

VISUALIZING MUSIC ON THE METRICAL CIRCLE

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Abstract

We propose a method called Metrical Circle Map for exploring the cyclic aspects of musical time. To this end, we furthermore introduce the notion of metrical Markov chains as n-th order transition probabilities of segments on the metrical circle.

Introduction

- Double nature of musical time: Linear and cyclic.
- The cyclic nature so far was mainly investigated in structure-oriented meter and rhythm research (e.g. [1] [2],[4]). Counting of metrical position was already done in [3], but with different focus and scope.
- Extended method: Metrical Circle Map (MCM) and metrical Markov chains for data-oriented visualisation and analysis of metrical time.

Metrical Circle Map

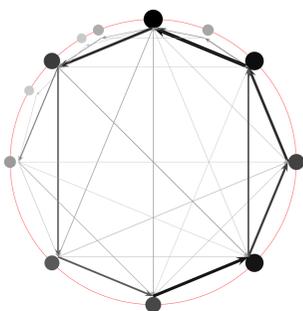
- Events of metrically-bound music are organized around underlying beats, which are grouped into higher level units.
- We consider here isochronous beats with bars as main grouping unit and no meter changes.
- For rhythms conceived as a sequence of time-points t_i , and a bar time T the *Metrical Circle Map* M_T is defined as a mapping from the reals into the complex unit circle:

$$M_T(t_i) = z_i = e^{2\pi i \frac{t_i - \varphi}{T}} \quad (1)$$

- Normalized, so that time is running counter-clockwise, and beginning of bars lie at 3 o'clock.

Metrical Markov Chains

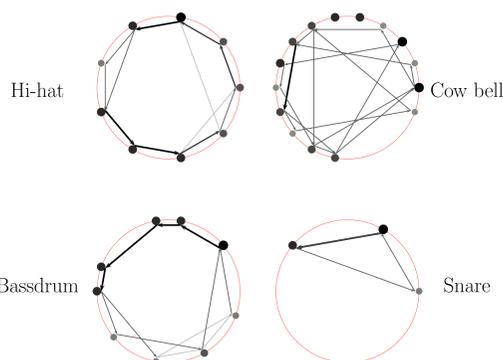
- Define N equidistant intervals on the unit circle (with $N = 48$ being a good choice for many applications.)
- Map sequence of time-points onto a sequence of intervals on the metrical circle.
- Define Markov transitions for this sequences of intervals. Here: Restriction to zeroth and first order.
- Zeroth-order probabilities are displayed by circles at corresponding circle position with radius and blackness proportional to probability
- First-order probabilities displayed by arrows with thickness and blackness proportional to probability.
- Example below: Melody of *Mandy* by Barry Manilow. Notice the preference for events at beginning and end of the bar with beat 2 the most frequent position, the mere absence of 16th notes, as well as the prominent syncopated (and symmetric) transitions, $4+ \rightarrow 1+$ and $2+ \rightarrow 3+$.



Vocal line of *Mandy* by Barry Manilow

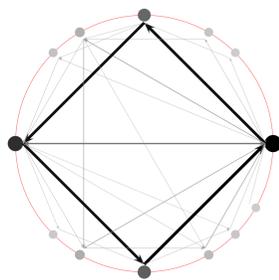
Example: A Complex Drum Groove

- *Cross-Fade* by Steve Coleman features a highly complex four-bar groove in 9/4 time.
- Cow bell: highly asymmetrical clave pattern actually yielding a 36-beats period.
- Hi-hat: Main time-keeper playing nearly on every quarter beat.
- Snare drum: Relatively simple pattern of 5 beats spread over two bars.
- Bass drum: Avoids the downbeat and repeats only after a four-bar cycle, but with some recurring inner patterns.

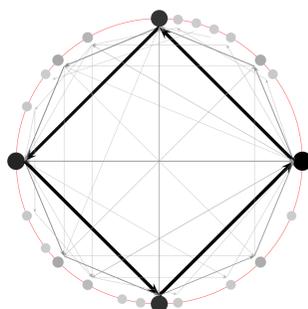


Analysis of Melody Collections

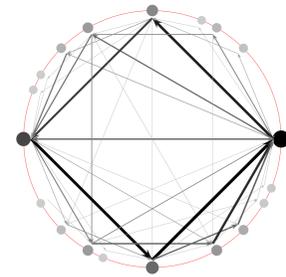
- We analysed the metrical Markov chains of different song collections: 61 Irish Folk songs, 586 Luxembourgian folk songs, 190 East-polish chants, and 207 German children songs from the Essen Collection and 53 contemporary pop songs (data kindly provided by Frank Riedemann.)
- Children songs are (non-surprisingly) the most metrically simple.
- Irish folk songs have much higher proportion of triple and compound duple meters, and a considerably high metrical variety.
- Vocal lines of pop songs show the highest metrical variety with many syncopations and little movement in quarter notes. In contrast to all other corpora, the most frequent metrical position is not the 1 but the 4+, the 1 being the second most frequent.



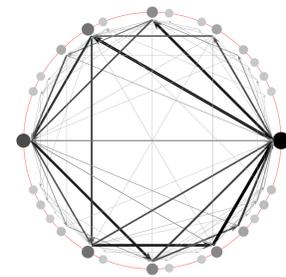
207 German Children Songs



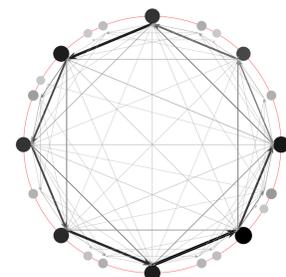
190 East-polish Chants



586 Luxembourgian Folk Songs



61 Irish Folk Tunes



53 Pop Tunes

Metrical Complexity

- (Normalized) entropies of zeroth- and first-order metrical Markov chains provide a simple metrical complexity measure. The results corroborate the visual impression.

	Children	Polish	Luxembourg	Irish	Pop
H_0	0.48	0.58	0.59	0.68	0.68
H_1	0.34	0.42	0.44	0.50	0.53

Conclusion & Outlook

- Metrical circle map and metrical Markov chains are helpful tools for the metrical analysis of a wide range of music.
- Entropies of metrical Markov chains serve as a (to my knowledge) novel complexity measure.
- Idea: Development of a meter induction algorithm based on minimizing metrical complexity as a function of bar time.

References

- [1] Anku, Willie. Circles and Time: A Theory of Structural Organization of Rhythm in African Music, *Music Theory Online*, 6(1), <http://www.societymusictheory.org/mto>, 2004.
- [2] London, Justin *Hearing in Time*. Oxford University Press, Oxford, England, 2004.
- [3] Palmer, C. and Krumhansl, C.L. Mental representation for musical meter. *Journal of Experimental Psychology - Human Perception and Performance*, 16(4), 728-41, 1990.
- [4] Toussaint, Godfried T. A comparison of rhythmic similarity measures. In *Proc. 5th International Conference on Music Information Retrieval*, Universitat Pompeu Fabra, Barcelona, Spain, 2004.