

Lecture

Music Processing Analysis (MPA)

Overview

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Music

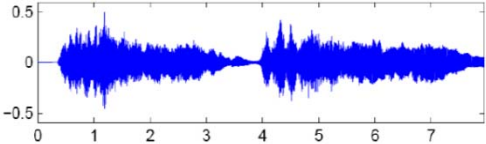


Music Processing

Sheet Music (Image)



CD / MP3 (Audio)



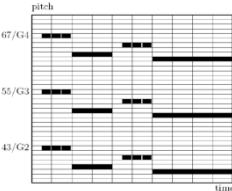
MusicXML (Text)

```
<note>  
  <pitch>  
    <step>E</step>  
    <alter>-1</alter>  
    <octave>4</octave>  
  </pitch>  
  <duration>2</duration>  
  <type>half</type>  
</note>
```

Dance / Motion (Mocap)



MIDI



Singing / Voice (Audio)



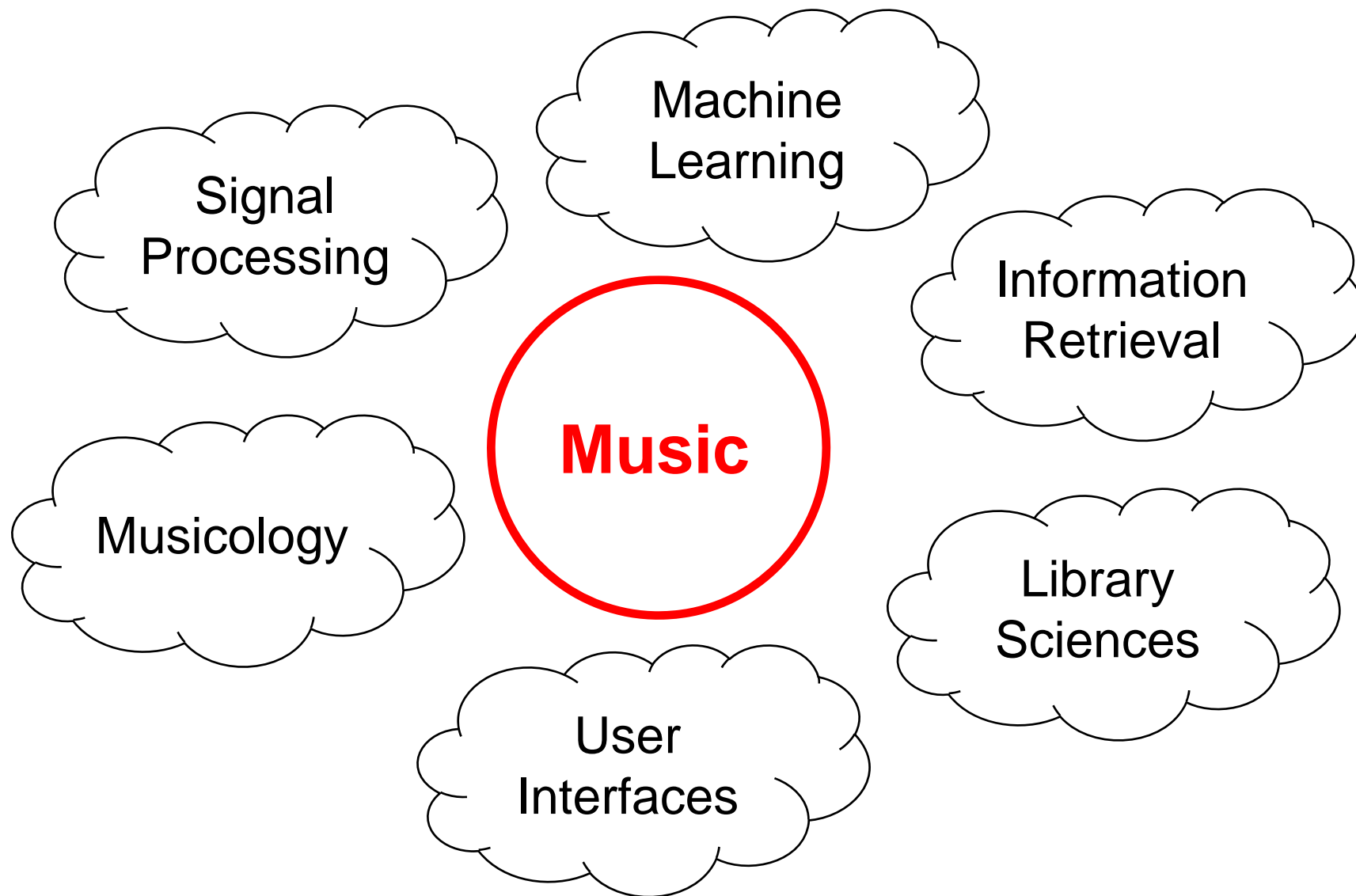
Music Film (Video)



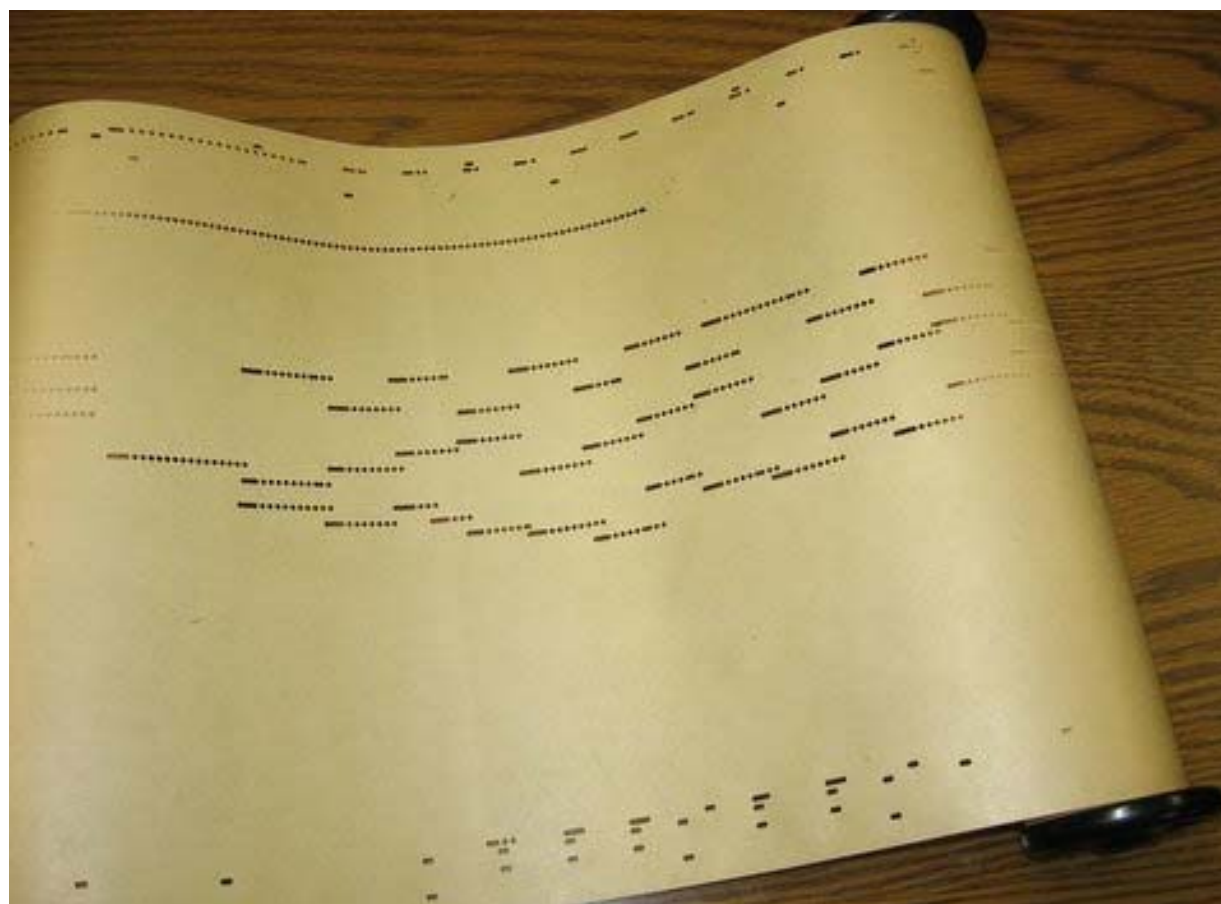
Music Literature (Text)



