Evaluation of a Multiresolution Model of Musical Rhythm Expectancy on Expressive Performances

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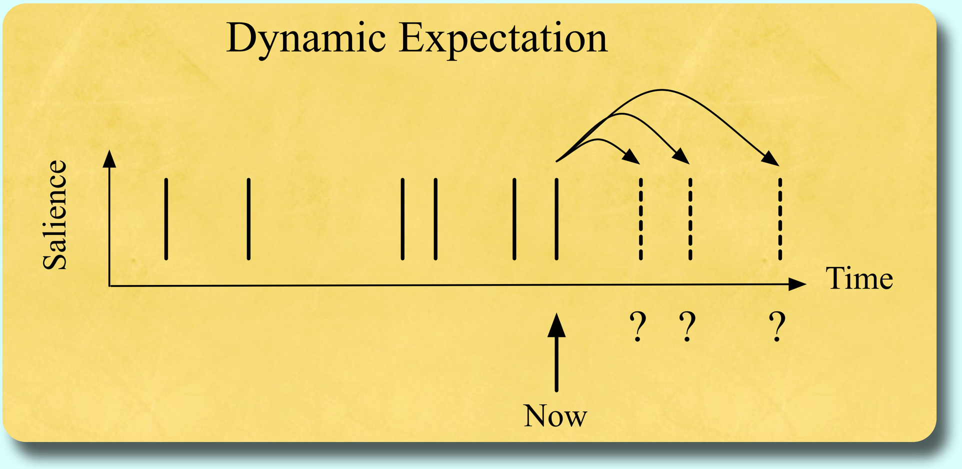
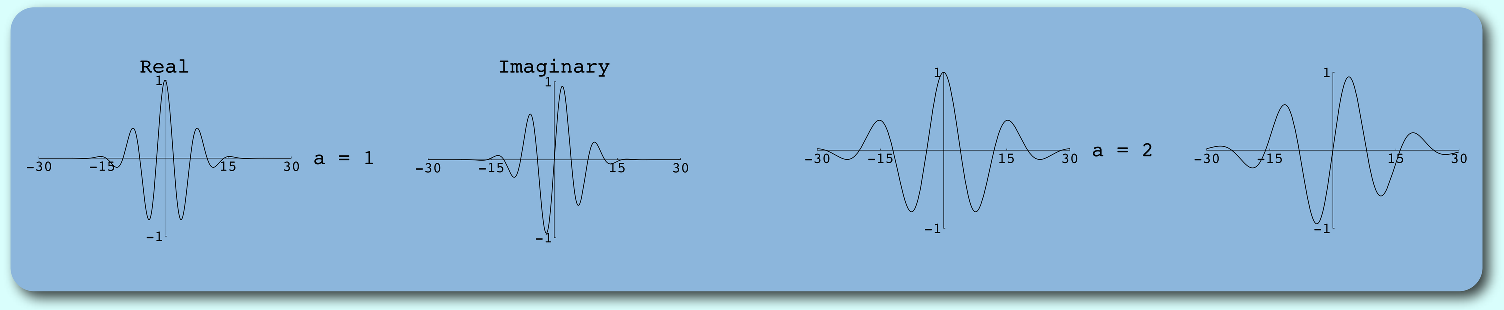
- What contribution to expectation arises from the temporal structure of a rhythm?
- What rhythmic structure emerges from these expectation cues?
- Expectation can be used as a measure of rhythmic complexity, by measuring the degree of contradiction to expectation.
- Rhythmic complexity is applicable in models of rhythmic similarity used, for example, in music information retrieval applications.

