

Recording-based performance analysis: Feature extraction in Chopin mazurkas

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Extraction Process

estimate note locations
in audio based on musical score

↓

automatically adjust estimations
based on observation of audio

↓

manual correction of
automatic output

↓

automatic extraction of refined
information

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

↓

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

↓


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

↓

- individual note onsets & loudnesses


Input to Andrew's System

Scan the score




↓

Convert to symbolic data with SharpEye



<http://www.vtsiv.co.uk>

Tap to the beats in Sonic Visualiser



<http://www.sonicvisualiser.org>

↓

Create approximate performance score


Simplify for processing in Matlab

Convert to Humdrum data format

<http://www.humdrum.org>

→

Input Data Example



↓

Humdrum score

```

**time **Notes **Notes
* * *staEE2 *staEE1
* * c3leEP4 *c1eEG2
+ * *M3/4 *M3/4
1912 4r (4ac\
=1 =1
2558 4r B,EE\
3021 . 36ee\Uk
3175 4A\ 4d\ (4E\ 4dd\
3778 4A\ 4d\ (4E\ 4EE\
=2 =2
4430 4r ZEE\
4914 4A\ 4e\ (4E\ .
5541 4A\ 4e\ (4e\ 4ee\

```

↑ tapped timings ↑ left hand notes ↑ right hand notes

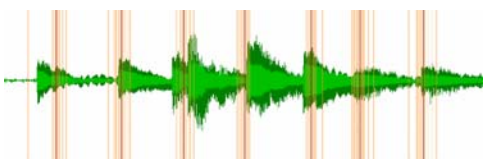
Matlab input data

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

on-time duration MIDI key metric level measure beat numb. hand

Reverse Conducting

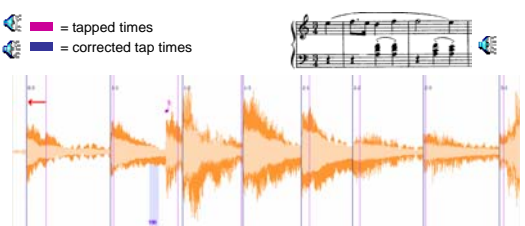
- Orange = individual taps (multiple sessions) which create bands of time about 100 ms wide.
- Red = average time of individual taps for a particular beat



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.

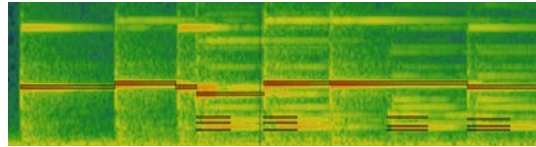
Performance Data

- **Currently extracting:**
 - note/chord onsets
 - note/chord loudnesses
- **Currently ignoring:**
 - note offsets: useful for -- articulations (staccato, legato) -- pedaling
- **What to do with data?**
 - Mostly examining 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 matching performers tempo beat-by-beat:
 tempo = avg. of performance (pause at beginning)

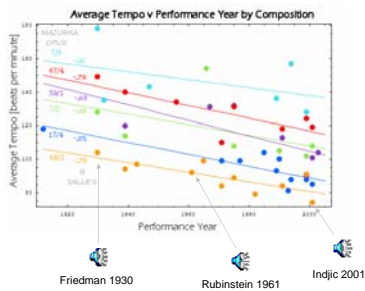
MIDI file imported as a note layer in Sonic Visualiser:



- Superimposed on spectrogram
- Easy to distinguish pitch/harmonics
- Legato; LH/RH time offsets

Average tempo over time

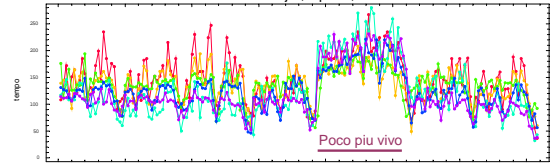
- Performances of mazurkas slowing down over time:



- Slowing down at about 3 BPM/decade

Tempo Graphs

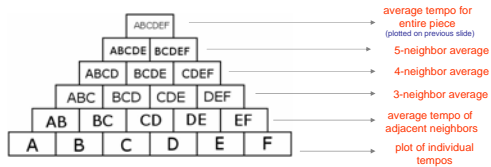
Mauzurka in F major, Op. 68, No. 3



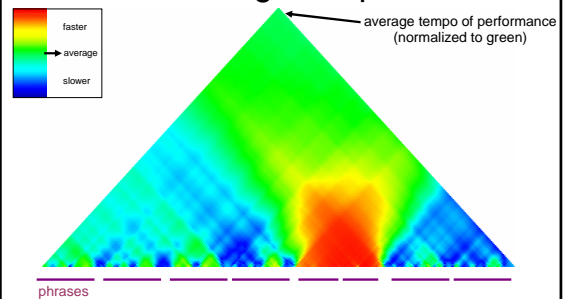
	avg. tempo	vivo avg.	non-vivo avg.
■ Rubenstein 1938	147	190	137
■ Rubenstein 1961	137	158	131
■ Smith 1975	135	158	130
■ Luisada 1991	122	203	102
■ Chiu 1999	125	175	112
■ Indjic 2001	118	196	98

Timescapes

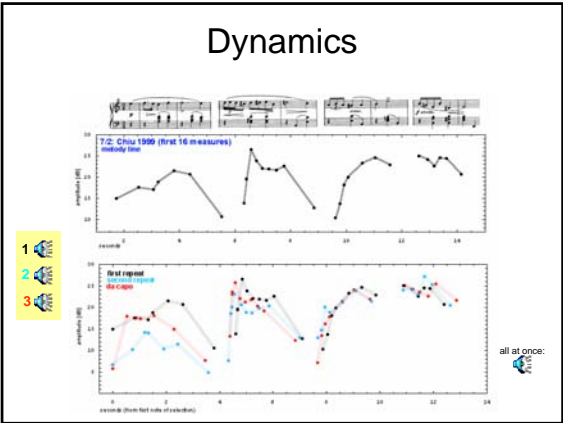
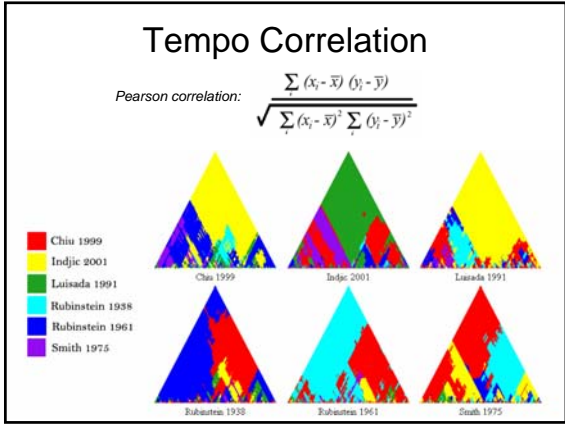
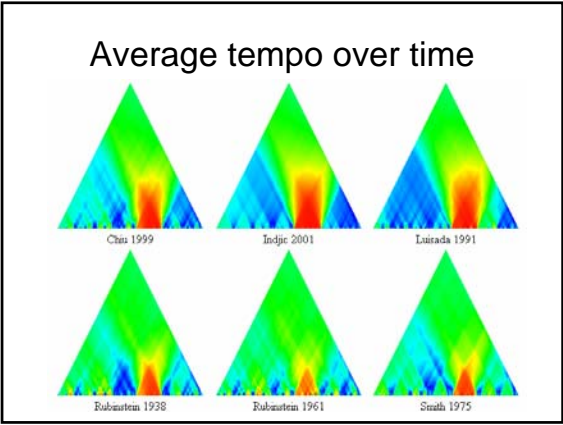
- Examine the internal tempo structure of a performances
 - where is tempo faster/slower?
- Plot average tempos over various time-spans in the piece
- Example of a piece with 6 beats at tempos A, B, C, D, E, and F:



Average tempo



Mazurka in F major, Op. 67, No. 3: Frederic Chiu; 1999



For Further Information

Mazurka Project
AHRC Research
Centre for the History and Analysis of Recorded Music

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

<http://mazurka.org.uk>