

Performance Analysis



Let's analyze some performances

Franz Schubert: Six Moments Musicaux, op. 94 No. 3

Allegro moderato

Performance I ▶

Performance II ▶

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Comparison of the two performances

	Performance I ▶	Performance II ▶
Global Tempo		
Local Tempo / Agogics		
Local Dynamics		
Articulation		

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Comparison of the two performances

	Performance I ▶	Performance II ▶
Global Tempo	Slightly slower	Slightly faster
Local Tempo / Agogics		
Local Dynamics		
Articulation		

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Comparison of the two performances

	Performance I ▶	Performance II ▶
Global Tempo	Slightly slower	Slightly faster
Local Tempo / Agogics	Quite static	More expressive (use of rubato)
Local Dynamics		
Articulation		

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Comparison of the two performances

	Performance I ▶	Performance II ▶
Global Tempo	Slightly slower	Slightly faster
Local Tempo / Agogics	Quite static	More expressive (use of rubato)
Local Dynamics	Quite static	Wider range
Articulation		

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Comparison of the two performances

	Performance I ▶	Performance II ▶
Global Tempo	Slightly slower	Slightly faster
Local Tempo / Agogics	Quite static	More expressive (use of rubato)
Local Dynamics	Quite static	Wider range
Articulation	Legato	Staccato

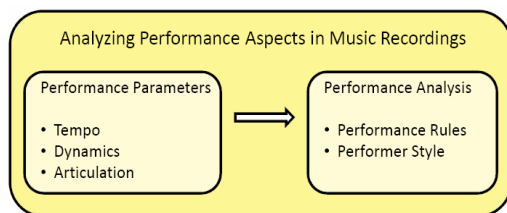
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Expressive Music Performance

- Art of shaping a musical piece by varying
 - tempo
 - dynamics
 - articulation
- Musicians give the piece of music a personal touch by
 - speeding up
 - slowing down
 - stressing certain notes

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Analyzing Performance Aspects in Music Recordings



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The two orthogonal tasks of Performance Analysis

- Are there commonalities between different performers which lead to fundamental principles and allow us to find general rules?
- Can one characterize formally what is special about the style of a particular pianist?

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Extracting Tempo Parameters

- Restrict ourselves to Western classical piano music

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Extracting Tempo Parameters

- Restrict ourselves to Western classical piano music
- Possibilities to find musically meaningful events (note onsets or beat)

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Extracting Tempo Parameters

- Restrict ourselves to Western classical piano music
- Possibilities to find musically meaningful events (note onsets or beat)
 - Manual annotation**
 - very labor-intensive
 - prohibitive in view of large audio collections

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Extracting Tempo Parameters

- Restrict ourselves to Western classical piano music
- Possibilities to find musically meaningful events (note onsets or beat)
 - Manual annotation**
 - Direct annotation**
 - use of a computer-monitored player piano



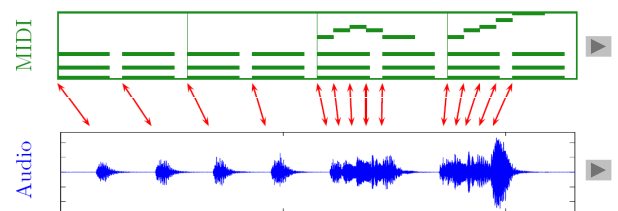
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Extracting Tempo Parameters

- Restrict ourselves to Western classical piano music
- Possibilities to find musically meaningful events (note onsets or beat)
 - Manual annotation**
 - Direct annotation**
 - Automatic annotation**
 - beat tracking
 - onset detection algorithms
 - results still unsatisfactory
 - usage of automated methods still problematic

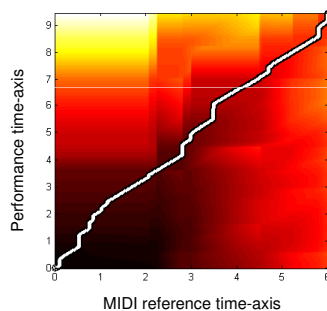
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Music Synchronization: MIDI-Audio