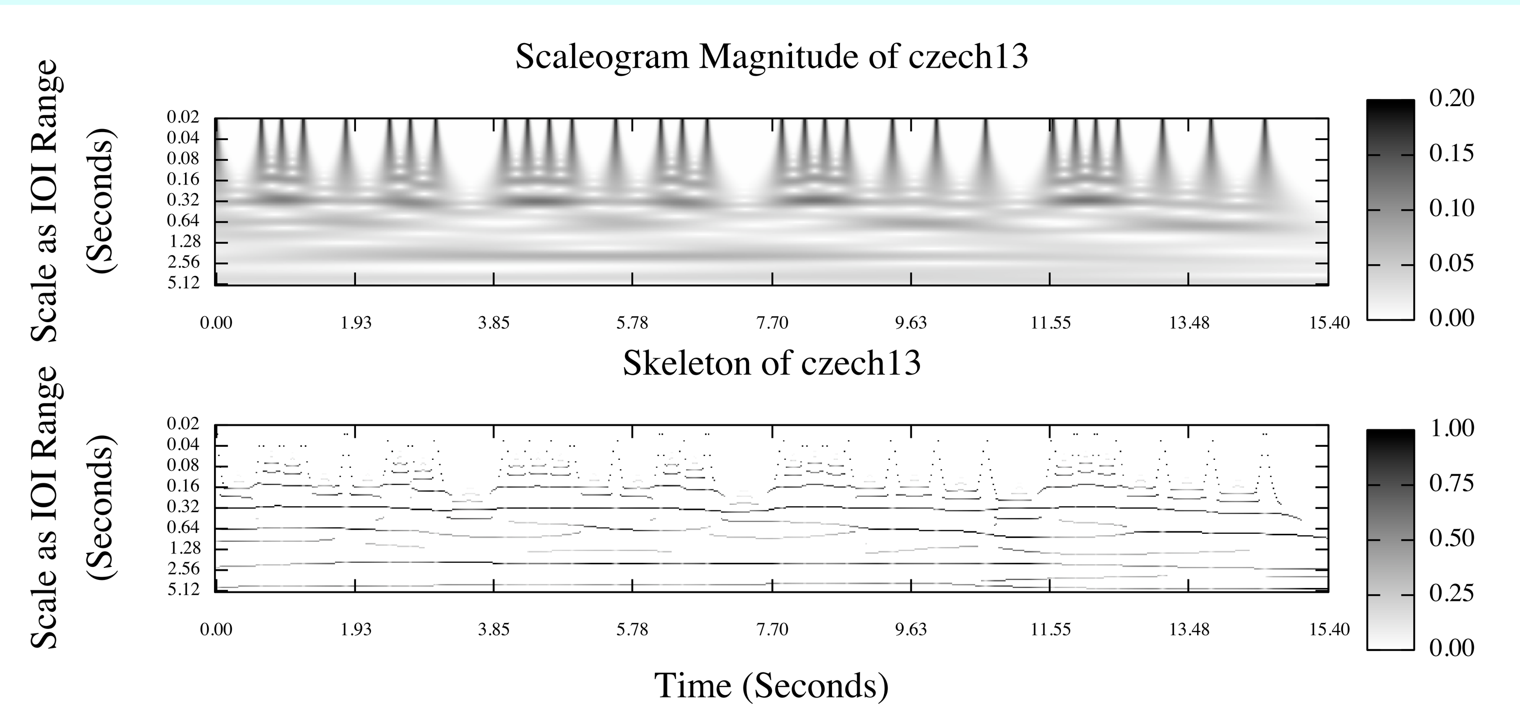


Wavelet Representation of Rhythm

- The Continuous Wavelet Transform (CWT) enables representation of temporal structure in terms of time varying rhythmic frequencies.
- Produces magnitude and phase measures which reveal time-frequency *ridges* indicating the frequencies present in the input rhythm signal (collectively a *skeleton*) (Smith & Honing 2008a).