Music Processing



Piano Roll Representation



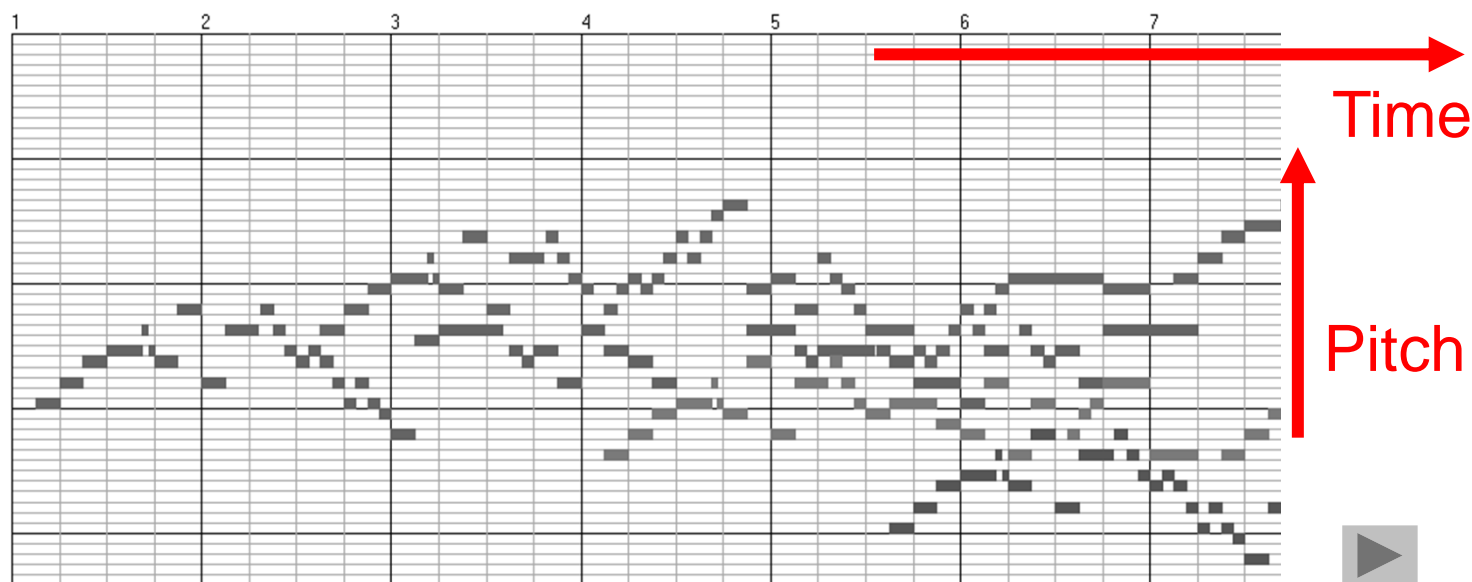
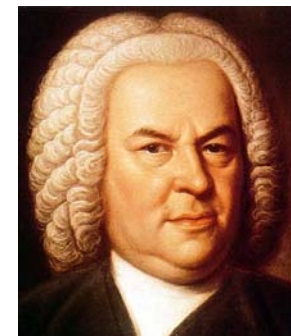
Player Piano (1900)



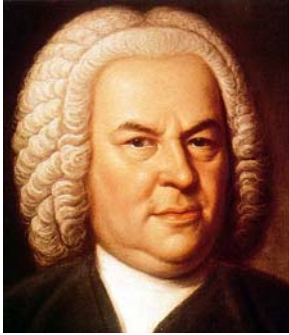
Piano Roll Representation (MIDI)

J.S. Bach, C-Major Fuge

(Well Tempered Piano, BWV 846)



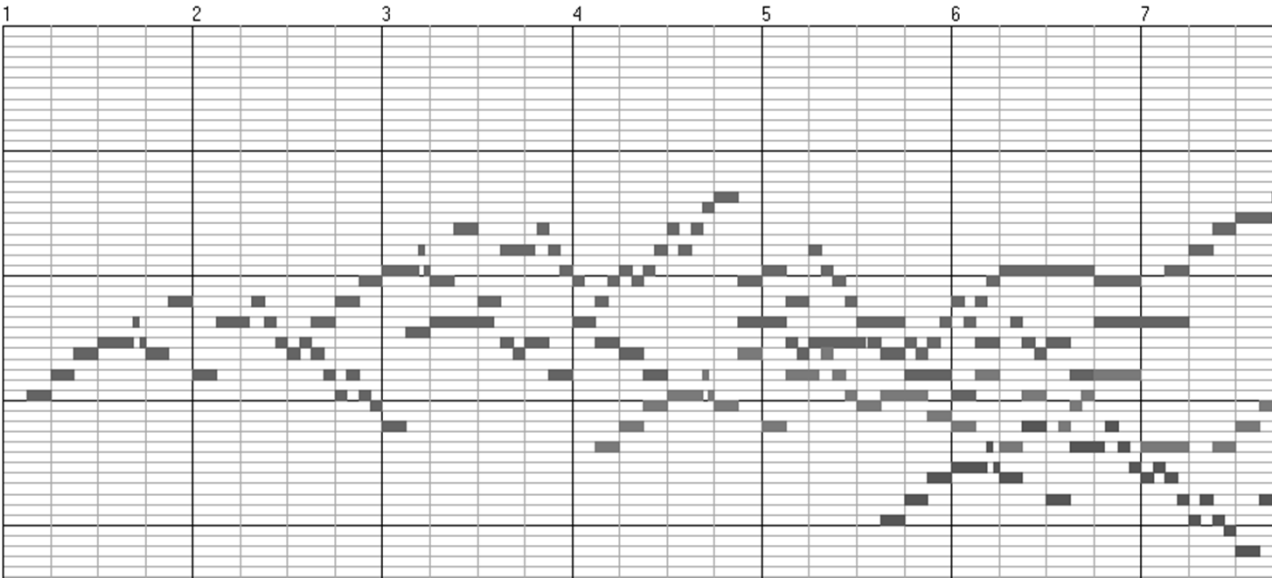
Piano Roll Representation (MIDI)



