

Lecture

Music Processing Analysis (MPA)

Overview

Meinard Müller

International Audio Laboratories Erlangen

meinard.mueller@audiolabs-erlangen.de

Music

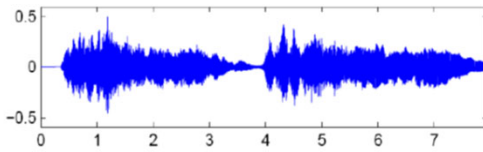


Music Information Retrieval (MIR)

Sheet Music (Image)



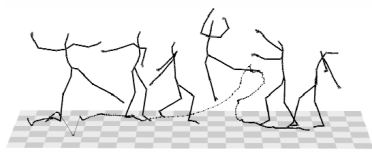
CD / MP3 (Audio)



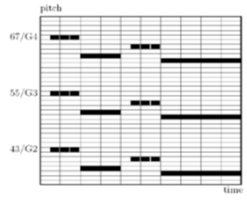
MusicXML (Text)

```
<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)



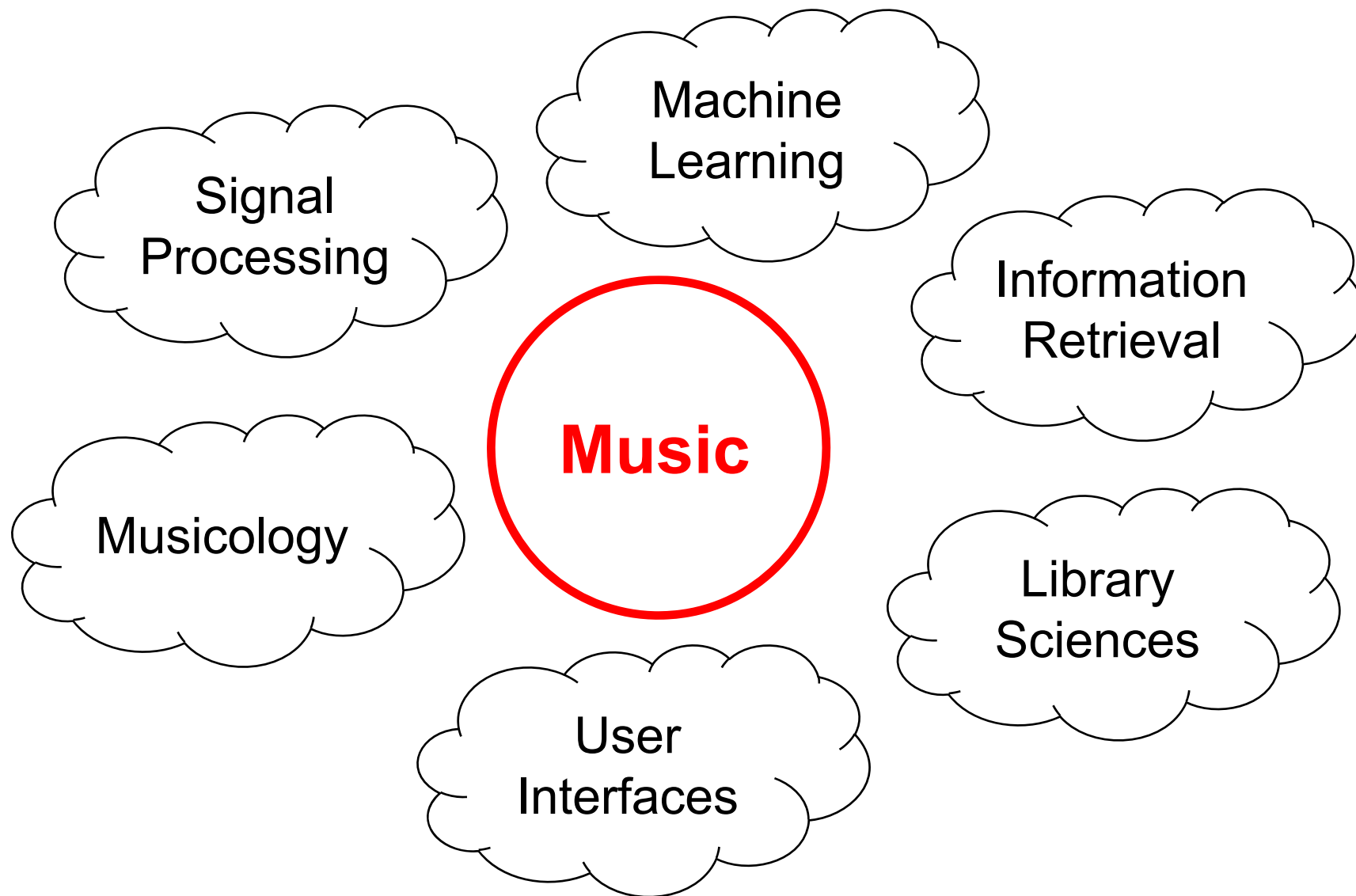
Music Film (Video)



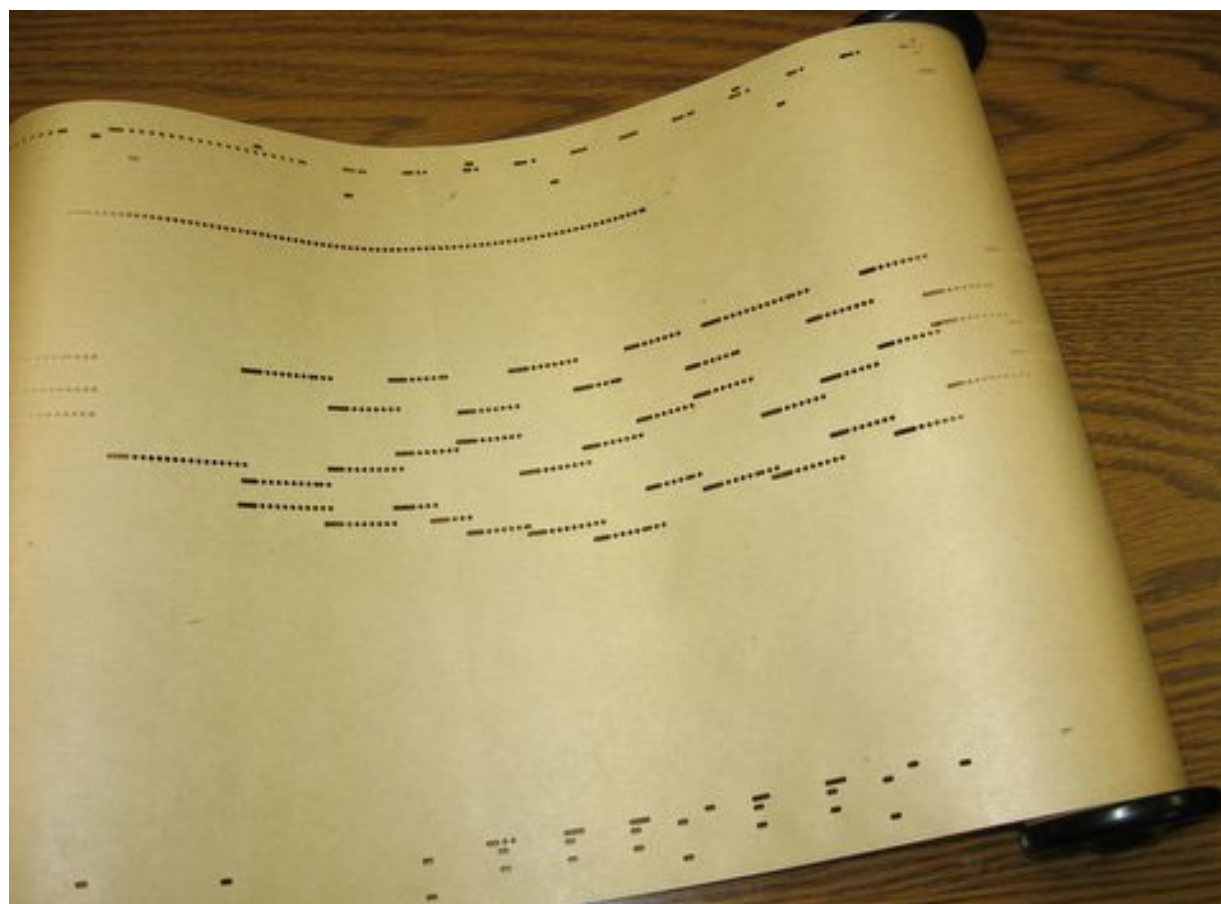
Music Literature (Text)



Music Information Retrieval (MIR)



Piano Roll Representation



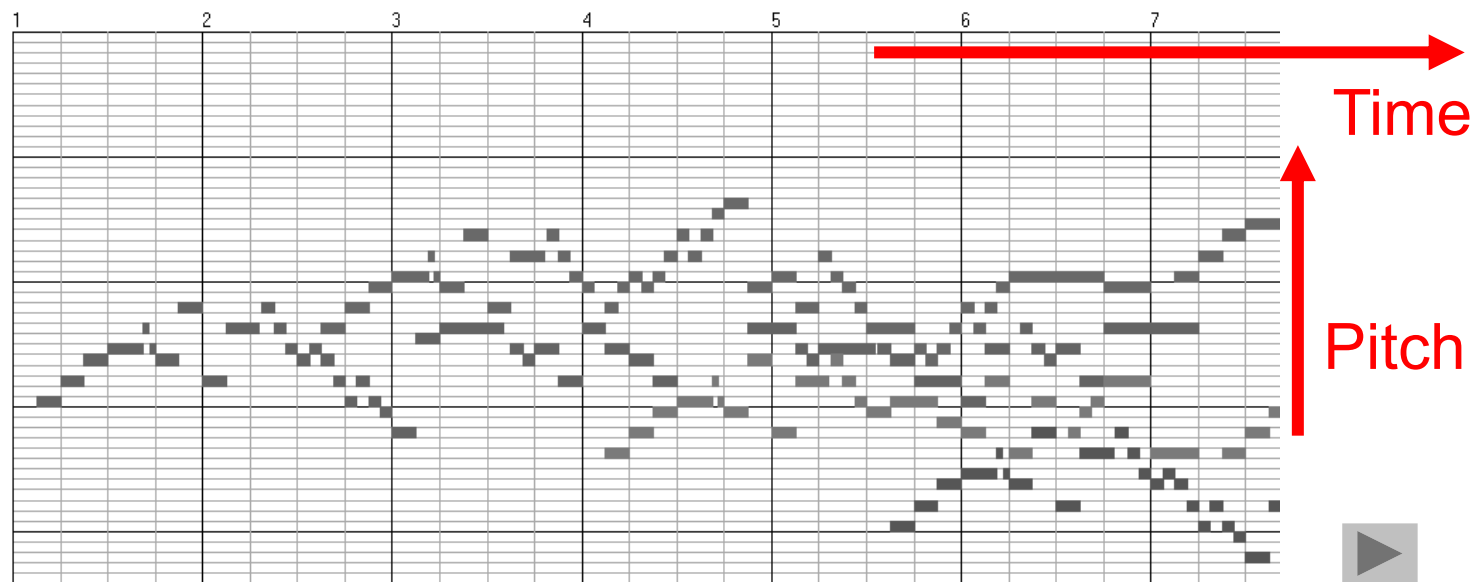
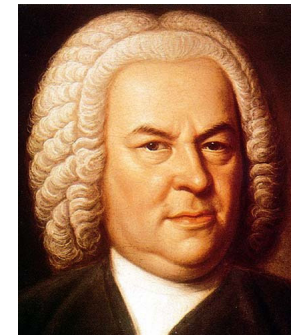
Player Piano (1900)



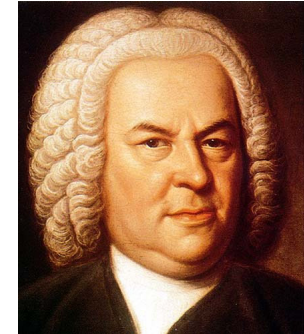
Piano Roll Representation (MIDI)

J.S. Bach, C-Major Fuge

(Well Tempered Piano, BWV 846)



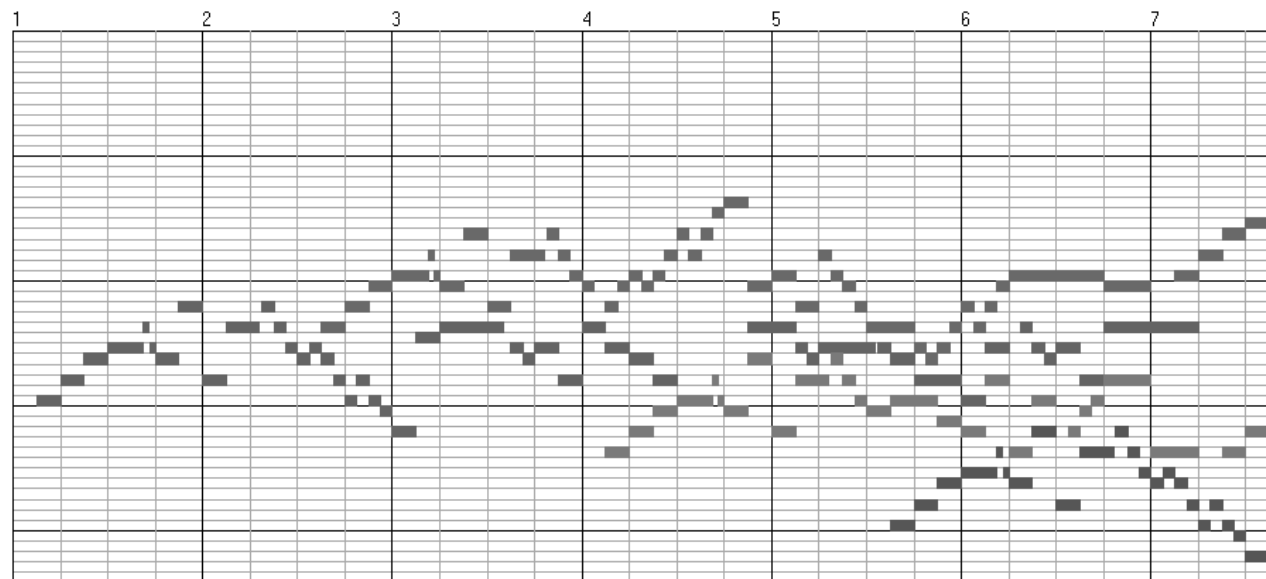
Piano Roll Representation (MIDI)