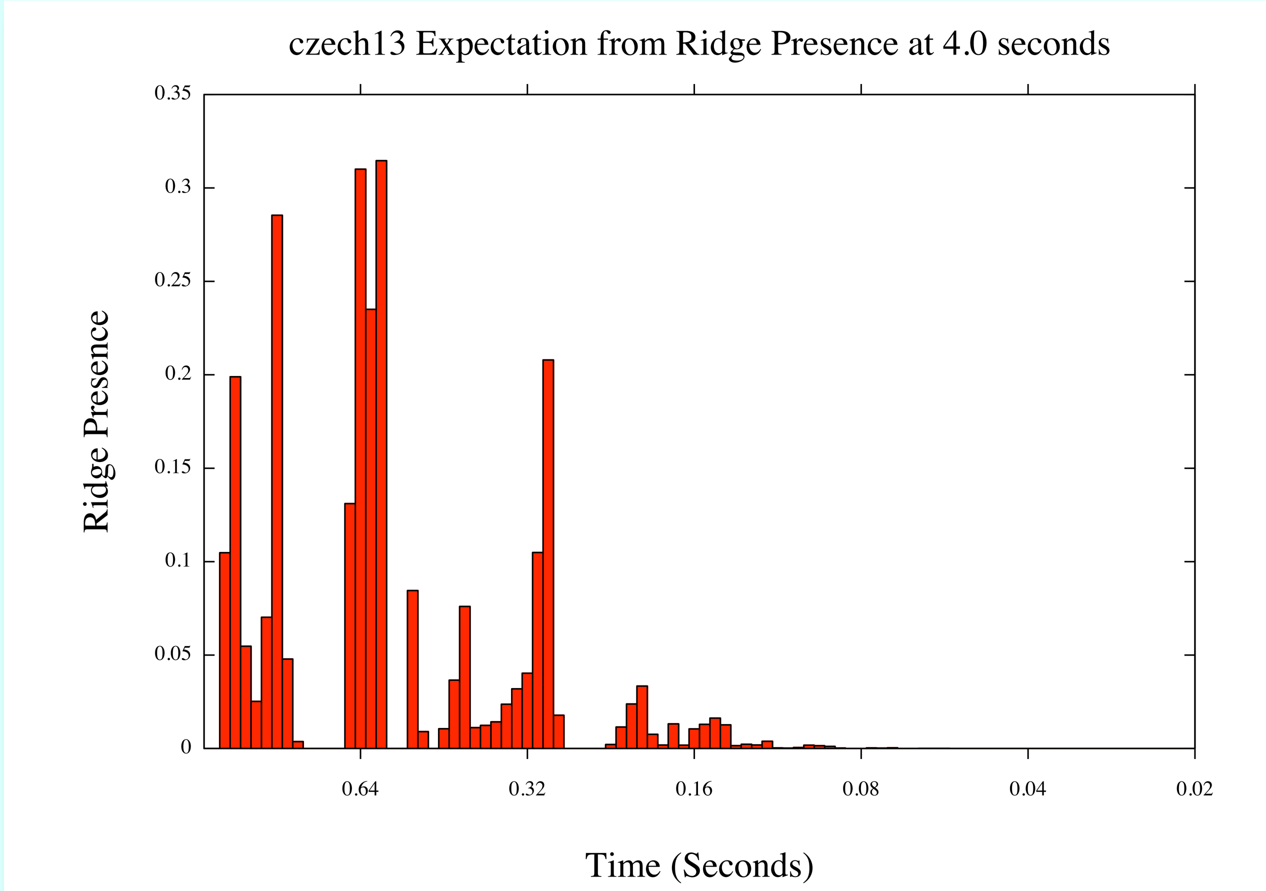


Example Time-Frequency Analysis



Expectation from time-frequency

The model generates expectations as forward predictions of times of future notes, a confidence weighting of the expectation, and a precision region. Expectation is calculated from the persistency of ridges across the rhythm. Presence is determined by integration (Smith & Honing 2008b). This is used to amass a likelihood measure of projected time periods.