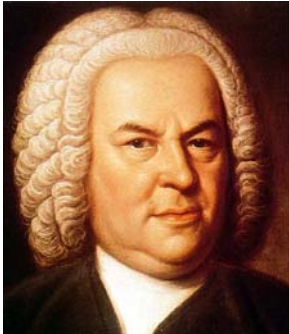
Query:



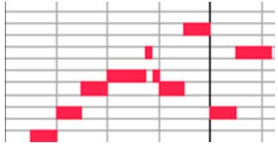
Goal: Find all occurrences of the query



Piano Roll Representation (MIDI)

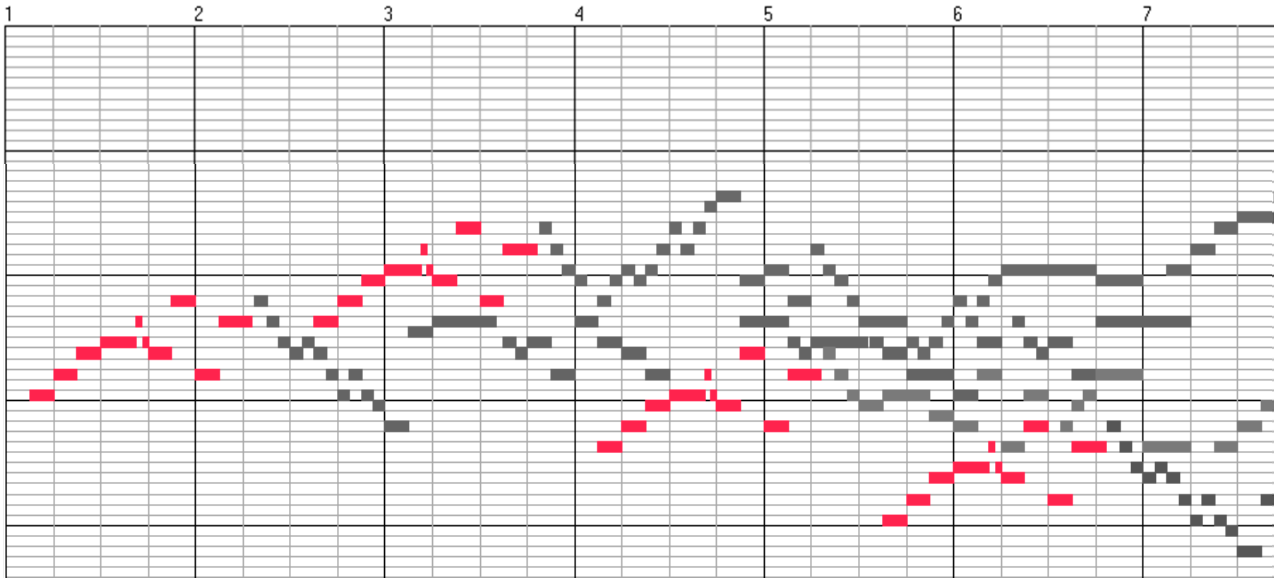


Query:

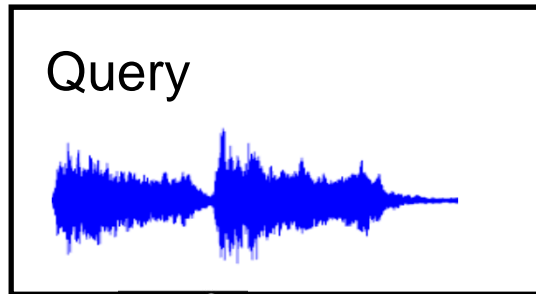


Goal: Find all occurrences of the query

Matches:



Music Retrieval

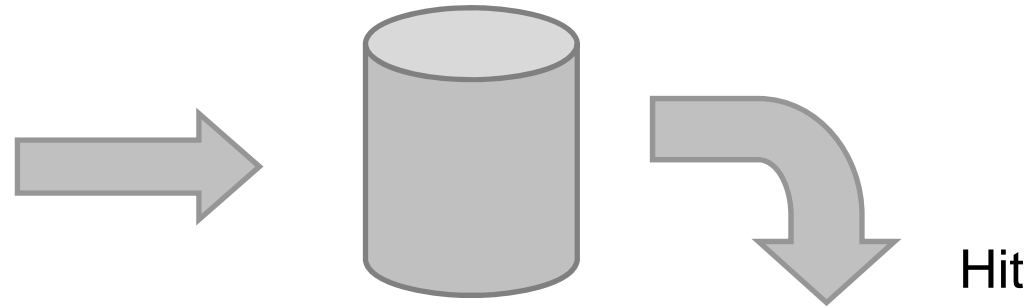


Audio-ID

Version-ID

Kategorie-ID

Database



Bernstein (1962)
Beethoven, Symphony No. 5

Beethoven, Symphony No. 5:

- Bernstein (1962)
- Karajan (1982)
- Gould (1992)