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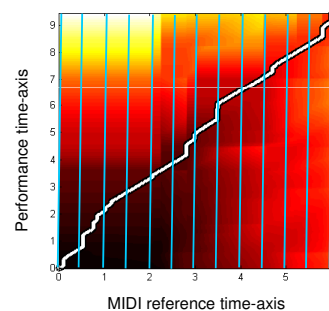
Computation of Tempo Curve



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Computation of Tempo Curve

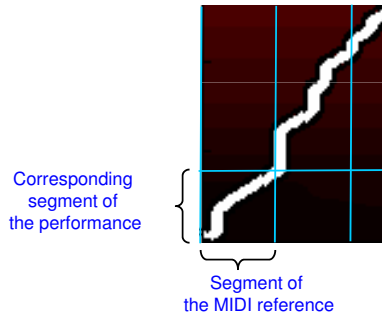
- Evaluate warping path at periodic intervals
- Compute tempo ratios



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Computation of Tempo Curve

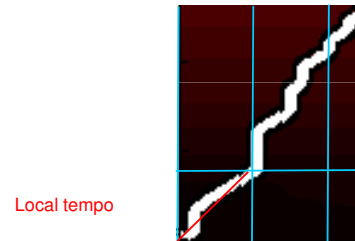
- Evaluate warping path at periodic intervals
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Computation of Tempo Curve

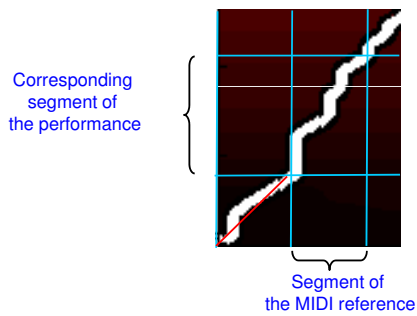
- Evaluate warping path at periodic intervals
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Computation of Tempo Curve

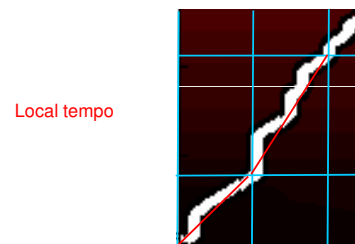
- Evaluate warping path at periodic intervals
- Compute tempo ratios



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Computation of Tempo Curve

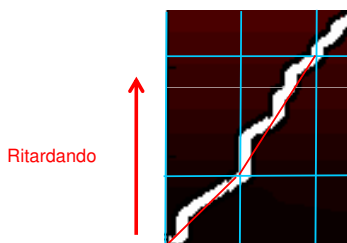
- Evaluate warping path at periodic intervals
- Compute tempo ratios



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Computation of Tempo Curve

- Evaluate warping path at periodic intervals
- Compute tempo ratios



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Computation of Tempo Curve

Choose the segment of the reference for which the tempo should be determined: segment_r

Use the warping path for the computation of the semantically corresponding segment in the performance: segment_p

Tempo in this segment is given by $\frac{\text{segment}_r}{\text{segment}_p}$

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Computation of Tempo Curve

Choose the segment of the reference for which the tempo should be determined: segment_r

Use the warping path for the computation of the semantically corresponding segment in the performance: segment_p

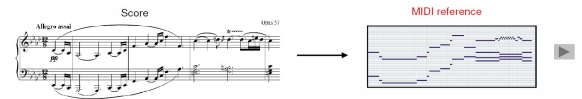
Tempo in this segment is given by $\frac{\text{segment}_r}{\text{segment}_p}$

Choice of parameters:

- Size of window
- Fixed window size vs. adaptive window size

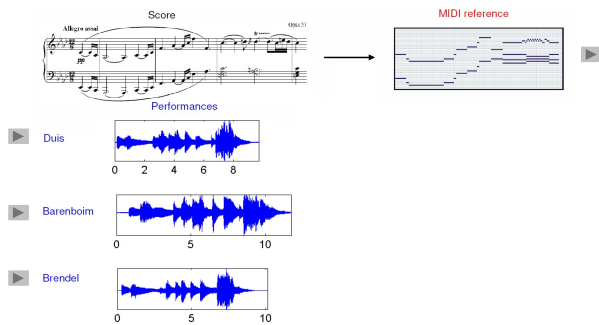
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Computation of Tempo Curve



