TEMPOGRAM TOOLBOX: MATLAB IMPLEMENTATIONS FOR TEMPO AND PULSE ANALYSIS OF MUSIC RECORDINGS

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1. INTRODUCTION

The extraction of local tempo and pulse information from audio recordings constitutes a challenging task, in particular for music with significant tempo variations. Furthermore, the existence of various pulse levels such as measure, tactus, and tatum often makes the determination of absolute tempo problematic. In this demo, we present the *tempogram toolbox*, which contains MATLAB implementations for extracting various types of recently proposed tempo and pulse-related audio representations [2, 3]. These representations are particularly designed to reveal useful information even for music with weak note onset information and changing tempo. The toolbox is provided under a GNU-GPL license at `www.mpi-inf.mpg.de/resources/MIR/tempogramtoolbox`.

2. FUNCTIONALITY

The functionality provided by our tempogram toolbox is illustrated in Figure 1, where an audio recording of Claude Debussy's Sonata for Violin and Piano in G minor (L 140) serves as an example. [1] Analyzing this recording with respect to tempo is challenging as it contains weak note onsets played by a violin as well as a number of prominent tempo changes.

Given an audio recording (Figure 1a), we first derive a novelty curve. The peaks of this curve indicate note onset candidates [1] (Figure 1b). The variant provided by the tempogram toolbox is particularly designed for capturing soft note onsets, as for string instruments. Given such a (possibly very noisy) onset representation the toolbox allows for deriving a predominant local pulse (PLP) curve as introduced in [2] (Figure 1c). This curve can be regarded as a local periodicity enhancement of the original novelty curve explaining the local periodic nature of the note onsets and provides musically meaningful local pulse information even in the case of complex music. The PLP concept yields a powerful mid-level representation that can be applied as a flexible tool for various music analysis tasks, such as onset detection, tempo estimation, or beat tracking [2].

As second main part, our tempogram toolbox facilitates various tempogram representations that reveal local tempo characteristics even for expressive music exhibiting tempo-changes. To obtain such a representation, the novelty curve is analyzed with respect to local periodic patterns. Here, the toolbox provides Fourier-based methods (Figure 1d,f) as well as autocorrelation-based methods (Figure 1e,g). Autocorrelation-based tempograms ideally complement Fourier-based tempograms as they indicate subharmonics while suppressing harmonics [4]. For both concepts, representations as time/tempo (Figure 1d,e) as well as time/time-lag tempogram (Figure 1f,g) are available. Furthermore, resampling and interpolation functions allow for switching between tempo and time-lag axes as desired.

The third main part of our toolbox provides functionality for deriving cyclic tempograms from the tempogram representations as introduced in [3]. Here, the idea is to form tempo equivalence classes by identifying tempi that differ by a power of two. The cyclic tempo features constitute a robust mid-level representation revealing local tempo characteristics of music signals while being invariant to changes in the pulse level (Figure 1h,i). Being the tempo-based counterpart of the chromagrams, cyclic tempograms are suitable for music analysis and retrieval tasks.

Finally, the tempogram toolbox contains a variety of functions for the visualization and sonification of extracted tempo and pulse information.

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[1] The audio recording is available from Saarland Music Data (SMD) `http://www.mpi-inf.mpg.de/resources/SMD/`.