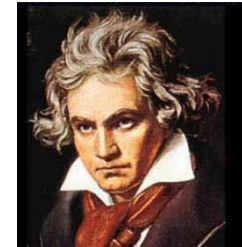


- Beethoven, Symphony No. 9
- Beethoven, Symphony No. 3
- Haydn Symphony No. 94



Music Synchronization: Audio-Audio

Beethoven's Fifth

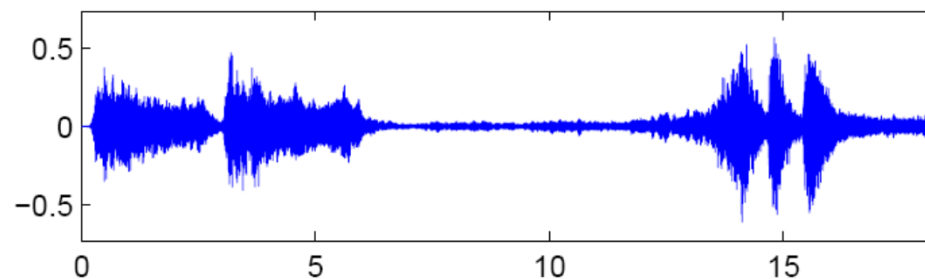


Music Synchronization: Audio-Audio

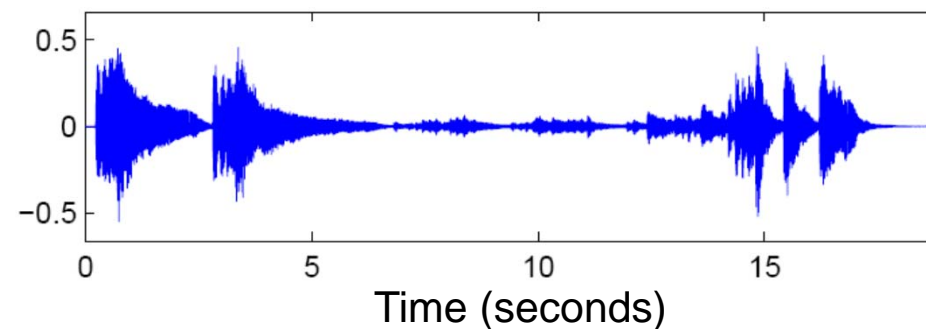
Beethoven's Fifth



Orchester
(Karajan)

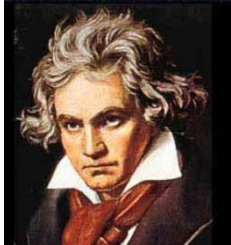


Piano
(Scherbakov)

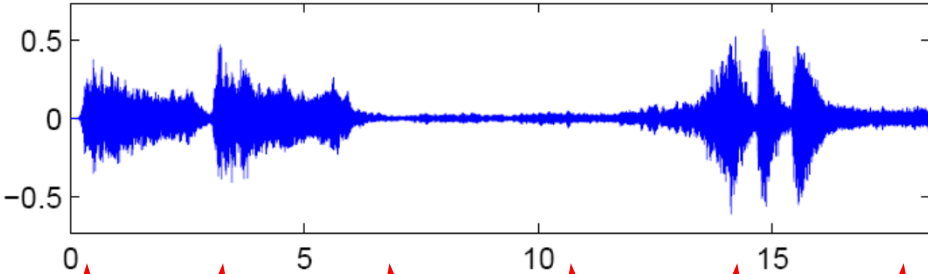


Music Synchronization: Audio-Audio

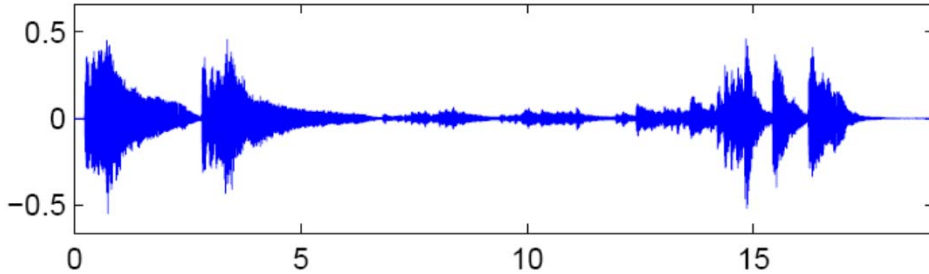
Beethoven's Fifth



Orchester
(Karajan)



Piano
(Scherbakov)



Time (seconds)



Application: Interpretation Switcher

The screenshot shows a software window titled "Interpretation Switcher" for "Beethoven, Op067-1_Symphony5". The interface features four horizontal progress bars, each representing a different interpretation: "midi", "Bernstein", "Sawallisch", and "Scherbakov". Each bar is divided into three segments: blue, red, and green. A white playhead marker is positioned on the red segment of each bar, indicating the current playback position. The total duration for each interpretation is displayed to the right of the bar: "midi" (00:44.18), "Bernstein" (01:00.64), "Sawallisch" (00:58.35), and "Scherbakov" (00:52.45). On the right side of the window, there is a list of checkboxes for selecting interpretations: "midi", "Bernstein", "Sawallisch", and "Scherbakov", all of which are currently checked. Below this list is a "Deselect all" button. At the bottom of the window, there is a control bar with the following elements: a radio button for "Absolute" (which is selected), a radio button for "Relative", a radio button for "Reference", a play/pause button, a stop button, a "Movement selection" button, a checkbox for "Interval Repeat" (which is unchecked), and an "Info" button. A "Deselect all" button is also present in the bottom right corner of the main content area.

