Recording-based performance analysis: Feature extraction in Chopin mazurkas

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Extraction Process

estimate note locations
in audio based on musical score

- *tap beats while listening to audio.*
- *use as click-track for score.*

↓

automatically adjust estimations
based on observation of audio

- *search for actual event onsets in neighborhood of estimated time.*

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manual correction of
automatic output

- *listen to results and fix any errors in extracted data.*

↓

automatic extraction of refined
information

- *individual note onsets & loudnesses*

Input to Andrew's System

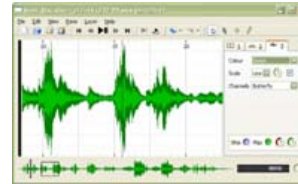**Scan the score**

Convert to symbolic data with SharpEye

http://www.visiv.co.uk

Tap to the beats in Sonic Visualiser

http://www.sonicvisualiser.org

Convert to Humdrum data format

http://www.humdrum.org

Create approximate performance score

Simplify for processing in Matlab

Input Data Example

Matlab input data

Humdrum score

**time	**kern	**kern
*	*staff2	*staff1
*	*clefF4	*clefG2
*	*M3/4	*M3/4
1912	4r	(4ee\
=1	=1	=1
2558	4r	8.ff\L
3021	.	16ee\Jk
3175	4A'\ 4d'\ (4f'\	4dd\
3778	4A'\ 4d'\ 4f'\)	4ff\
=2	=2	=2
4430	4r	2ff\
4914	4A'\ 4c'\ (4f'\	.
5541	4A'\ 4c'\ 4e'\)	4ee\)

tapped timings   left hand notes   right hand notes

on-time	duration	MIDI key	metric level	measure	beat numb.	hand
1912	646	76	1	0	0	1
2558	463	77	0	1	1	1
3021	154	76	-1	1	1.75	1
3175	603	57	0	1	2	2
3175	603	62	0	1	2	2
3175	603	65	0	1	2	2
3175	603	74	0	1	2	1
3778	652	57	1	1	3	2
3778	652	62	1	1	3	2
3778	652	65	1	1	3	2
3778	652	77	1	1	3	1
4430	1111	77	0	2	4	1
4914	627	57	0	2	5	2
4914	627	60	0	2	5	2
4914	627	65	0	2	5	2
5541	748	57	1	2	6	2
5541	748	60	1	2	6	2
5541	748	64	1	2	6	2
5541	748	76	1	2	6	1

Reverse Conducting

• Orange = individual taps (multiple sessions) which create bands of time about 100 ms wide.

• Red = average time of individual taps for a particular beat
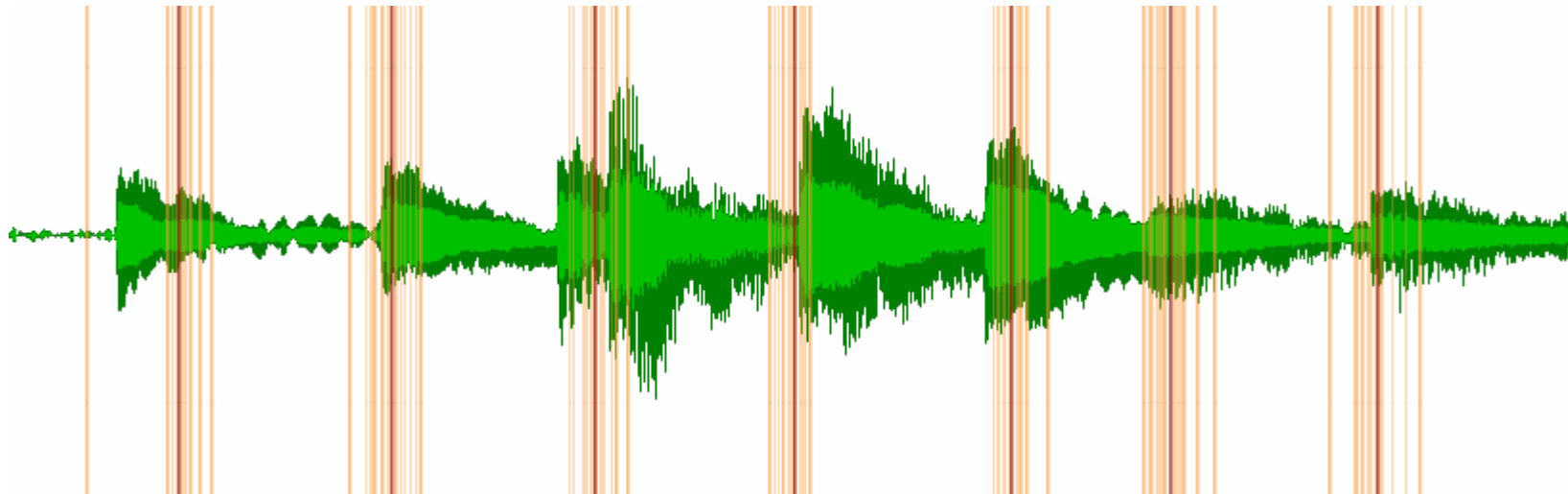
Refinement of tapped data

