

A Review of Automatic Rhythm Description Systems

by Fabien Gouyon and Simon Dixon

presented by Yu Shiu
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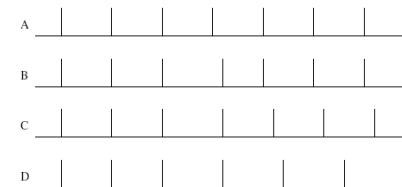
Review Paper

- Title: A review of automatic rhythm description systems
- Authors: Fabien Gouyon and Simon Dixon
- Rhythm
 - refer to all of the temporal aspects of a musical work
 - Tempo induction, beat tracking, quantization of performed rhythms, meter induction, intentional time deviations
- Goal
 - Propose unifying framework for automatic rhythm description systems
 - Review existing systems in this framework

Representation of Musical Rhythm

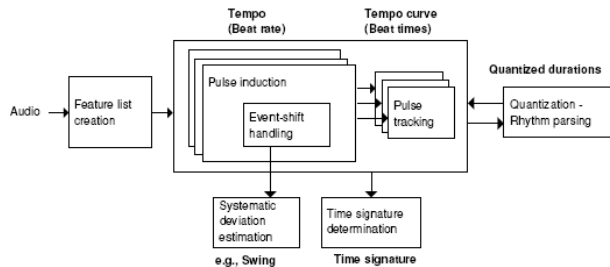
- Musical structure
 - Several metrical level
 - Tatum, tactus and measure
- Tempo
 - Number of beats per minute
 - Inter-beat interval
- Timing

Representation of Musical Rhythm



- A: Strictly metrical pulse
- B: one beat is displaced
- C: all beats from the 4th beat are displaced
- D: tempo change

Common Analytical Framework for Rhythm Description Systems



Encyclopedia Vol. I Feature List Creation

- My Murmuring: Let's read encyclopedia.....
- Onset time
- Duration
 - Inter-onset intervals (IOIs)
 - Cannot be reliably from audio data
- Relative Amplitude
 - Easily computable from MIDI
 - Absent from score notation
 - Might be computable for audio data (Dixon)
- Pitch
 - Easily from score and MIDI
 - Cannot be reliably extracted from polyphonic audio

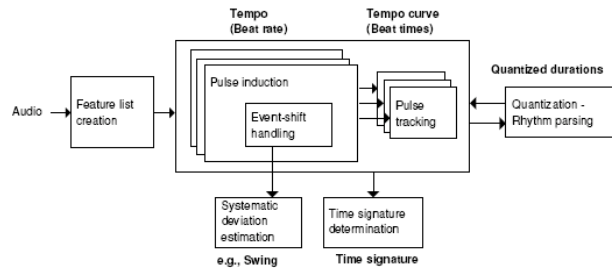
Encyclopedia Vol. I Feature List Creation (Cont)

- Chords
 - Measure of accentuation
 - Counting the number of simultaneous notes (Dixon 2001, Rosenthal 1992)
 - Detecting harmony change
 - As evidence of downbeat (Goto, 1999)
- Percussive instrument classes
 - Use specific drum sounds
 - To distinguish upbeats and downbeats (Goto 2001, Gouyon 2000)
 - MIDI: easily extracted
 - Audio: Isolated percussion samples are easy, too
 - Audio: recognition of percussive events in polyphonic audio mixture: ongoing research

Encyclopedia Vol. I Feature List Creation (Cont)

- Frame features
 - Feature extracted from low level frame: say, 10msec.
Given 44.1kHz SR, 441 samples signal
 - Energy
 - For whole frame or frequency subband
 - Low-frequency components as alternative to percussion detection (Alghoniemy 1999)
 - Variation of energy (Foote 2001)
 - First-order difference (Scheirer 1998)
 - Aggregation of subband energies (Klapuri 2003)
 - Others
 - Spectral flatness, temporal centroid (Gouyon 2003)
- Features on smallest metrical level

Common Analytical Framework for Rhythm Description Systems

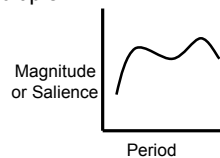


Encyclopedia Vol. II Pulse Induction

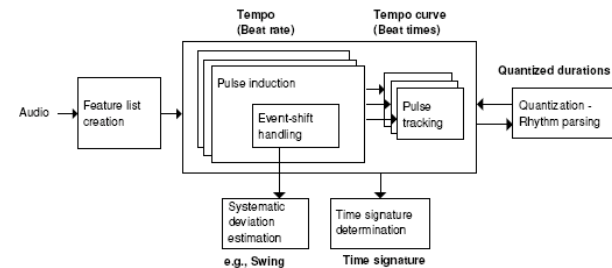
- Pulse
 - = metrical level, say, tatum, tactus, measure
 - Pulse induction = Tempo induction, period induction
 - Whole point
 - Seek periodic behaviors in feature list
- Assumption
 - The pulse period and phase is stable over the data
 - No significant speed variation
 - Remaining timing deviation are assumed to be short term
 - Either errors or expressivity feature, i.e., swing

Encyclopedia Vol. II Pulse Induction

- Pulse selection
 - IOI: defines a possible period
- Computing periodic function
 - Autocorrelation function (ACF)
 - Narrowed autocorrelation function (NACF)
 - Weighted sum of ACF at integer multiple of lag k
 - Weight decreases as k increases
 - $2k, 3k, \dots$ periodicity has effects on correlation coeff of lag k
 - Goto, Gouyon, Dixon, Tzanetakis
 - Comb filter, Sheirer



Common Analytical Framework for Rhythm Description Systems



Encyclopedia Vol. III Pulse Tracking

- Handles the short-term timing deviation
 - Determine changes in the phase
- State model
 - State variables: period or tempo, and phase
 - Consider events sequentially
 - Concurrent hypotheses
 - Sequences of states, Dannenberg, 1990
 - Multiple hypotheses search, Dixon, 2001
 - Predicted beat positions,
 - McAuley 1995, Desain & honing 1999

Encyclopedia Additional Volume Time signature determination

- Simplest approach
 - Find 2 peaks in periodicity function
 - Fast pulse as time signature denominator
 - Slow pulse as time signature numerator
 - Brown, 1993
- Complete musical structure, Temperly, 1999
- Determination the denominator
 - Then, segmentation in this level
 - Find periodicities in feature lists
 - Meudic, 2002; Gouyon, 2003
- Detection of chord change, Goto, 1999

Encyclopedia Additional Volume Rhythm parsing

- Rhythm parsing (quantization)
 - Several metrical structure
 - Emphasize the interdependency between tempo and rhythm
 - Raphael, 2002; Cemgil 2003
- Systematic deviation estimation
 - Swing

Discussion

- Qualitative comparison
- More like encyclopedia book
 - Give a framework
 - Who did what in which part
 - Global view of different methods with the same goal
 - Hard to understand every single method
 - We know what paper we might take a look in detail if we want

Question

• ???

• It's time to wake up and go home