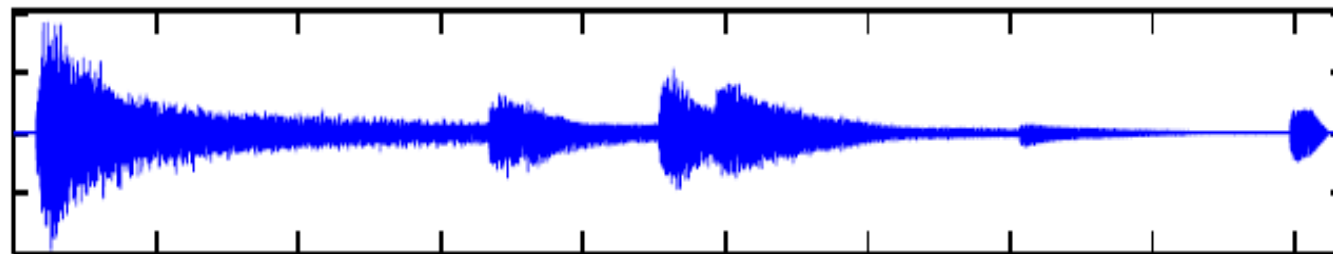


Music Synchronization: Image-Audio

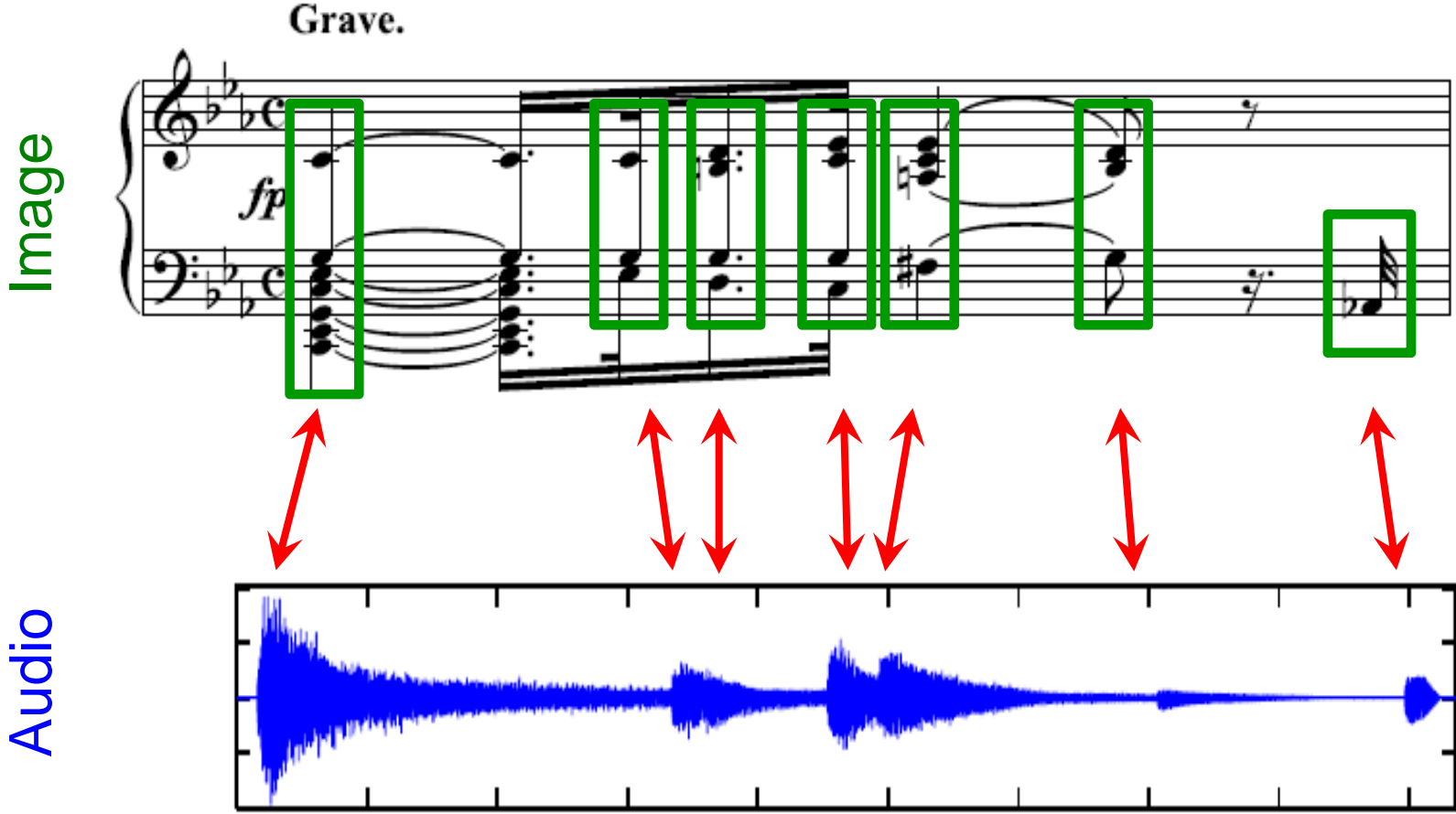
Image



Audio



Music Synchronization: Image-Audio

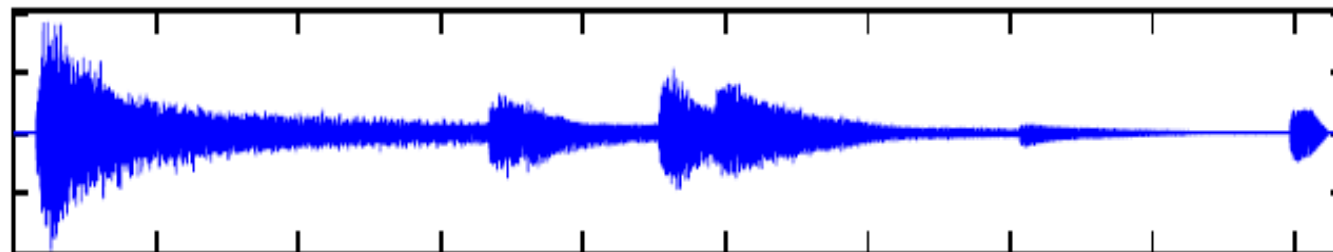


How to make the data comparable?

Image



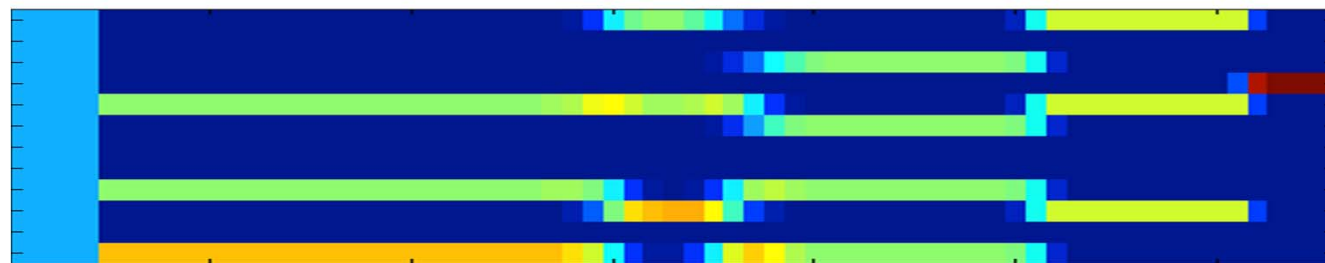
Audio



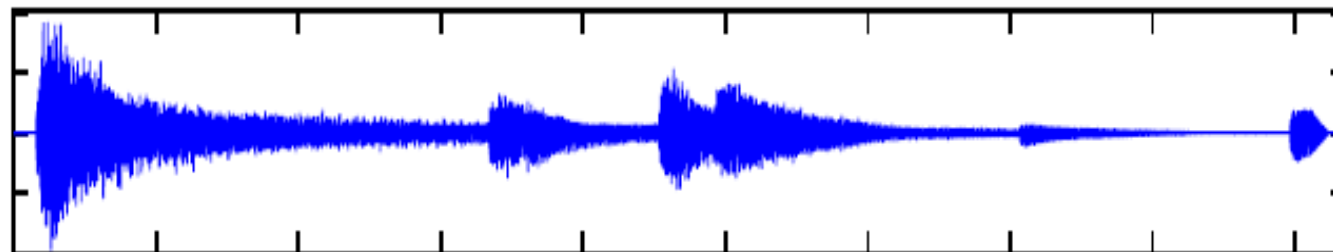
How to make the data comparable?