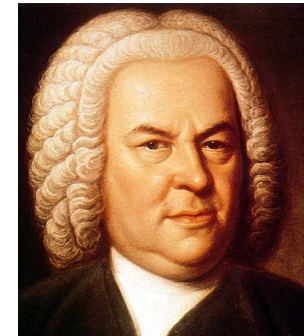
Query:



Goal: Find all occurrences of the query



Piano Roll Representation (MIDI)

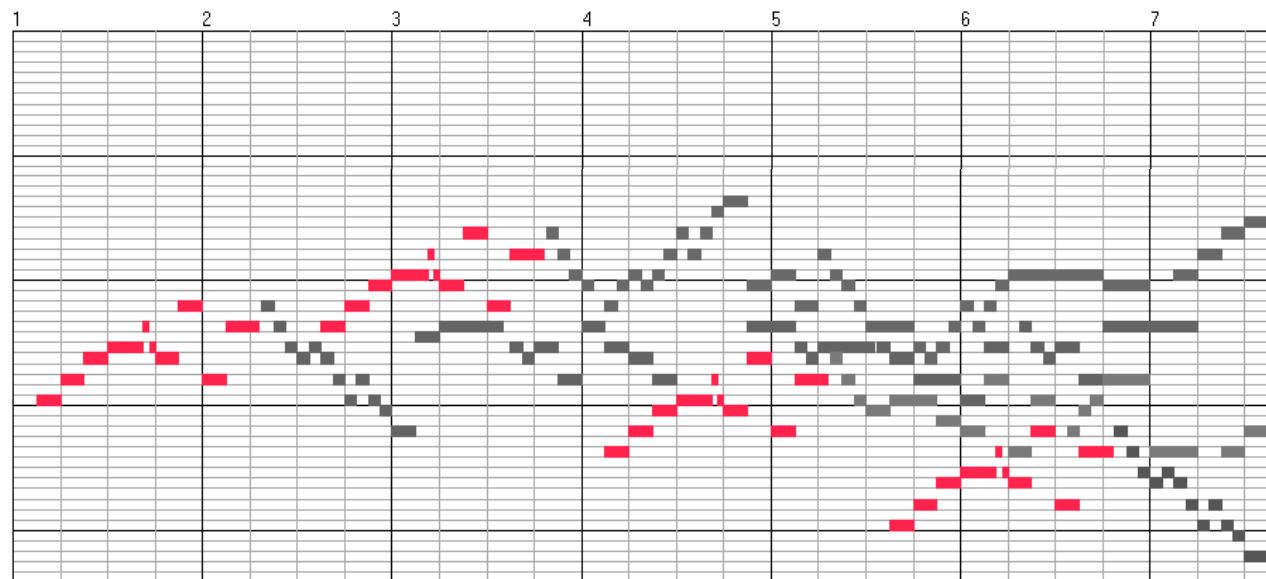


Query:

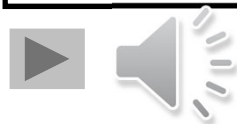
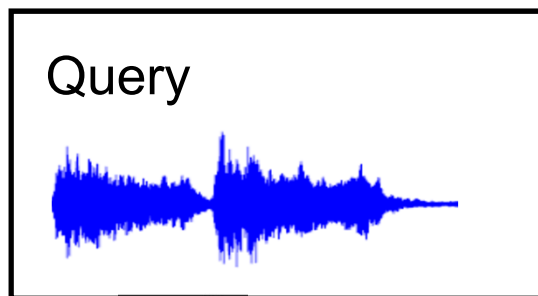


Goal: Find all occurrences of the query

Matches:



Music Retrieval

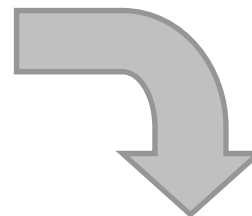
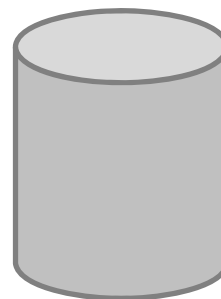


Audio-ID

Version-ID

Category-ID

Database



Hit

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

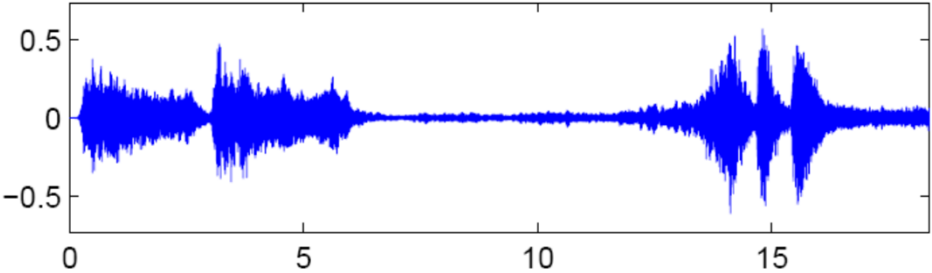


Music Synchronization: Audio-Audio

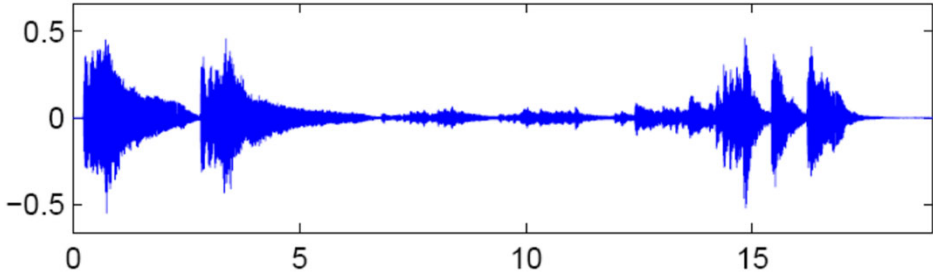
Beethoven's Fifth



Orchester
(Karajan)



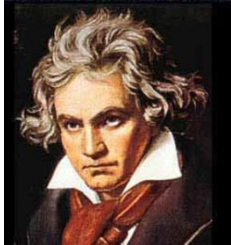
Piano
(Scherbakov)



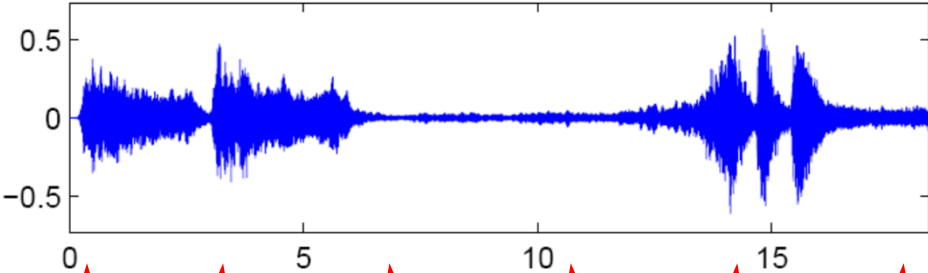
Time (seconds)

Music Synchronization: Audio-Audio

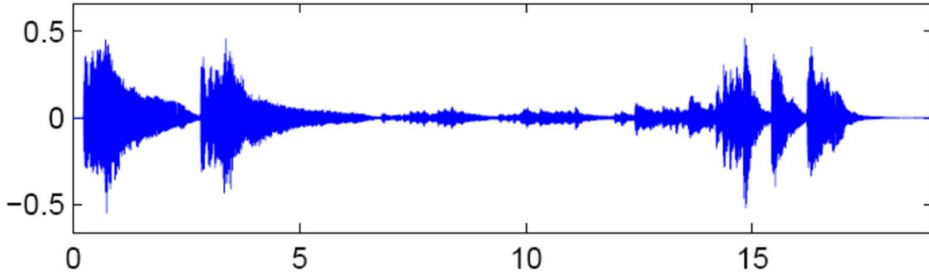
Beethoven's Fifth



Orchester
(Karajan)



Piano
(Scherbakov)



Time (seconds)

Application: Interpretation Switcher

The screenshot shows a software window titled "Interpretation Switcher" for the piece "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. The "midi" bar has the shortest segments, while "Bernstein" has the longest. The "Sawallisch" bar has a unique feature: a grey wedge-shaped area that tapers from left to right, overlapping the blue and red segments. To the right of the progress bars is a list of checkboxes for each interpretation, all of which are checked: "midi", "Bernstein", "Sawallisch", and "Scherbakov". Below the progress bars is a "Deselect all" button. At the bottom of the window is a control bar with the following elements from left to right: a radio button for "Absolute" (which is selected), a radio button for "Relative", a radio button for "Reference", a play button icon, a square stop button icon, a button labeled "Movement selection", a checkbox for "Interval Repeat", and a button labeled "Info".