■ = tapped times
■ = corrected tap times
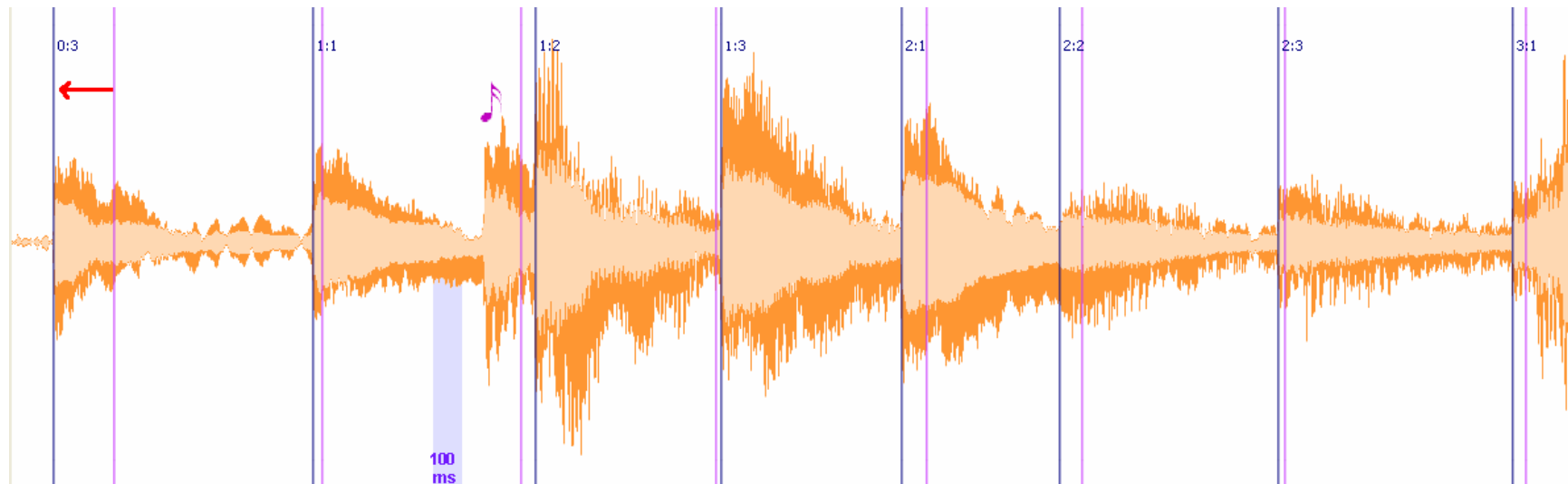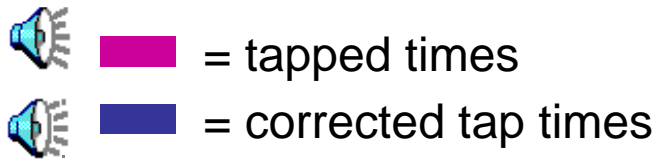
- Standard Deviation for tap accuracy is about 40-50 ms.
- Automatic adjustments are 3-5 times more accurate than tapping.

Performance Data

• **Currently extracting:**

    • note/chord onsets
    • note/chord loudnesses

• **Currently ignoring:**

    • note offsets:
      useful for -- articulations (staccato, legato)
                  -- pedaling

• **What to do with data?**

    • Mostly examing tempo thus far
    • Starting to work with dynamics
    • Need to examine individual note onsets (LH/RH)

• **Long-term goals:**

    • Quantify and examine the performance layer of music
    • Characterize pianists / schools of performance
    • Automatic performance generation

MIDI Performance Reconstructions

"straight" performance

tempo = avg. of performance

matching performers tempo
beat-by-beat:

(pause at beginning)