Image Processing: Optical Music Recognition

Image



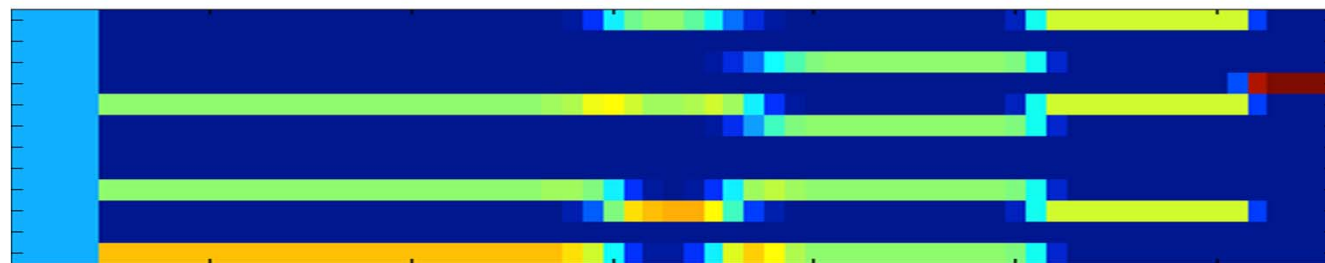
Audio



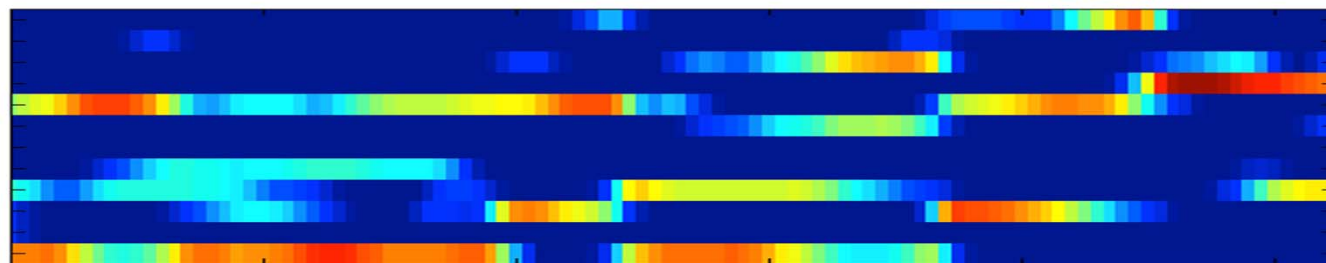
How to make the data comparable?

Image Processing: Optical Music Recognition

Image



Audio

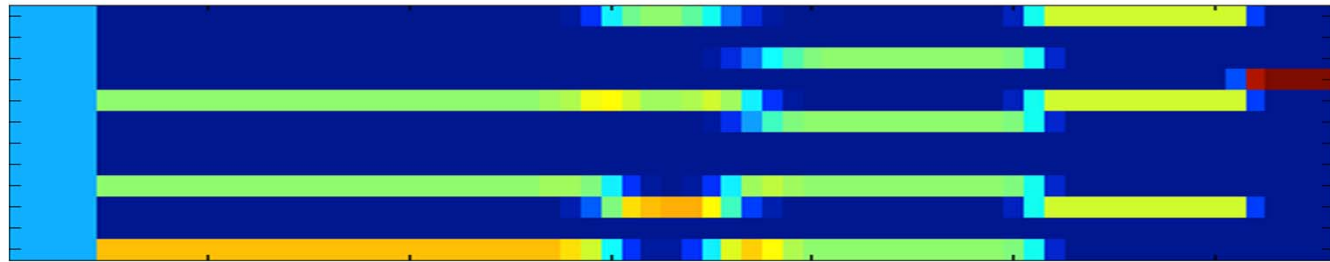


Audio Processing: Fourier Analyse

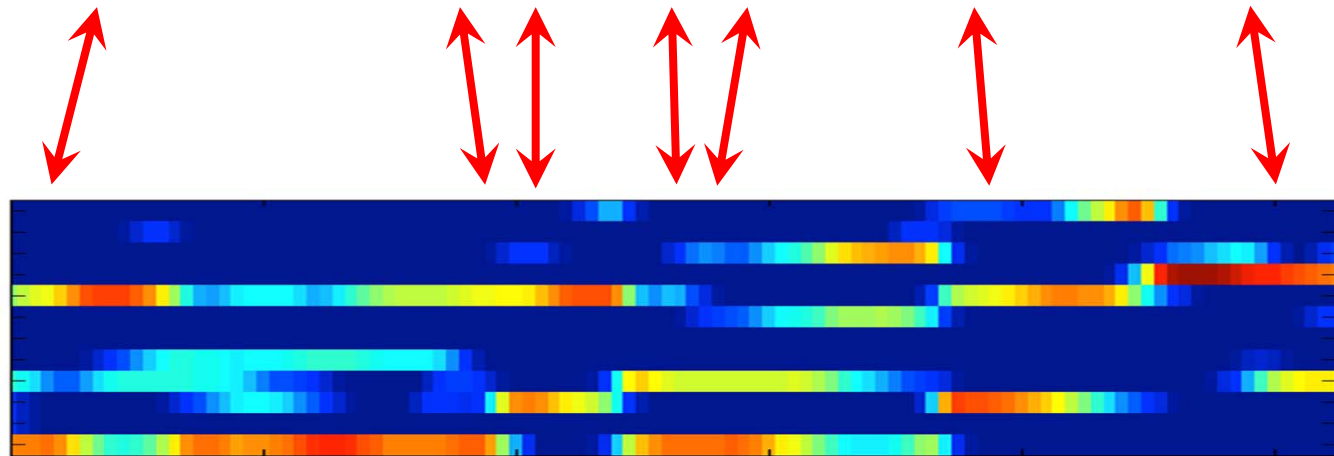
How to make the data comparable?

Image Processing: Optical Music Recognition

Image



Audio



Audio Processing: Fourier Analyse



Application: Score Viewer

The AudioViewer window displays the album cover for "Beethoven - Complete Piano Sonatas - Daniel Barenboim". Below the cover is a tracklist for "Disc 3".

Track	Duration
01 Sonata no.7 in D major, op.10 no.3: Presto	7:08
02 Sonata no.7 in D major, op.10 no.3: Largo e mesto	10:02
03 Sonata no.7 in D major, op.10 no.3: Menuetto (Allegro)	2:53
04 Sonata no.7 in D major, op.10 no.3: Rondo (Allegro)	4:05
05 Sonata no.8 in C minor, op.13, "Pathetique" / Allegro di molto e con brio	9:32
06 Sonata no.8 in C minor, op.13, "Pathetique" / Adagio cantabile	5:19
07 Sonata no.8 in C minor, op.13, "Pathetique" / Rondo (Allegro)	4:53
08 Sonata no.9 in E major, op.14 no.1: Allegro	6:48
09 Sonata no.9 in E major, op.14 no.1: Allegretto	4:16
10	

Navigation controls include a volume icon, a play/pause button, and a progress bar. Below the progress bar, the current selection is shown as "Disc: 3 / 10" and "Track: 7".

The ScoreViewer window displays a digital score for "Beethoven - Klaviersonaten Band 1 - Henle", specifically "Sonata no.8 in C minor, op.13, 'Pathetique' / Rondo (Allegro)". The score is presented as a two-page spread with musical notation. A yellow highlight is visible on the right page, and a yellow arrow points to it from the right. The interface includes navigation controls for track, bar, and page, as well as playback controls.