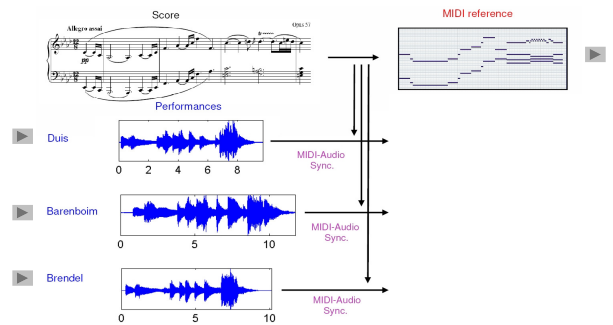
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Computation of Tempo Curve



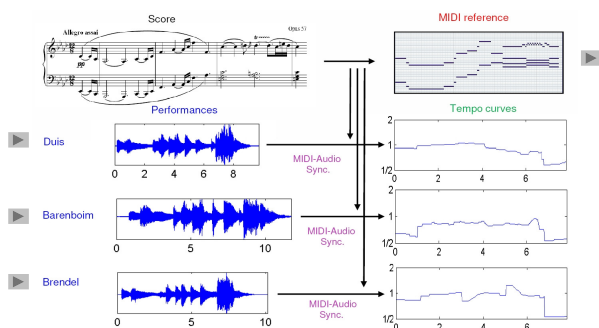
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Computation of Tempo Curve



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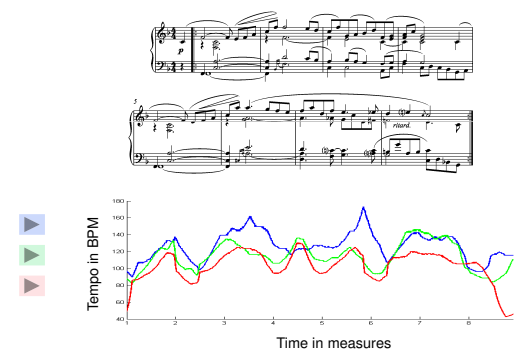
Computation of Tempo Curve



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Tempo Curves

Schumann's "Träumerei"

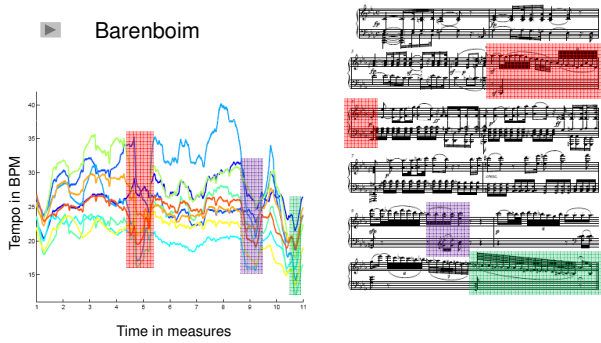


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Tempo Curves

Beethoven's Pathétique

► Barenboim

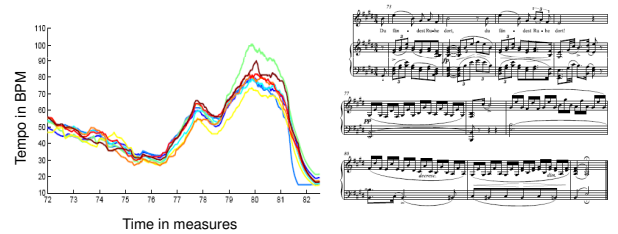


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Tempo Curves

Schubert Song "Der Lindenbaum"

► Oliemans

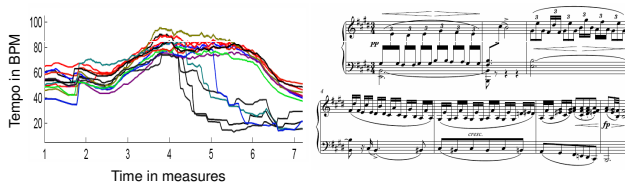


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Tempo Curves

Schubert Song "Der Lindenbaum"