Music Synchronization: Image-Audio

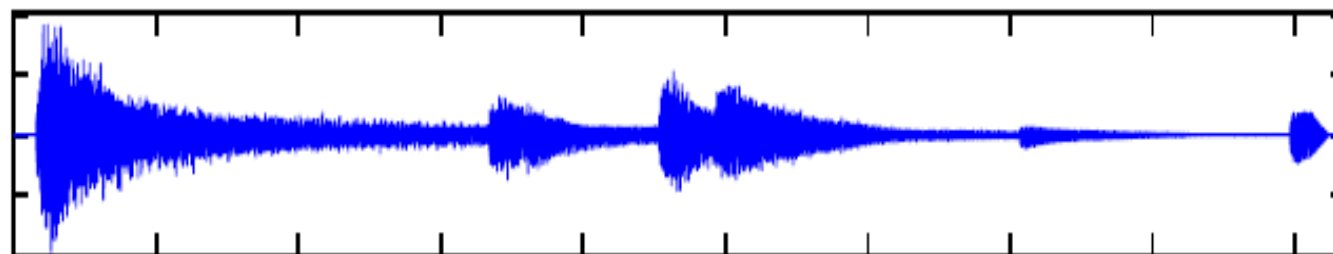
Image

Grave.

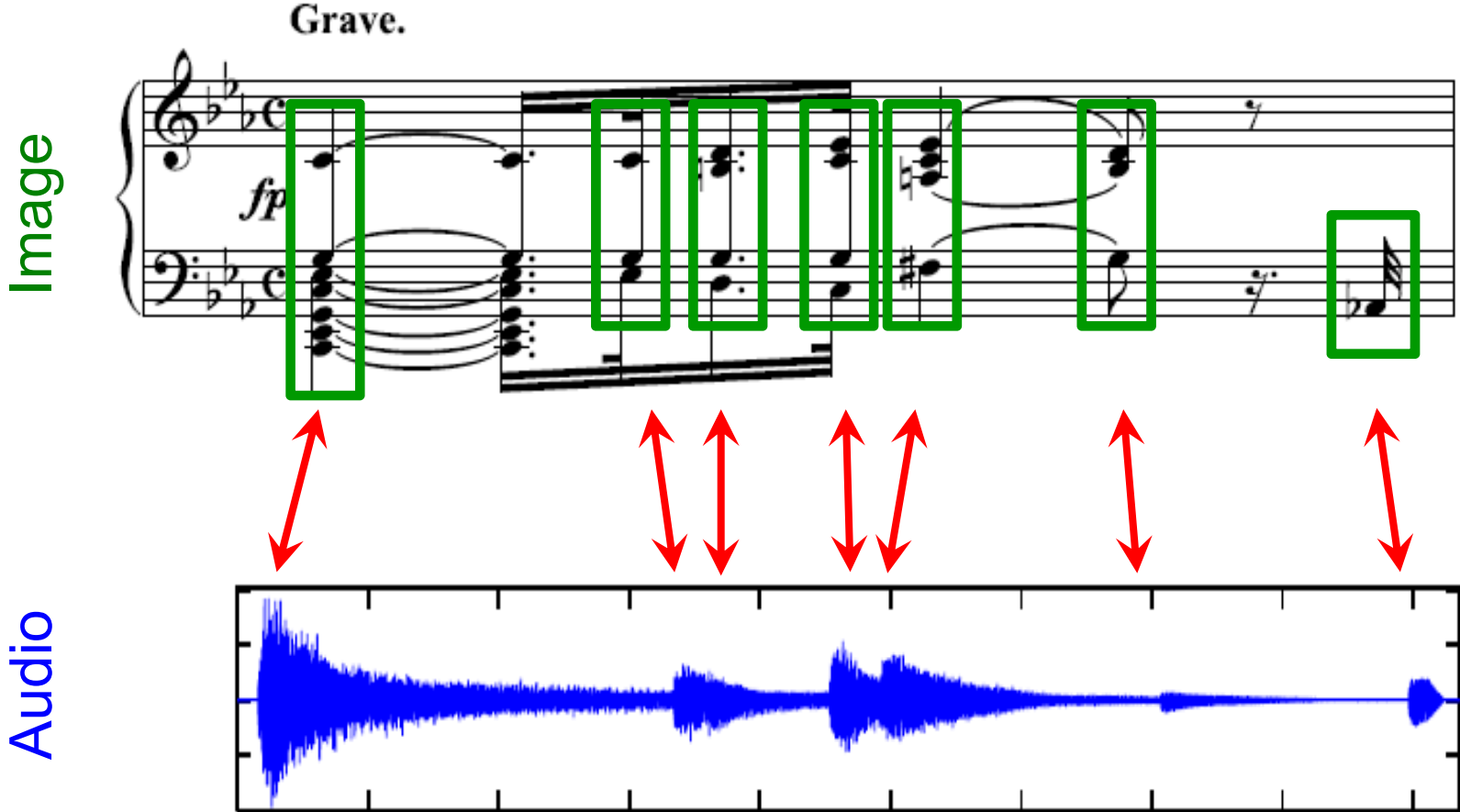


The image shows a musical score for piano, marked "Grave." and "fp". The score is written in a grand staff with a treble and bass clef. The key signature has two flats (B-flat and E-flat), and the time signature is common time (C). The music features a slow, somber melody with long, sustained notes and a heavy, low-register accompaniment in the bass. The tempo is indicated as "Grave." (very slow), and the dynamic is "fp" (fortissimo piano).

Audio



Music Synchronization: Image-Audio

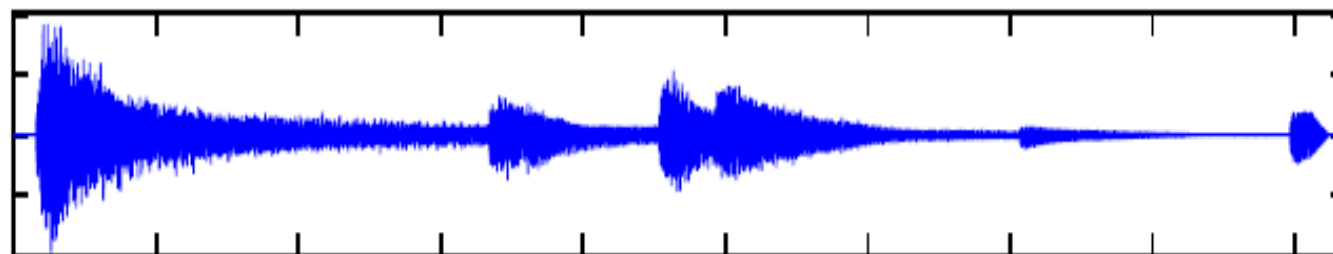


How to make the data comparable?