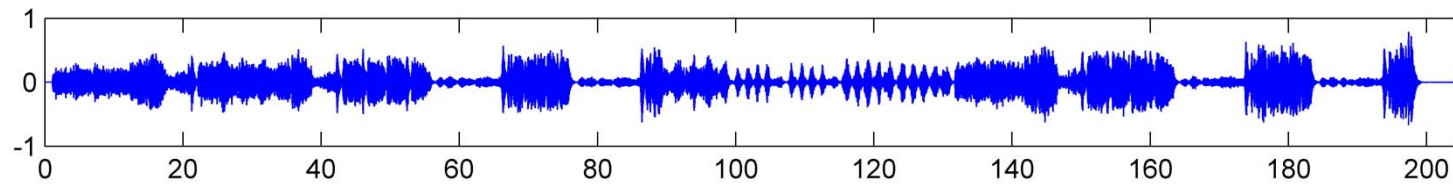
Track: 29 / 54 Bar: 9 / 211 Page: 159 / 285

Score Following Off Play Stop



Music Structure Analysis

Example: Brahms Hungarian Dance No. 5 (Ormandy)

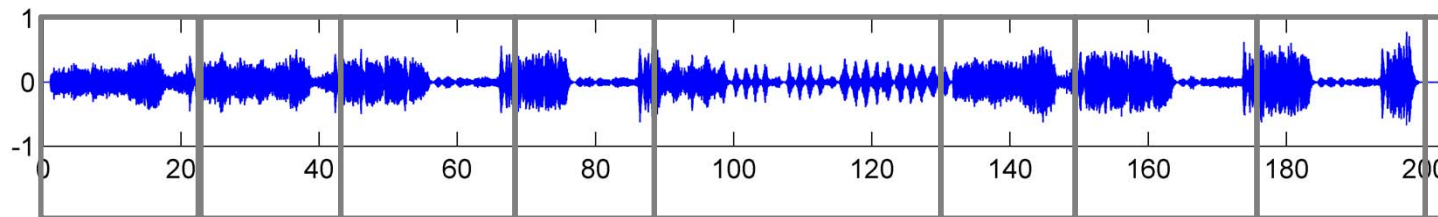


Time (seconds)



Music Structure Analysis

Example: Brahms Hungarian Dance No. 5 (Ormandy)

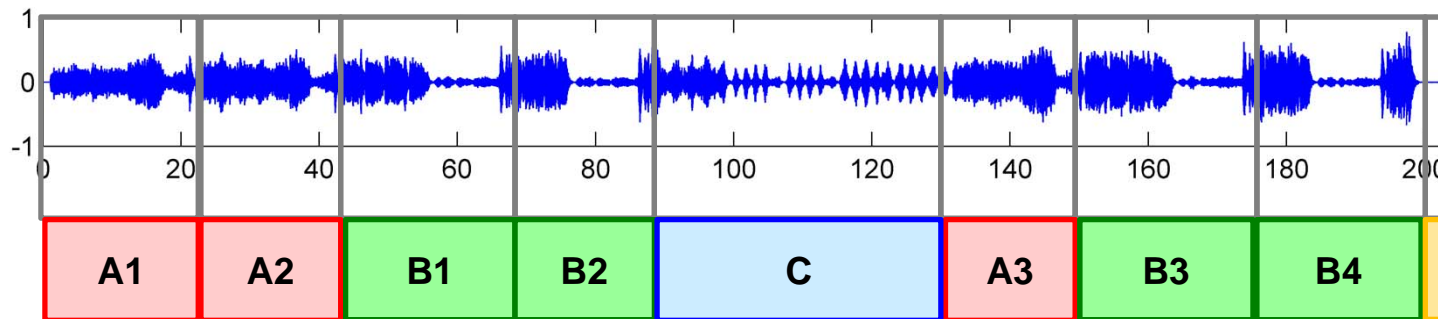


Time (seconds)



Music Structure Analysis

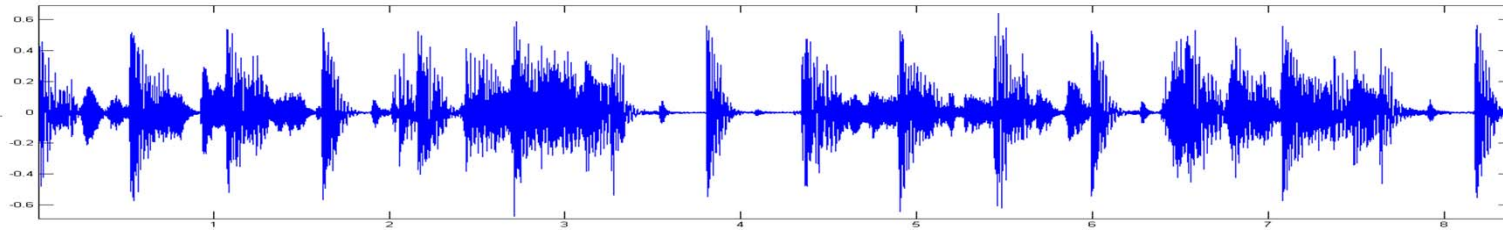
Example: Brahms Hungarian Dance No. 5 (Ormandy)



Tempo Estimation and Beat Tracking

Basic task: “Tapping the foot when listening to music”

Example: Queen – Another One Bites The Dust

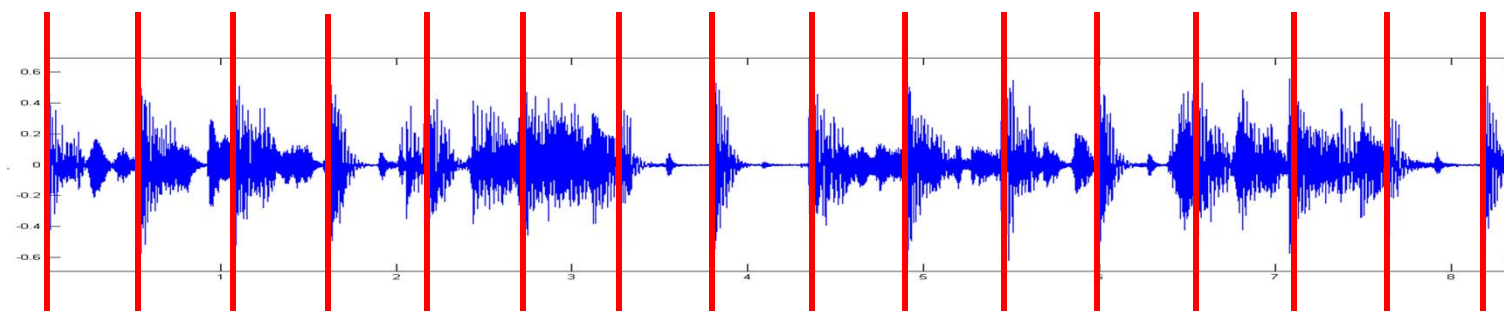


Time (seconds)