MIDI file imported as a note layer in Sonic Visualiser:
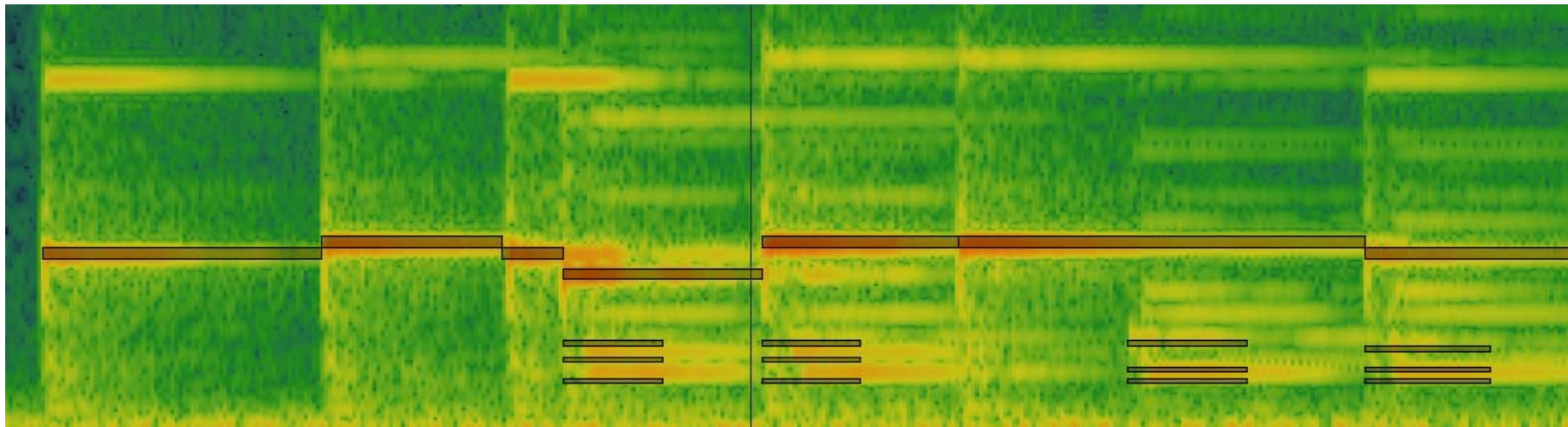
- Superimposed on spectrogram

- Easy to distinguish pitch/harmonics

- Legato; LH/RH time offsets

Average tempo over time

• Performances of mazurkas slowing down over time:

Friedman 1930   Rubinstein 1961   Indjic 2001
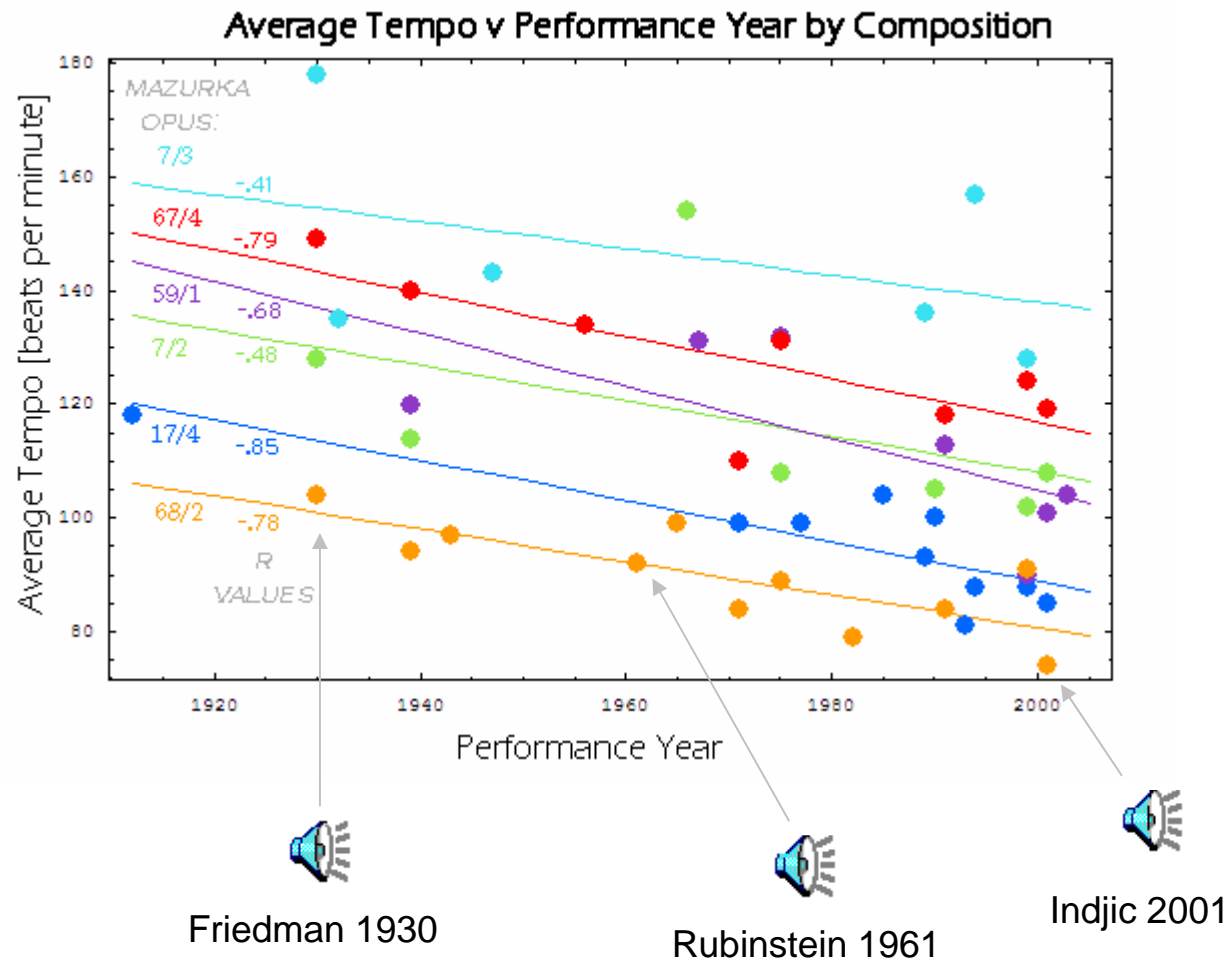
• Slowing down at about 3 BPM/decade