Image



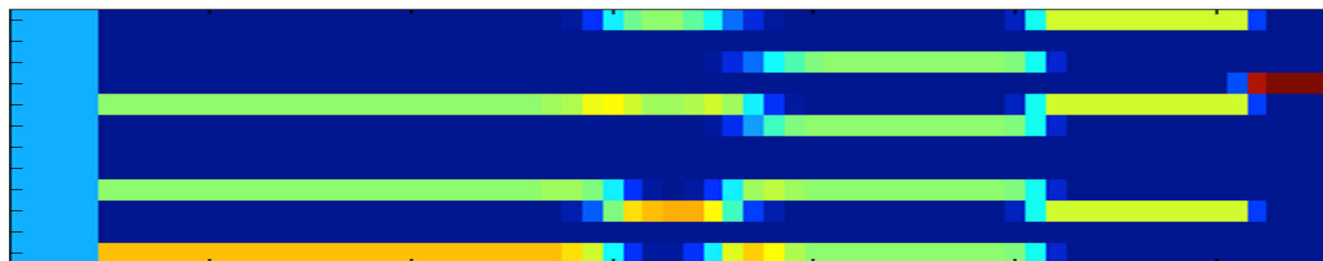
Audio



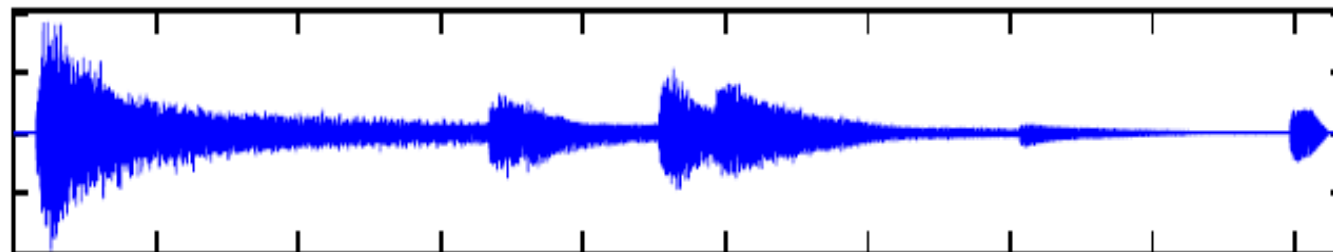
How to make the data comparable?

Image Processing: Optical Music Recognition

Image



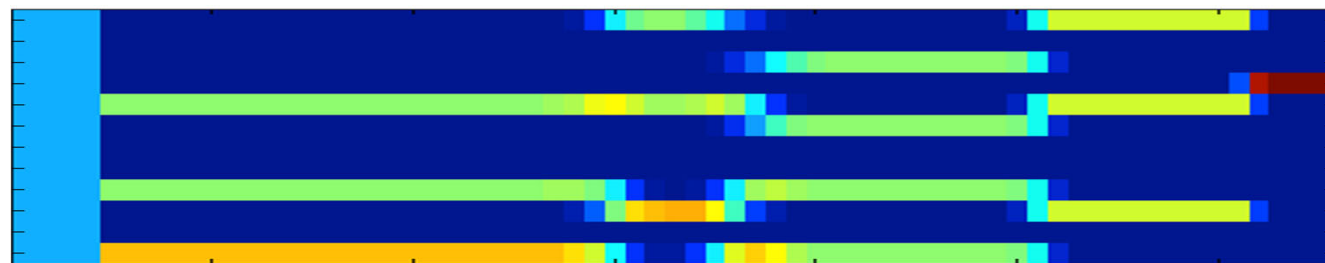
Audio



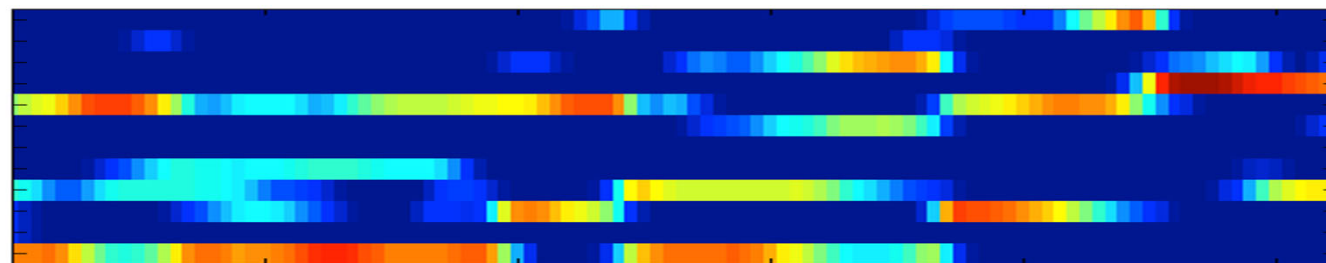
How to make the data comparable?

Image Processing: Optical Music Recognition

Image



Audio

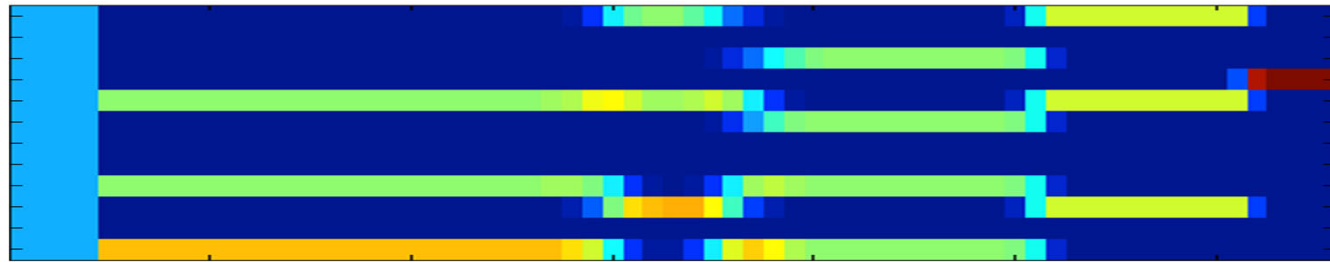


Audio Processing: Fourier Analysis

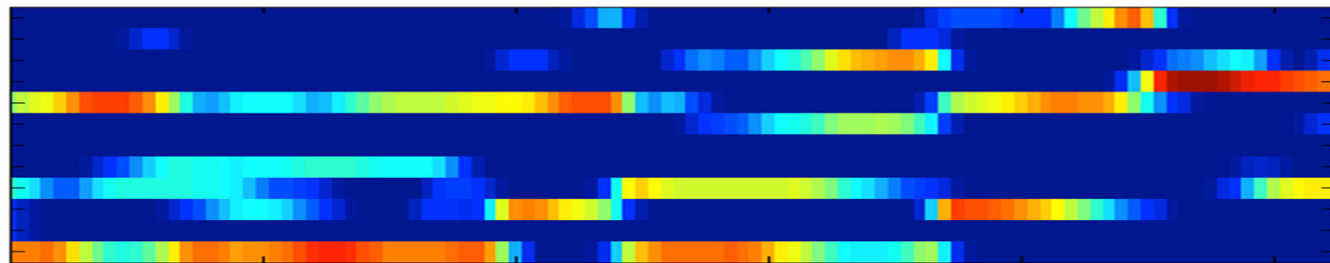
How to make the data comparable?

Image Processing: Optical Music Recognition

Image



Audio



Audio Processing: Fourier Analysis



Application: Score Viewer

The image displays two windows from a music application. The top window, titled "ScoreViewer", shows a digital score for Beethoven's Piano Sonata no. 8 in C minor, op. 13, "Pathétique", Rondo (Allegro). The score is presented in a multi-staff format with a yellow highlight on the first few measures of the Rondo section. Below the score, a control bar shows "Track: 29 / 54", "Bar: 1 / 211", and "Page: 159 / 285". It also includes a "Score Following On" indicator, "Play" and "Stop" buttons, and a right-pointing arrow button.