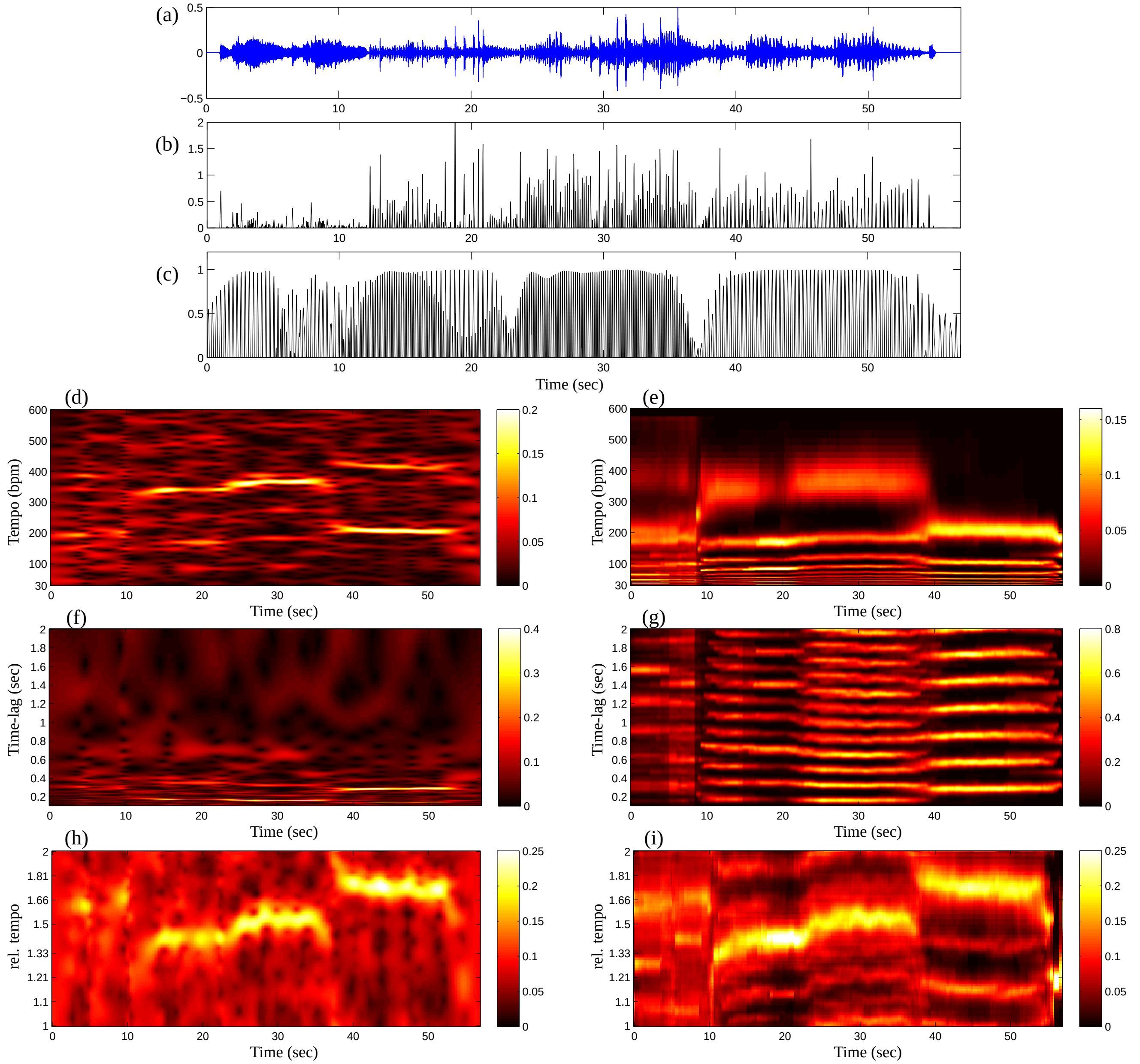

Figure 1: Illustration of the functionality of the tempogram toolbox using an excerpt (second movement, bars $79 - 107$) of an audio recording of Claude Debussy's Sonata for Violin and Piano in G minor (L 140). **(a)** Waveform of the excerpt. **(b)** Novelty curve extracted from the audio recording indicating note onset candidates. **(c)** PLP curve revealing the predominant local pulse. **(d)** Fourier-based tempogram. **(e)** Autocorrelation-based tempogram. **(f)** Fourier-based tempogram with time-lag axis. **(g)** Autocorrelation-based tempogram with time-lag axis. **(h)** Fourier-based cyclic tempogram. **(i)** Autocorrelation-based cyclic tempogram.

3. REFERENCES

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