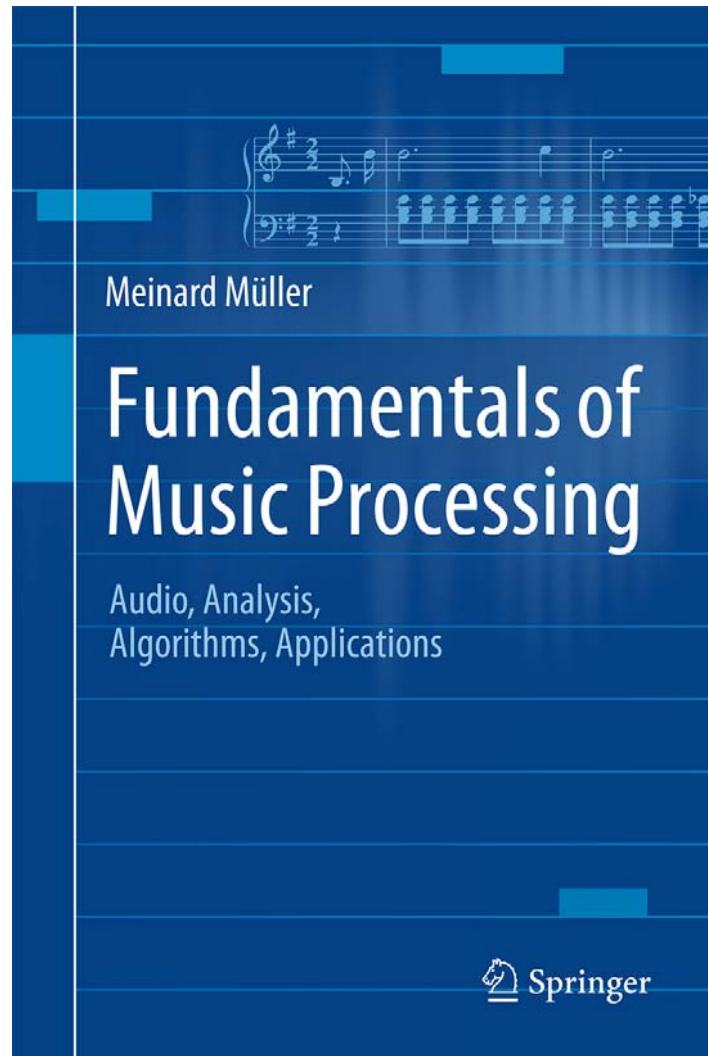


Book: Fundamentals of Music Processing



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

Music

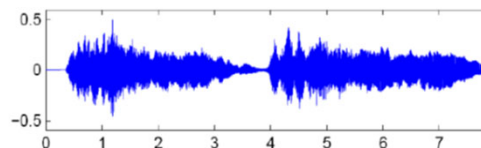


Music Information Retrieval (MIR)

Sheet Music (Image)



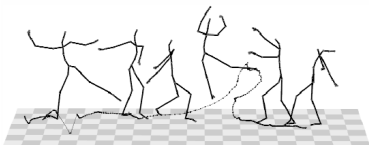
CD / MP3 (Audio)



MusicXML (Text)

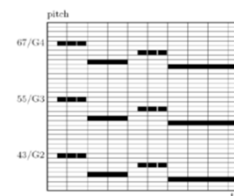
```
<note>
  <pitch>
    <step>E</step>
    <alter>-1</alter>
    <octave>4</octave>
  </pitch>
  <duration>2</duration>
  <type>half</type>
</note>
```

Dance / Motion (Mocap)



Music

MIDI



Singing / Voice (Audio)