Tempo Graphs

Mauzurka in F major, Op. 68, No. 3

Poco piu vivo
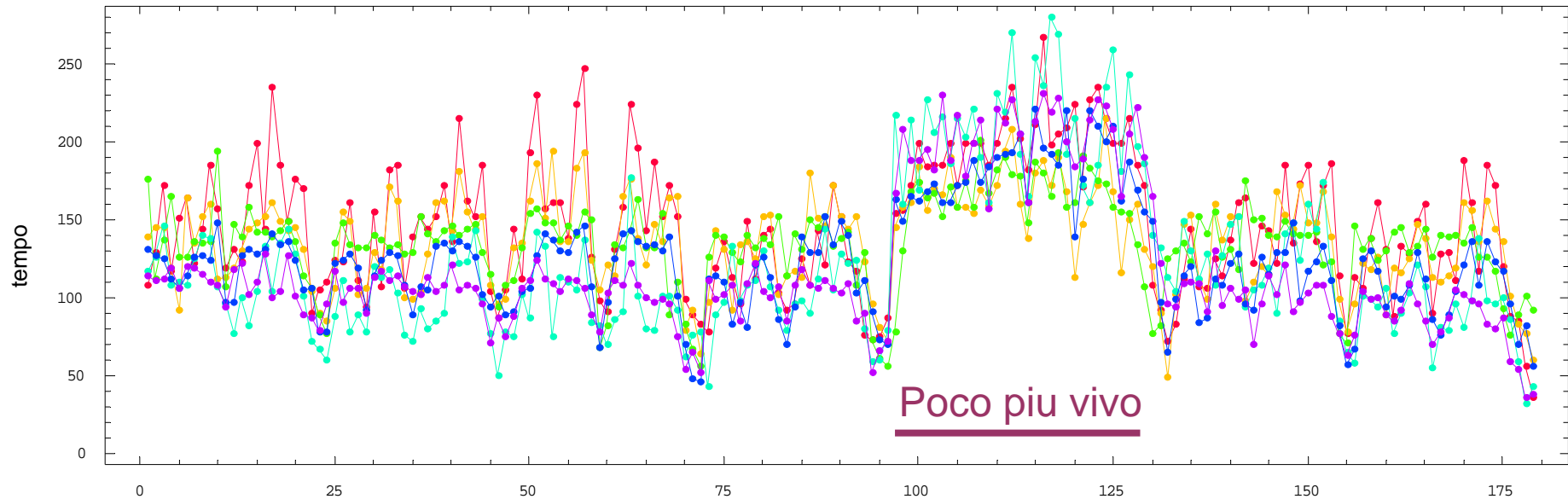
	avg. tempo	vivo avg.	non-vivo avg.
Rubenstein 1938	147	190	137
Rubenstein 1961	137	158	131
Smith 1975	135	158	130
Luisada 1991	122	203	102
Chiu 1999	125	175	112
Indjic 2001	118	196	98

Timescapes

- Examine the internal tempo structure of a performances
  - *where is tempo faster/slower?*