The bottom window, titled "AudioViewer", displays a track list for "Beethoven - Piano Sonatas - Alfred Brendel". The list includes tracks 03 through 11, with track 11, "Sonata no. 8 in C minor, op. 13 'Pathétique' / Rondo (Allegro)", selected and highlighted in yellow. The track list table is as follows:

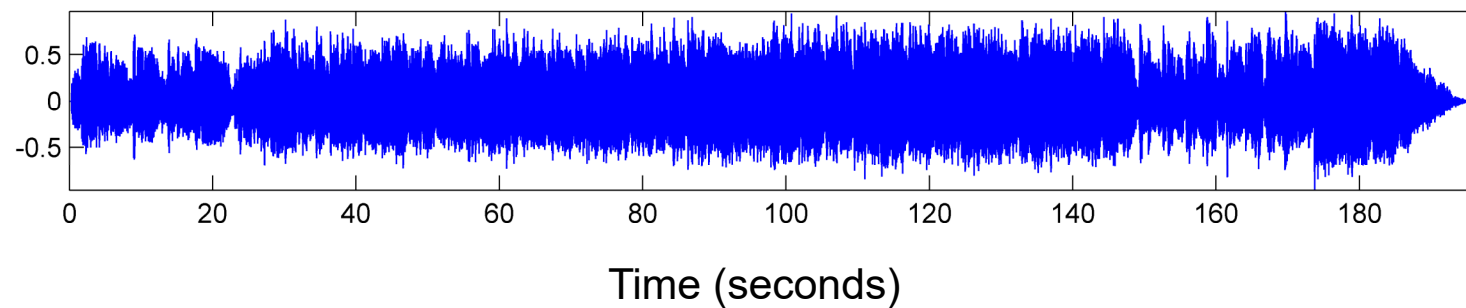
Track	Track Name	Duration
03	Sonata no. 1 in F minor, op. 2 no. 1 / Menuetto (Allegretto)	3:24
04	Sonata no. 1 in F minor, op. 2 no. 1 / Prestissimo	5:32
05	Sonata no. 2 in A major, op. 2 no. 2 / Allegro vivace	7:15
06	Sonata no. 2 in A major, op. 2 no. 2 / Largo appassionato	6:28
07	Sonata no. 2 in A major, op. 2 no. 2 / Scherzo (Allegretto)	3:30
08	Sonata no. 2 in A major, op. 2 no. 2 / Rondo (Grazioso)	7:03
09	Sonata no. 6 in C minor, op. 13 "Pathétique" / Allegro di molto e con brio	9:40
10	Sonata no. 8 in C minor, op. 13 "Pathétique" / Adagio cantabile	5:17