► Oliemans

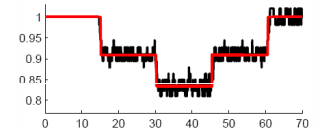


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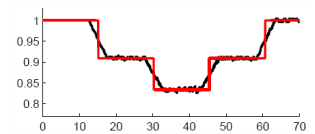
Tempo Curves

Dependence on window size

Small window



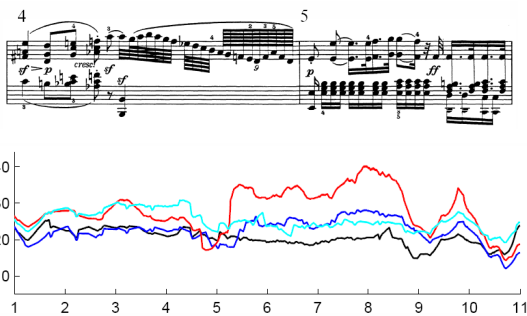
Large window



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Tempo Curves

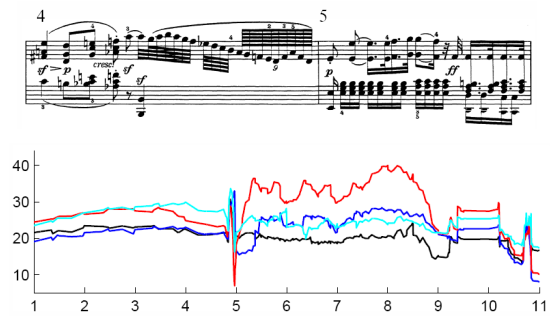
Fixed window size



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Tempo Curves

Adaptive window size



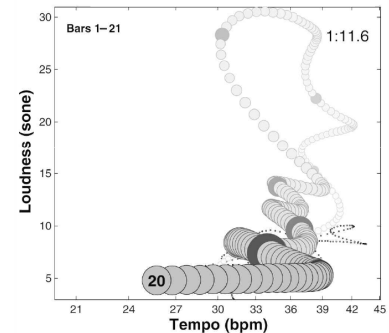
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Summary

- So far good estimations of overall tempo
- Extracting other performance parameters such as dynamics
- Tradeoff between accuracy and robustness
- Problems arise in the case of faulty alignment paths as a result of synchronization problems
 - Automated extraction of fine tempo nuances very difficult problem!

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Widmer's Performance Worm

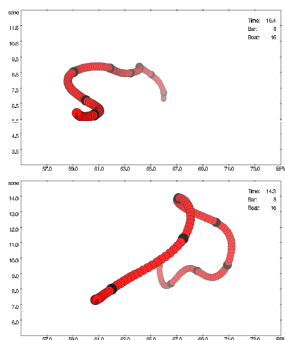


Source: [Langner2003]

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Widmer's Performance Worm

Schumann's "Von fremden Ländern und Menschen"



Martha Argerich

Vladimir Horowitz

Source: [Widmer2005]

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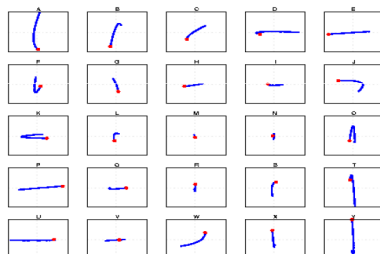
Widmer's Performance Worm

- The Performance Worm is cut into segments of a specified length
- Cluster the segments
- Computation of a prototype for each of the clusters
 - Alphabet of performance
- Transfer of the musical problem into string analysis

Source: [Widmer2005]

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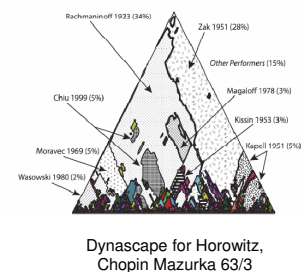
A typical Chopin Performance Alphabet



Source: [Widmer2005]

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Sapp's Scapeplot



Source: [Sapp2008]

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