- Plot average tempos over various time-spans in the piece

- Example of a piece with 6 beats at tempos A, B, C, D, E, and F:
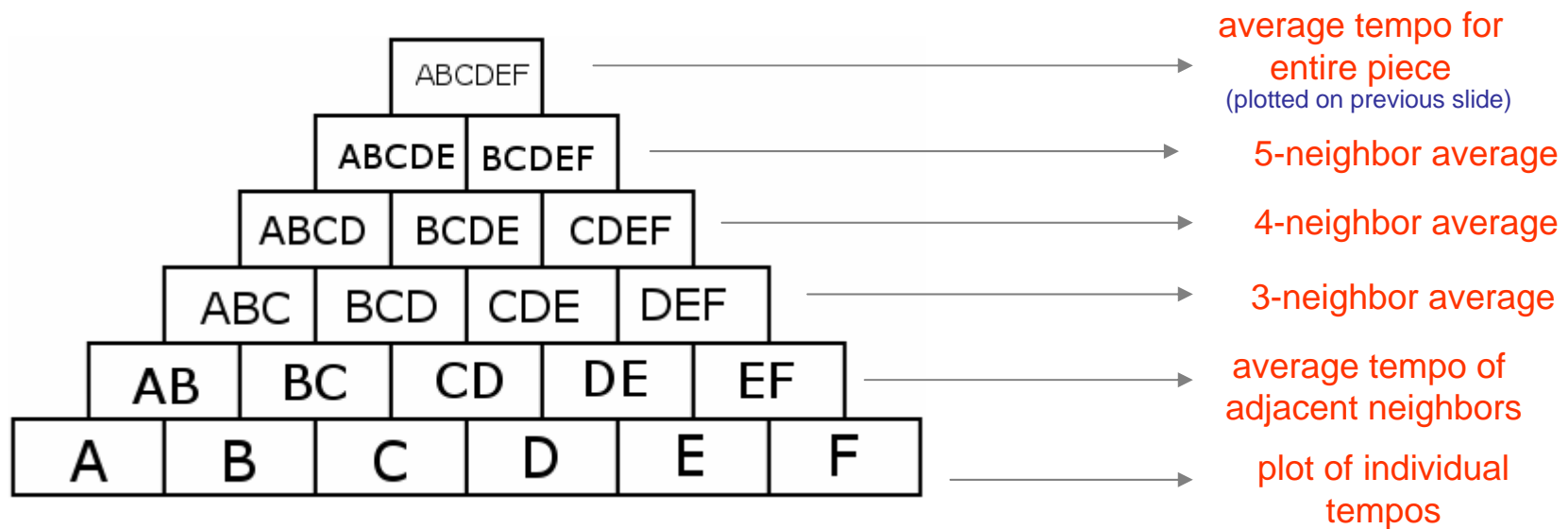
Average tempo
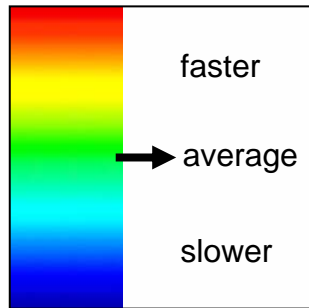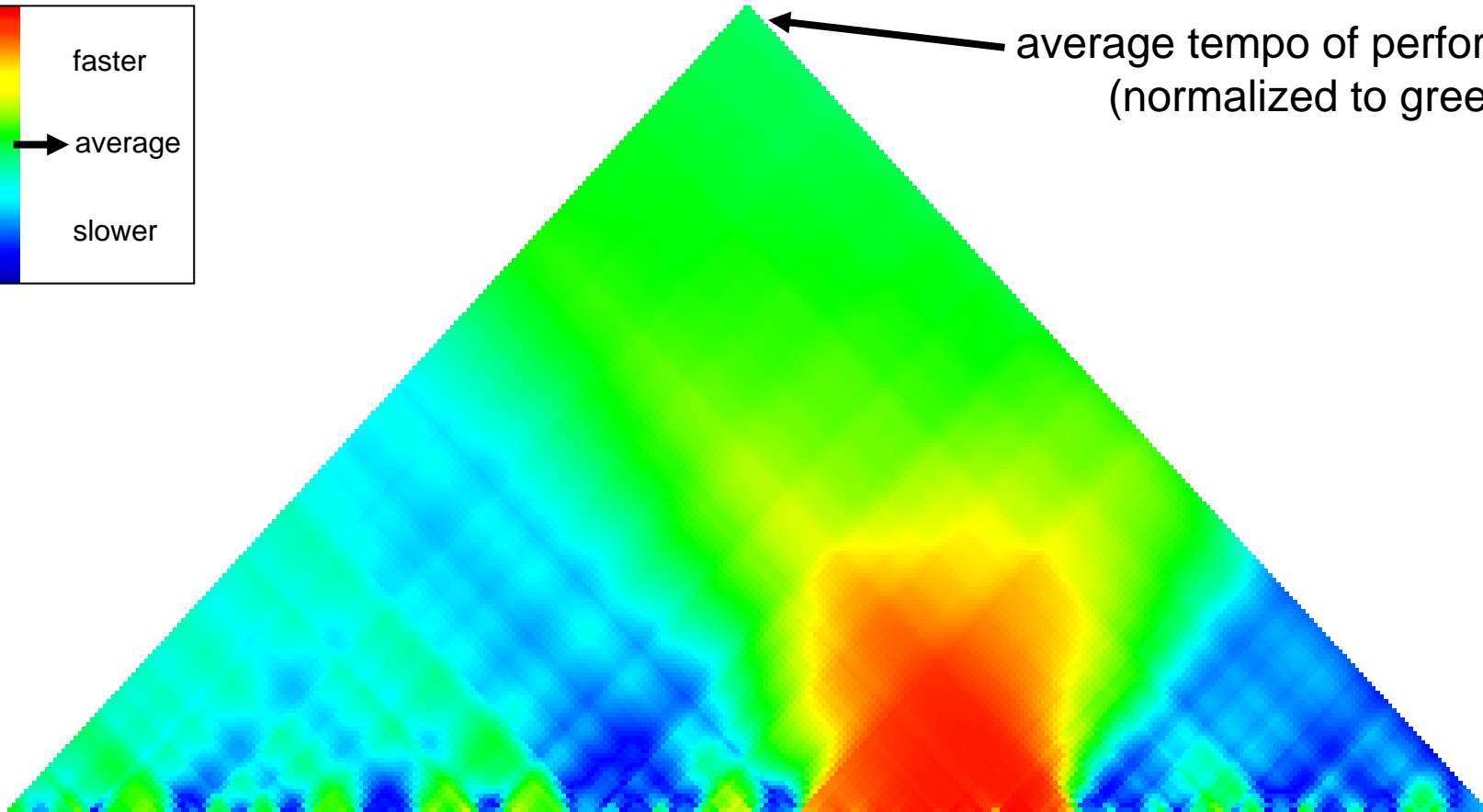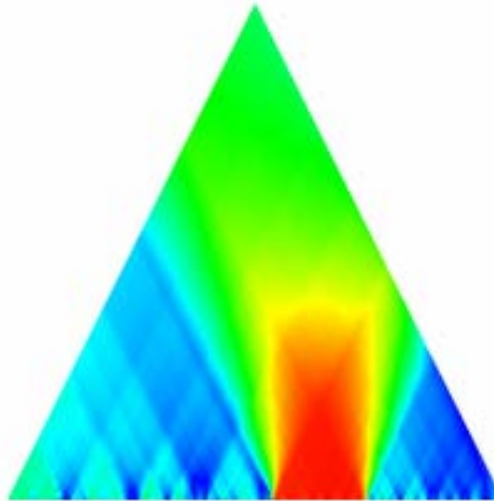