11	Sonata no. 8 in C minor, op. 13 "Pathétique" / Rondo (Allegro)	4:30

Below the track list, there is a waveform visualization. At the bottom, a control bar shows "Disc: 1 / 11", "Track: 11 / 11", and "Time: 00:00.00 / 4:30.35". It also includes "Play" and "Stop" buttons.



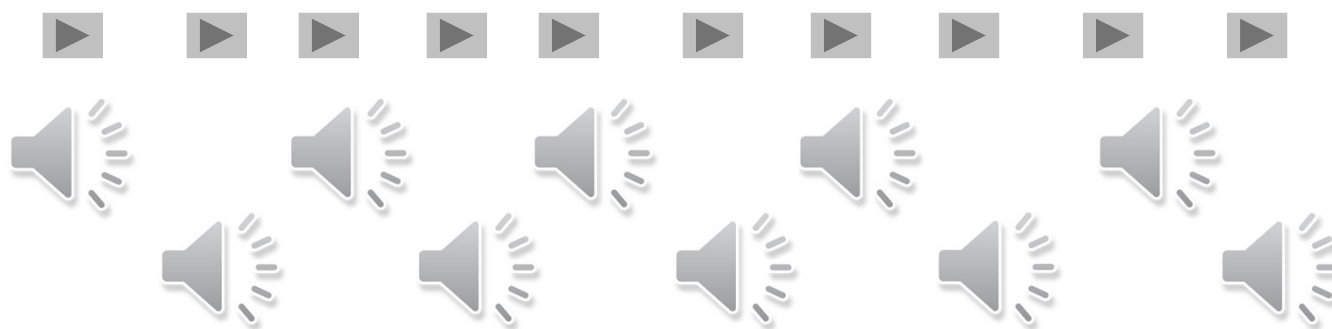
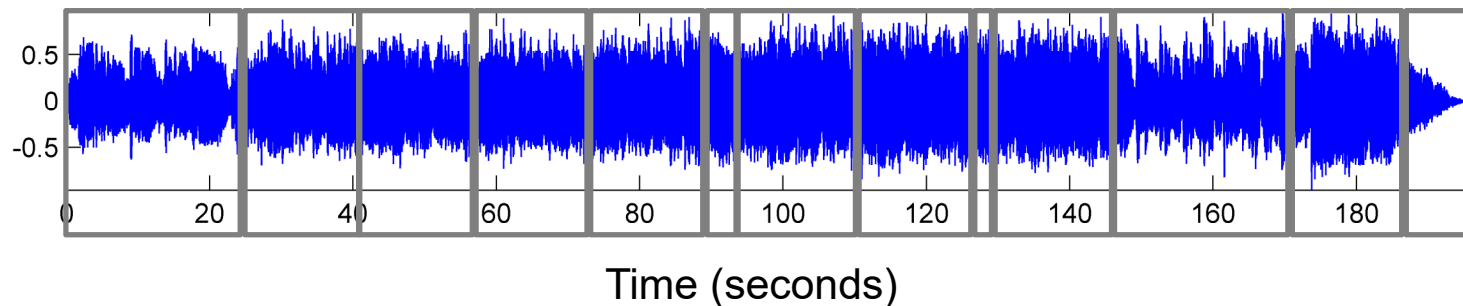
Music Structure Analysis

Example: Zager & Evans “In The Year 2525”



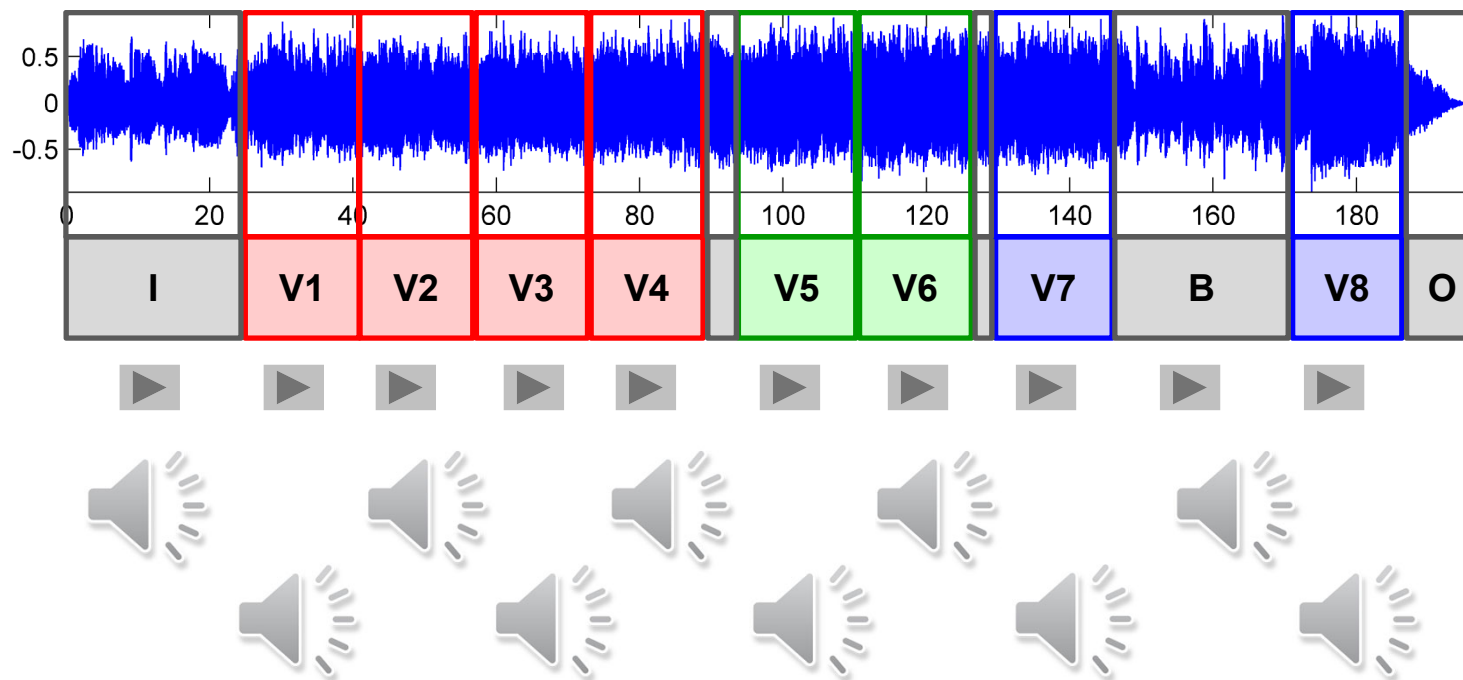
Music Structure Analysis

Example: Zager & Evans “In The Year 2525”



Music Structure Analysis

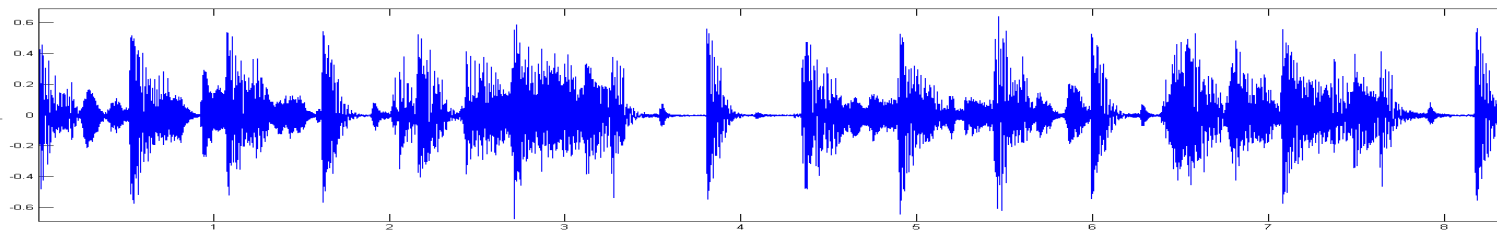
Example: Zager & Evans “In The Year 2525”



Tempo Estimation and Beat Tracking

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

Example: Queen – Another One Bites The Dust

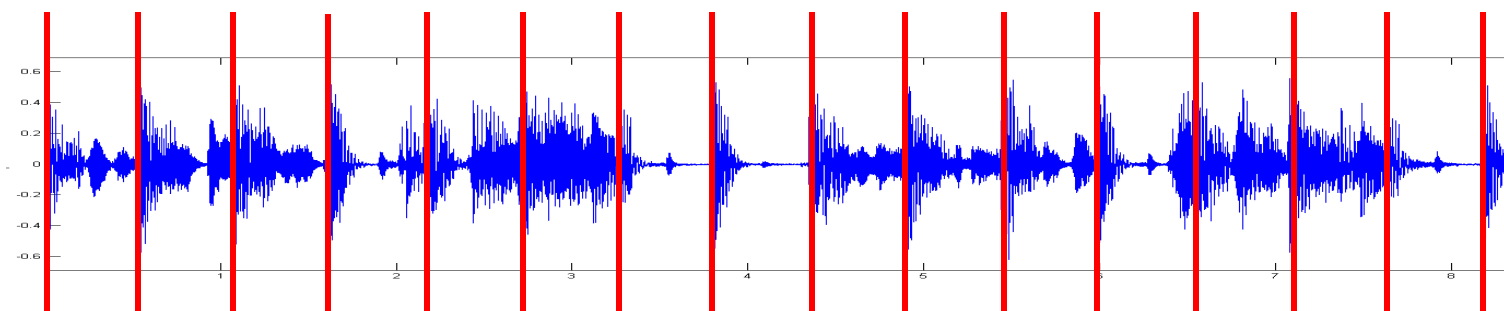


Time (seconds)

Tempo Estimation and Beat Tracking

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

Example: Queen – Another One Bites The Dust