Tempo Estimation and Beat Tracking

Basic task: “Tapping the foot when listening to music”

Example: Queen – Another One Bites The Dust



Time (seconds)



Tempo Estimation and Beat Tracking

Light effects

Music recommendation

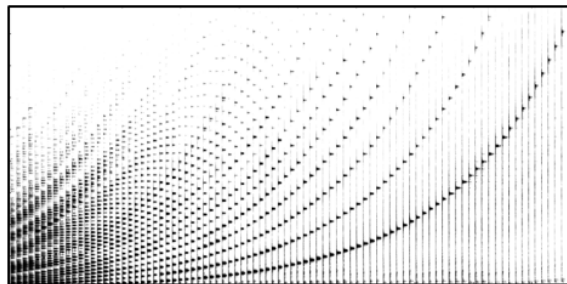
DJ

Audio editing

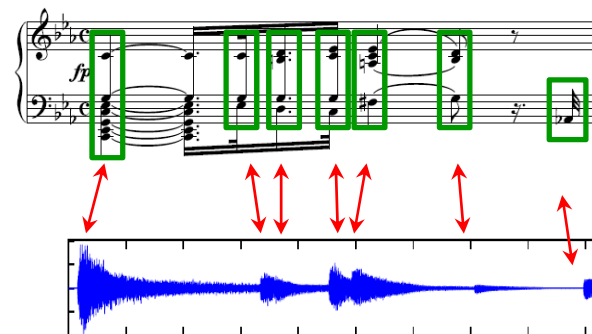


Music Processing

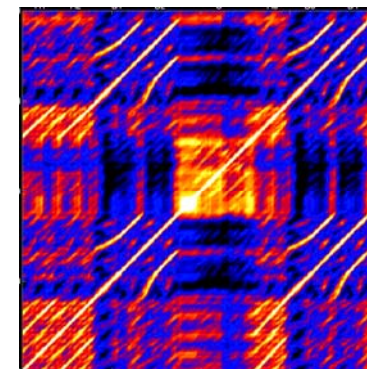
**Fourier Transform
Audio Features**



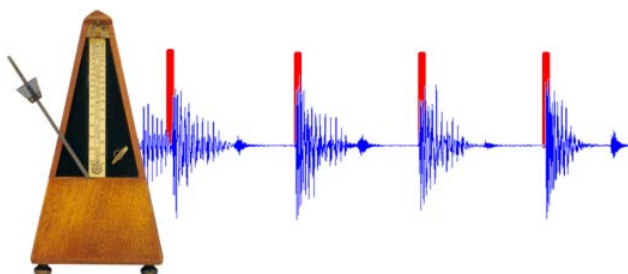
Music Synchronization



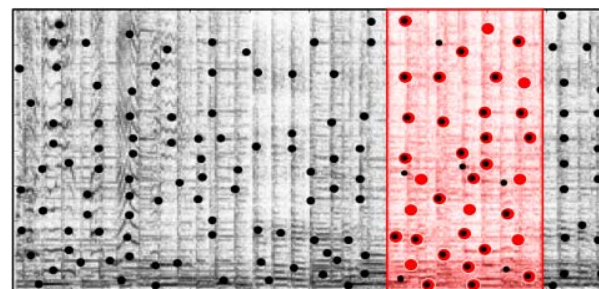
Structure Analysis



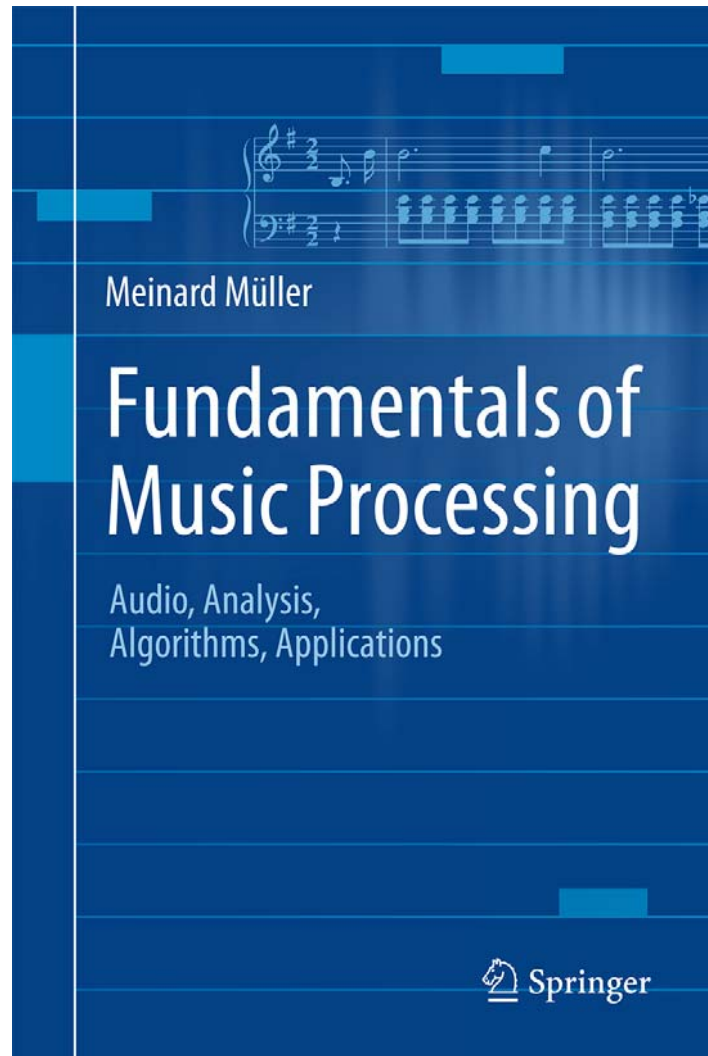
Tempo and Beat Tracking



Audio Identification



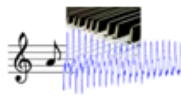

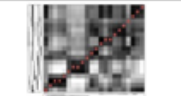
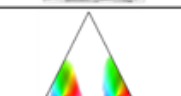

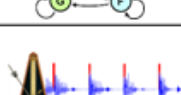


Book: Fundamentals of Music Processing



Meinard Müller
Fundamentals of Music Processing
Audio, Analysis, Algorithms, Applications
483 p., 249 illus., hardcover
ISBN: 978-3-319-21944-8
Springer, 2015

Accompanying website:
www.music-processing.de

Book: Fundamentals of Music Processing

Chapter		Music Processing Scenario
1		Music Representations
2		Fourier Analysis of Signals
3		Music Synchronization
4		Music Structure Analysis
5		Chord Recognition
6		Tempo and Beat Tracking
7		Content-Based Audio Retrieval
8		Musically Informed Audio Decomposition

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