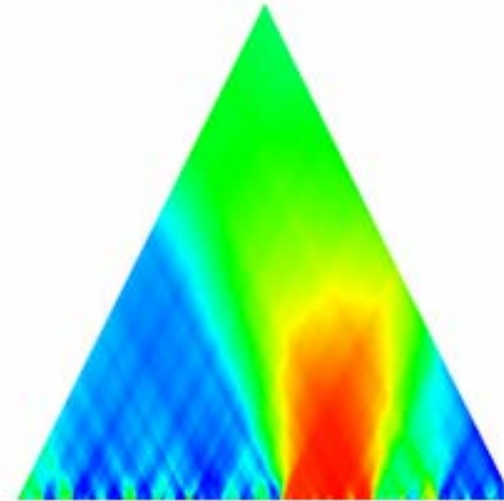Mazurka in F major, Op. 67, No. 3: Frederic Chiu; 1999
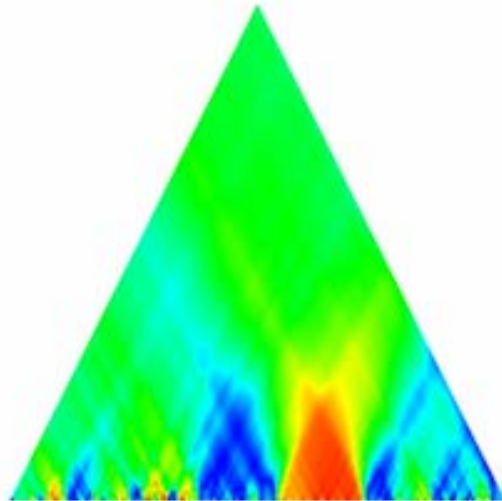
Average tempo over time
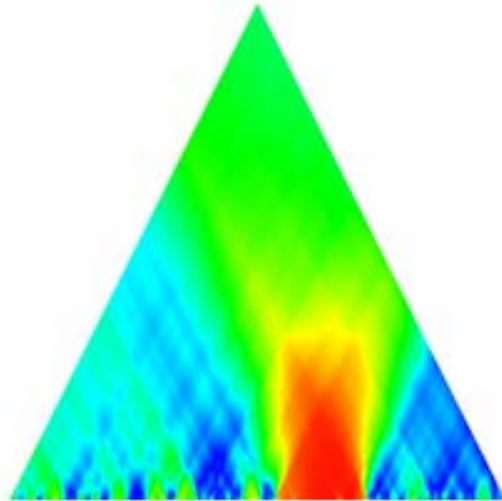
Chiu 1999