Time (seconds)



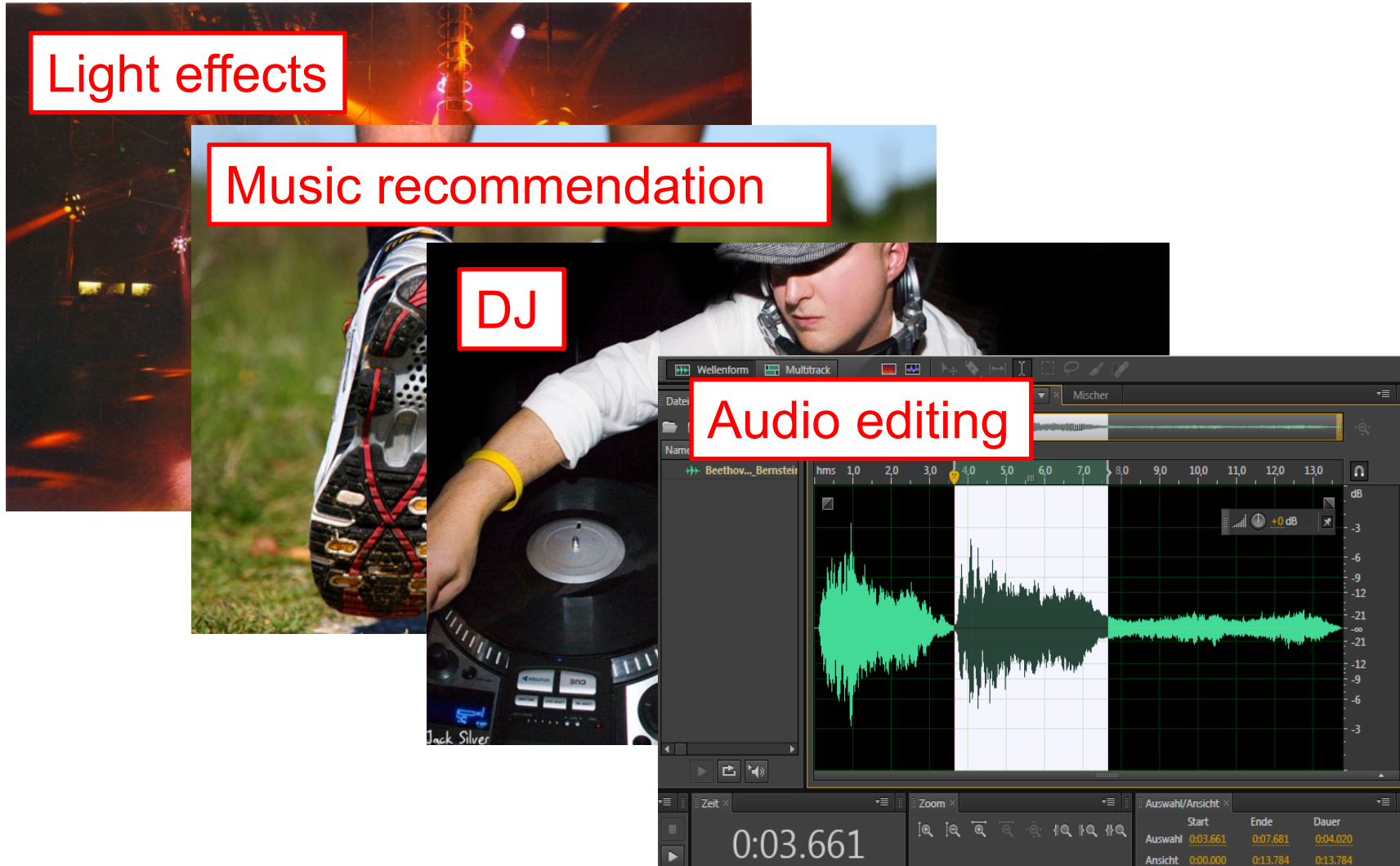
Tempo Estimation and Beat Tracking

Light effects

Music recommendation

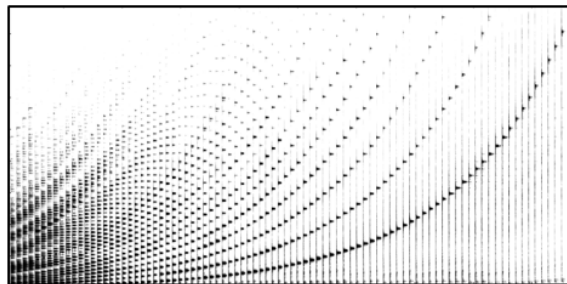
DJ

Audio editing

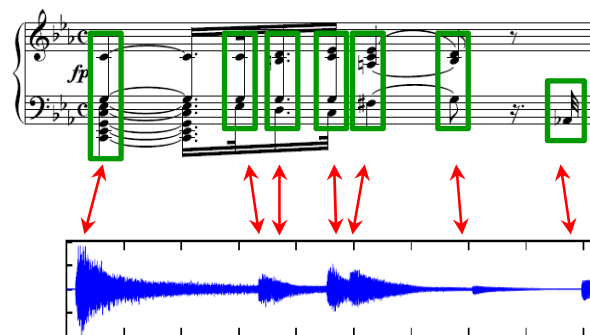


Music Processing

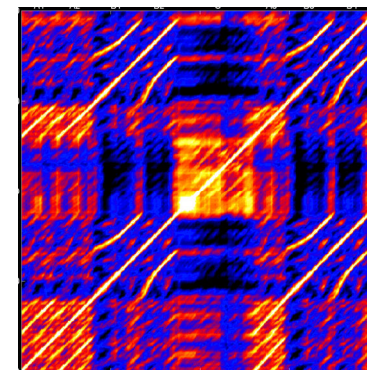
Fourier Transform
Audio Features



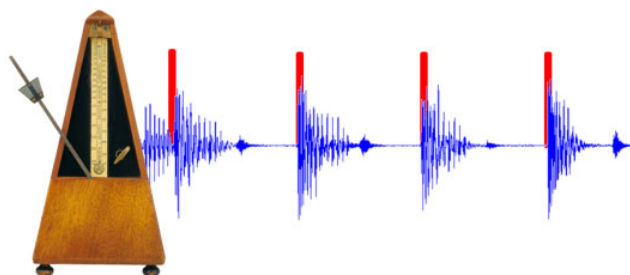
Music Synchronization



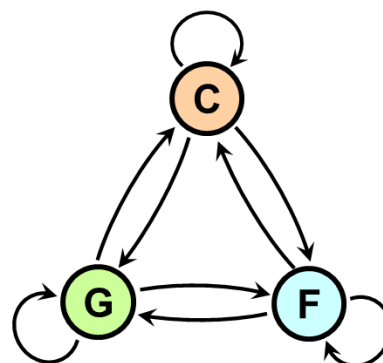
Structure Analysis



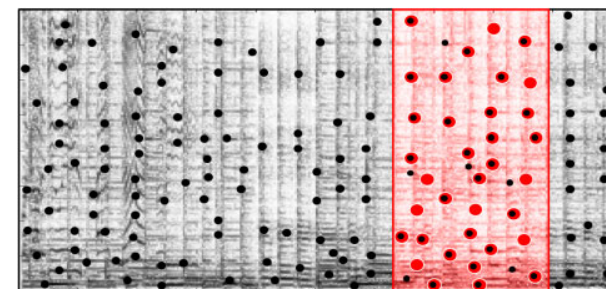
Tempo and Beat Tracking



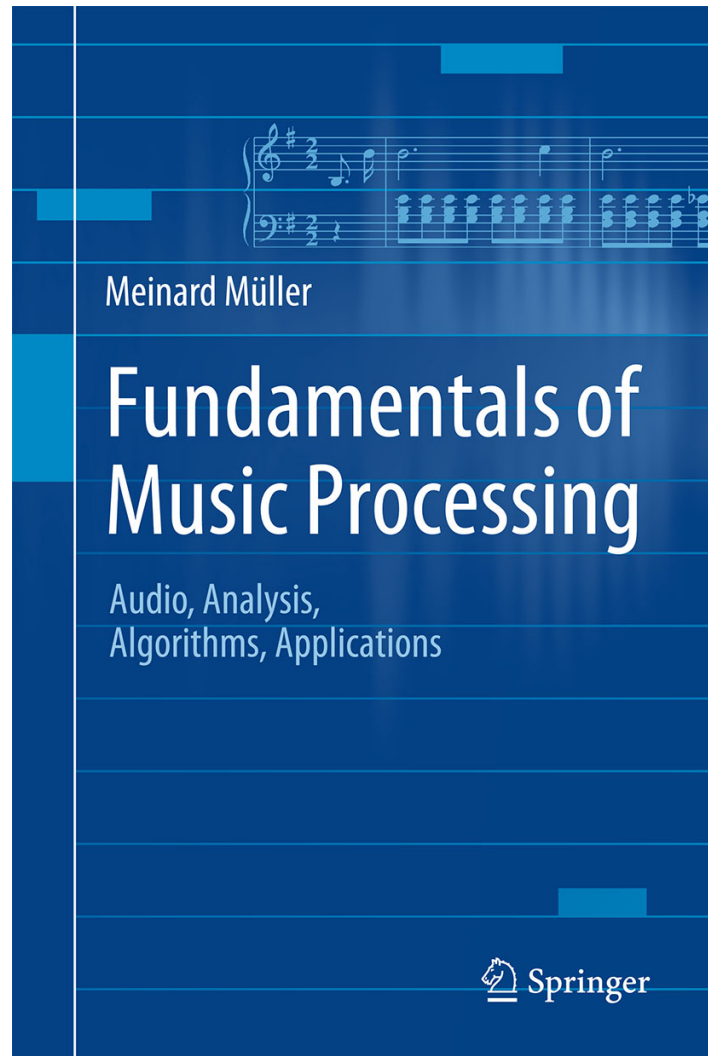
Chord Recognition



Audio Fingerprinting



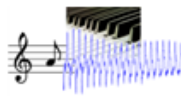

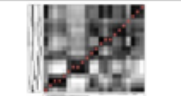
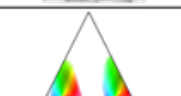

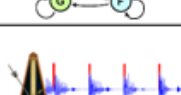


Book: Fundamentals of Music Processing



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

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