a jump of at least 3, 4 or 5 semitones
JMPBEA[3,4,5]	Accent on notes before and after a jump of 3, 4 or 5 semitones
JMPLOC	Accent on second note of an interval that is at least two semitones larger than its successor and predecessor interval
	<b>Pitch Contour</b>
EXTREM	Accent on note where predecessor and successor notes are both lower or higher
EXTRST	Same as PEXTREM but filtering for change notes in the definition of Steinbeck
EXTRMF	Same as PEXTREM but filtering for change notes in the definition of Müllensiefen & Frieler
EXTRSTA	Accent on note following note accented by PEXTRST
HOM	Accent weight according to Thomassen's algorithm (1982), which is based on the even possible pitch direction patterns that can be formed by 2-interval chains (3-note patterns)
HOMTHR	Dichotomous version of thom. All values <0.5 are assigned the value 0, all other values are set to 1.
	<b>Interonset Interval</b>
ONGPR	Accent on note starting an IOI longer than predecessor IOI
ONG2PR	Accent on note starting an IOI at least 2x as long as predecessor IOI
ONGMOD	Accent on note starting an IOI longer than mode of IOIs in melody
ONG2MOD	Accent on note starting an IOI at least 2x as long as the mode of IOIs in melody
HORTPR	Accent on note starting an IOI shorter than predecessor IOI
HORT2PR	Accent on note starting an IOI at most half as long as predecessor IOI
NDLOIOI	Accent on note that ends IOI which is at least 2x the mode of IOIs in melody

# Definition of accent rules (2)

<b>RULE NAME</b>	<b>Description</b>
	<b>Position in Phrase</b>
PHRASEBEG	Accent on phrase beginning
PHRASEND	Accent on phrase end
SHORTPHR	Accent on second note of melody phrase consisting of only two notes
	<b>Meter / Syncopation</b>
BEAT1	Accent on beat 1 of a bar
BEAT13	Accent on beat 1 and 3 of a bar
BEAT1234	Accent on all beats of a bar
SYNK1	Accent on note with onset not on any beat of a bar and with IOI extending over the next beat
SYNK2	Accent on note with onset less than a crotchet before beats 1 or 3 of a bar and with IOI extending over next beat 1 or 3
SYNC1234	Accent on a note not on any beat of a bar and with IOI extending over the next beat position
SYNCHALF	Accent on a note with an onset on beat 2 or 4 of a bar and an IOI extending over next beat position 3 or 1
SYNC0	Accent on a note with an onset on the first subdivision level of the beat level (quaver or quaver triplet) with IOI longer than the time span of the subdivision.
SYNC8S	Accent on a note with an onset on a second subdivision level of the beat level (semiquaver or semiquaver sextuplet) with an IOI longer than the time span of the subdivision.
SYNC16S	Accent on a note with an onset on a third subdivision level of the beat level with inter-onset interval longer than the IOI of the subdivision.
	<b>Harmony</b>
HARMONY	Accent on note that is part of the accompanying harmony
DISSBEAT	Accent on note on a beat but not part of the accompanying harmony
TRIAD	Accent on note that is part of implied harmony of the bar
TRIADPHEN	Accent on note that is part of implied harmony of the bar and ends a phrase





# Results

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## Perceptual:

- Melodic accents are best perceived and modeled as binary attributes
- Rather additive principle in accent perception than hierarchical rule selection

## MIR related (through logistic regression model):

- Selection of 6 resp. 7 accent rules (from different conceptual categories; little redundancy)
- Relative weighting of rules
- Absolute accent threshold (replace by relative one)

# Results

## Logistic Regression Model

$$p_n(a = 1) = \frac{1}{1 + e^{-z_n}}$$

with  $z_n$  for monophonic melodies:

$$\begin{aligned} z_n = & -7.966 \\ & +3.907 \cdot \text{beat}3 \\ & +3.311 \cdot \text{synd}234 \\ & +2.748 \cdot \text{jumpaf}4 \\ & +2.457 \cdot \text{pextrem} \\ & +2.233 \cdot \text{thomthr} \\ & +2.965 \cdot \text{phrasend} \\ & +1.277 \cdot \text{longmod} \end{aligned}$$

with  $z_n$  for melodies in song context:

$$\begin{aligned} z_n = & -3.493 \\ & +3.907 \cdot \text{beat} \\ & +0.994 \cdot \text{jumpaf}4 \\ & +1.804 \cdot \text{pextrmf} \\ & +2.62 \cdot \text{phrasend} \\ & +1.329 \cdot \text{longmod} \\ & -2.56 \cdot \text{shortphr} \end{aligned}$$

# Example

## Melody 1 and associated accent values



Musical notation for Melody 1, labeled "Tenor". The notation consists of two staves. The first staff has a treble clef, a key signature of three flats (B-flat, E-flat, A-flat), and a common time signature (C). The notes are: G4, A4, B-flat4, A4, G4, F4, E4, D4, C4. The second staff has a treble clef, the same key signature, and a common time signature. The notes are: B-flat4, A4, G4, F4, E4, D4, C4, B-flat4, A4, G4, F4, E4, D4, C4. The notes B-flat4, A4, and G4 in both staves are circled in red. Below the notes are numerical accent values: 6.7, 2.8, 2, 2.7, 3, 8, 1.8, 5.5, 8, 5.7, 3.4. The values 1.8 and 3.4 are underlined.

## Melody 2 and associated accent values



Musical notation for Melody 2, labeled "Tenor". The notation consists of two staves. The first staff has a treble clef, a key signature of one flat (F-flat), and a common time signature (C). The notes are: G4, A4, B-flat4, A4, G4, F4, E4, D4, C4. The notes B-flat4 and A4 in the first staff are circled in red. The second staff has a treble clef, the same key signature, and a common time signature. The notes are: B-flat4, A4, G4, F4, E4, D4, C4, B-flat4, A4, G4, F4, E4, D4, C4. The notes B-flat4, A4, and G4 in the second staff are circled in red. Below the notes are numerical accent values: 8, 4.1, 3.3, 4.1, 6.7, 3, 8, 5.5. The values 6.7 and 3 are underlined.



# Use in context of similarity measurement

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1. Categorise notes according to distribution of accent probabilities
  - Use only highly accented notes as input to any similarity algorithm
  - Use 'fingerprint' areas around strong accents
  - Simple edit distance on note categories
2. Edit distance with cost function (e.g. cost  $\sim$  accent probability)
3. Use any similarity measure that operates on real numbers



# Applications

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- ‘Theme and Variations’-type melodies (e.g. strongly ornamented versions of same melody)
- Audio transcriptions with note over- or under-segmenting
- Intelligent plagiarism
- Detection of similar structural models despite of different surface (e.g. archetypes of themes from classical era)

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