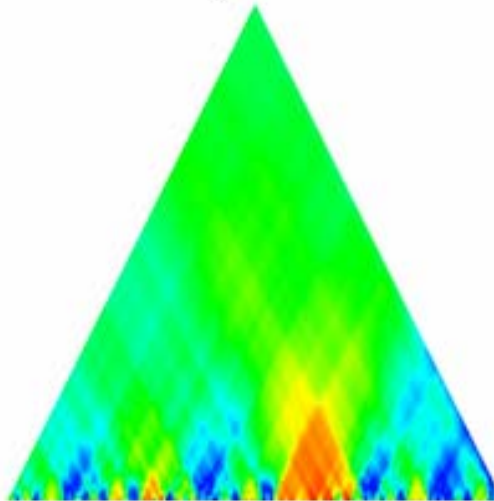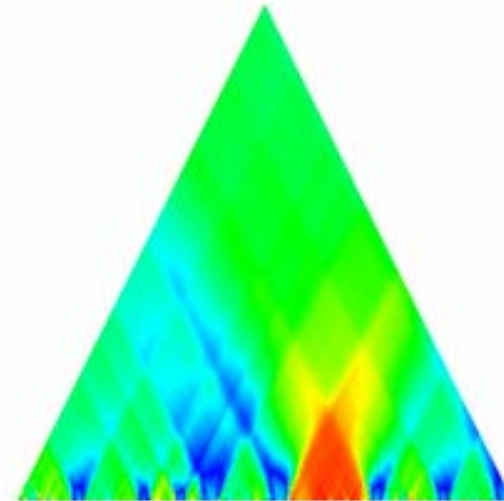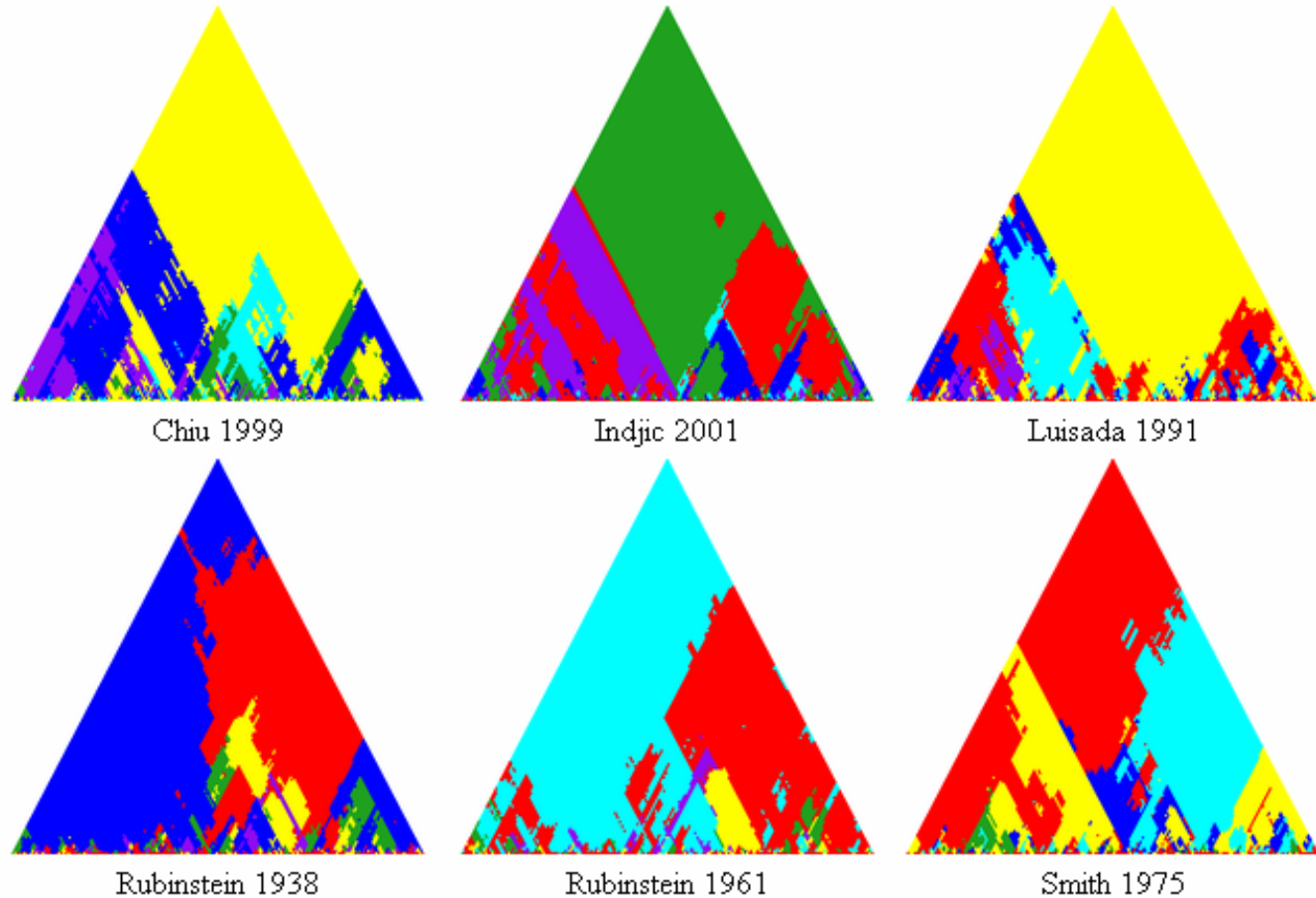Indjic 2001