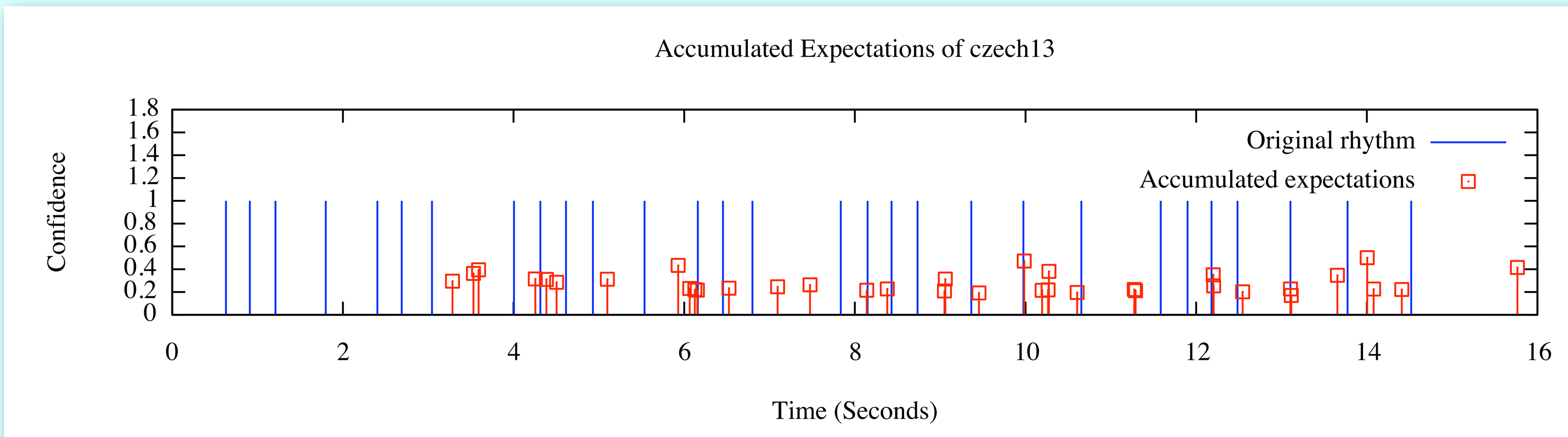
Method

The model is evaluated for it's capability to generate accurate expectation from musical performances. Evaluation consisted of generating successive expectations from a fragment of the rhythm, expanded in duration on each iteration. A region beginning with the first 3 seconds is successively expanded 1 second per iteration, generating a set of expectancies for each iteration.

These expectations were then scored by comparison against the onset times of notes actually then performed. A precision window of 50 milliseconds is used to score a correct expectation. The evaluation is repeated across each rhythm. Scores were computed using information retrieval measures of precision, recall and F-score (van Rijsbergen 1979) for each rhythm.

- Recall: (# onsets correct / # onsets performed) ⇒ deletions.
- Precision: (# onsets correct / # onsets computed) ⇒ additions.
- F-Score: = 2 × P × R / (P + R) per rhythm.

Expectation Example



Performed Rhythmic Data

- **Dataset 1:** Rhythmic timing of 63 monophonic MIDI keyboard performances of pieces of the Essen Folk Song collection (Temperley 2007).
  - Includes pieces in 2/4 (15), 3/4 (13), 4/4 (16), 6/8 (14) meters.
- **Dataset 2:** 50 audio recordings of popular music annotated for beat location (Quaero dataset).
  - Individual note onsets are not annotated, therefore forward expectation is measured against the annotated beat period.
  - Selected a maximum of the first 30 seconds of each piece.
  - 48 pieces at least partially in 4/4, but includes pieces in 6/8, 12/8, and pieces with sections in 2/4, 5/4, 6/8, and 3/4.
- **Chance unbounded (H0):** Randomly generating a number of expectation times up to the number of remaining onsets in the rhythm, on each iteration, over the rhythms of Dataset 1.
- **Chance bounded (H0):** Randomly generating 3 expectation times per iteration, up to the complete duration of the rhythm, over the rhythms of Dataset 1.

Results

(Mean values)	Precision	Recall	F-Score
Temperley MIDI	0.297	0.370	0.326
Quaero Audio	0.238	0.420	0.291
Chance unbounded	0.138	0.520	0.208
Chance bounded	0.177	0.219	0.195

Outcomes

- Proposed a causal method of evaluation of dynamic expectancy.
- Evaluated one model of dynamic expectancy based on periodicities contained within the rhythm.
- Indicates performance above chance, but well below perfection.
- Further methods of assessment of expectations against octave errors and with ranges of precision windows required.

- C.V. van Rijsbergen. Information Retrieval. Butterworth, London; Boston, 2nd edition, 1979.
- L.M. Smith & H. Honing 2008a, Time-frequency representation of musical rhythm by continuous wavelets. Journal of Mathematics & Music 2(2), 81-97
- L. M. Smith and H. Honing "A Multiresolution Model of Rhythmic Expectancy" Proceedings of the Tenth International Conference on Music Perception and Cognition, 2008b pages 360-365
- D. Temperley. Music and Probability. MIT Press, Cambridge, Mass., 2007.