Luisada 1991

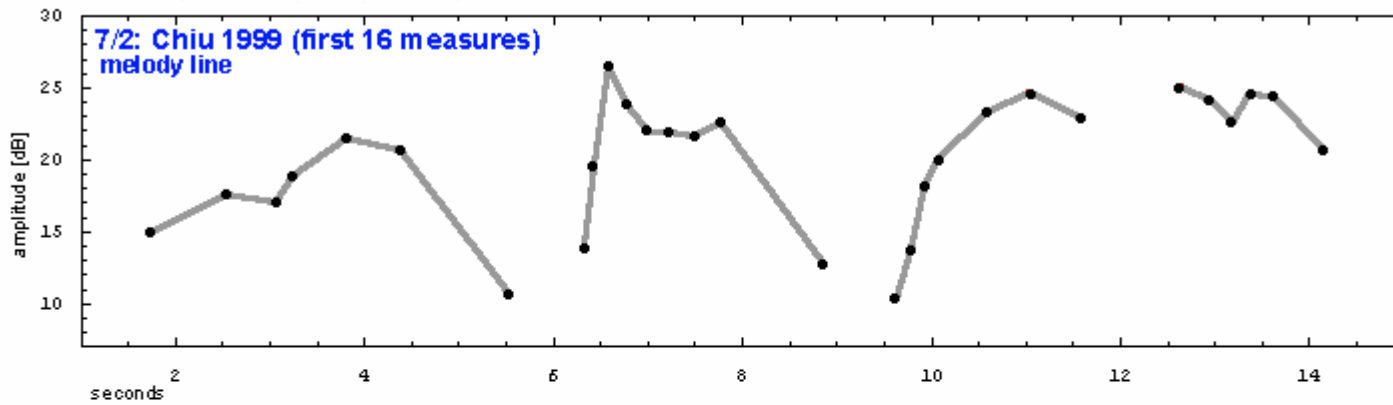Rubinstein 1938

Rubinstein 1961

Smith 1975

Tempo Correlation

Pearson correlation:

$$\frac{\sum_i (x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_i (x_i - \overline{x})^2 \sum_i (y_i - \overline{y})^2}}$$

Chiu 1999
Indjic 2001
Luisada 1991
Rubinstein 1938
Rubinstein 1961
Smith 1975
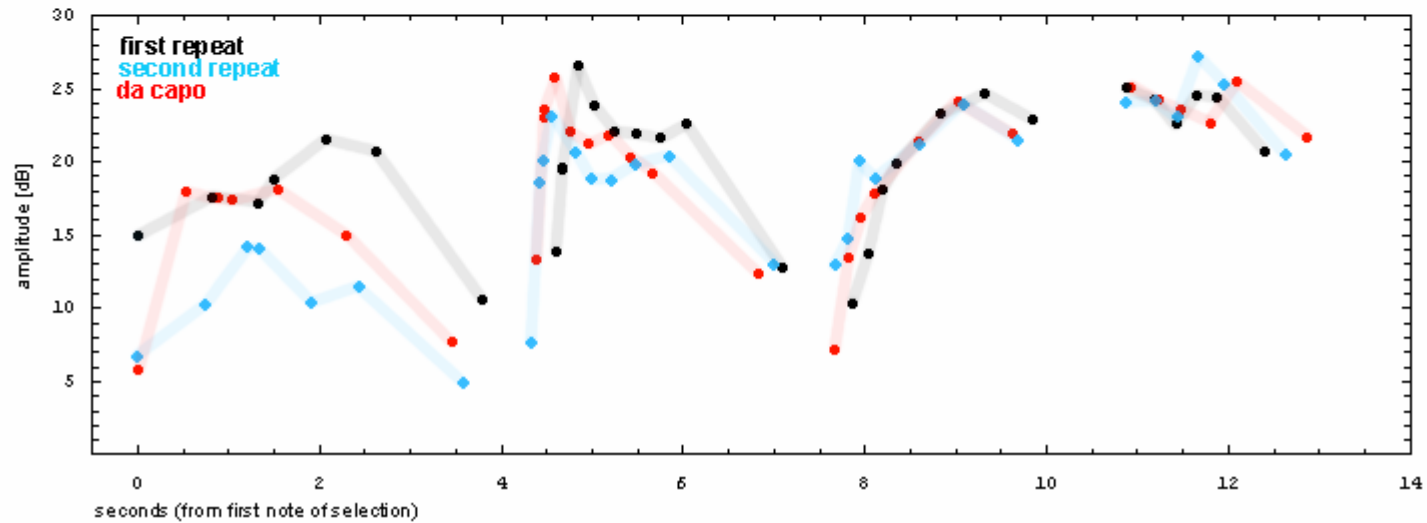
Chiu 1999   Indjic 2001   Luisada 1991

Rubinstein 1938   Rubinstein 1961   Smith 1975

Dynamics

all at once:

For Further Information

http://www.charm.rhul.ac.uk/

http://mazurka.org.uk