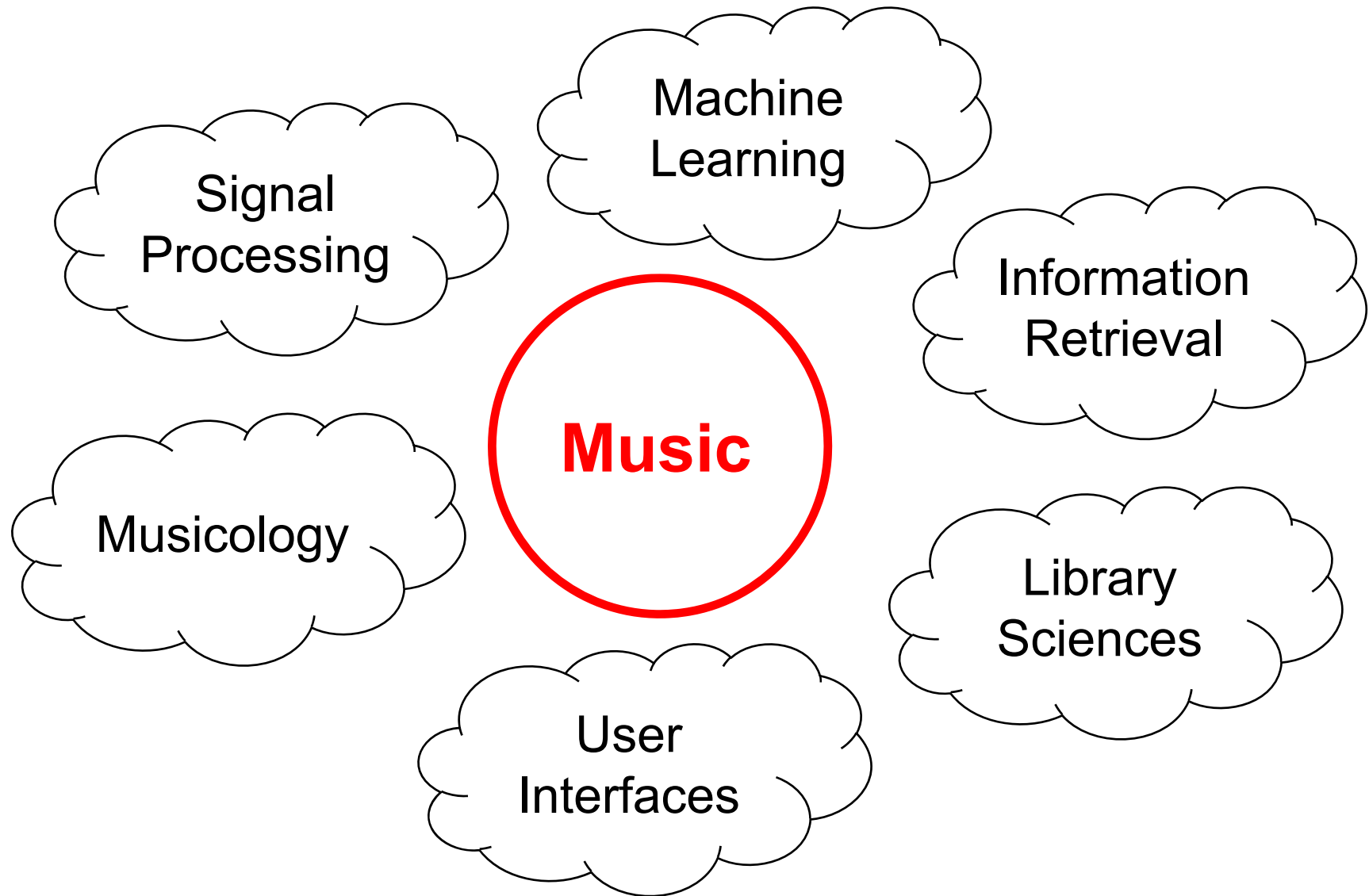
Music Film (Video)



Music Literature (Text)



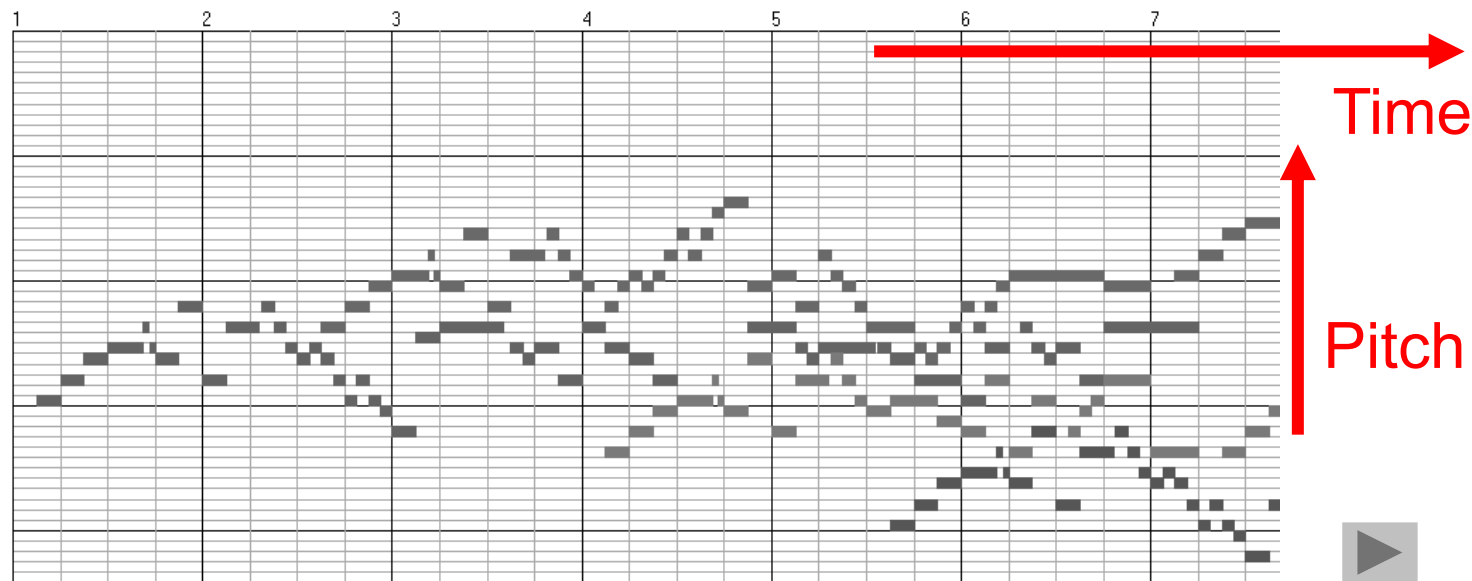
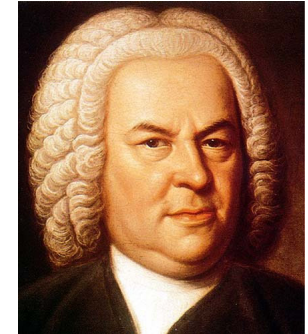
Music Information Retrieval (MIR)



Piano Roll Representation (MIDI)

J.S. Bach, C-Major Fuge

(Well Tempered Piano, BWV 846)

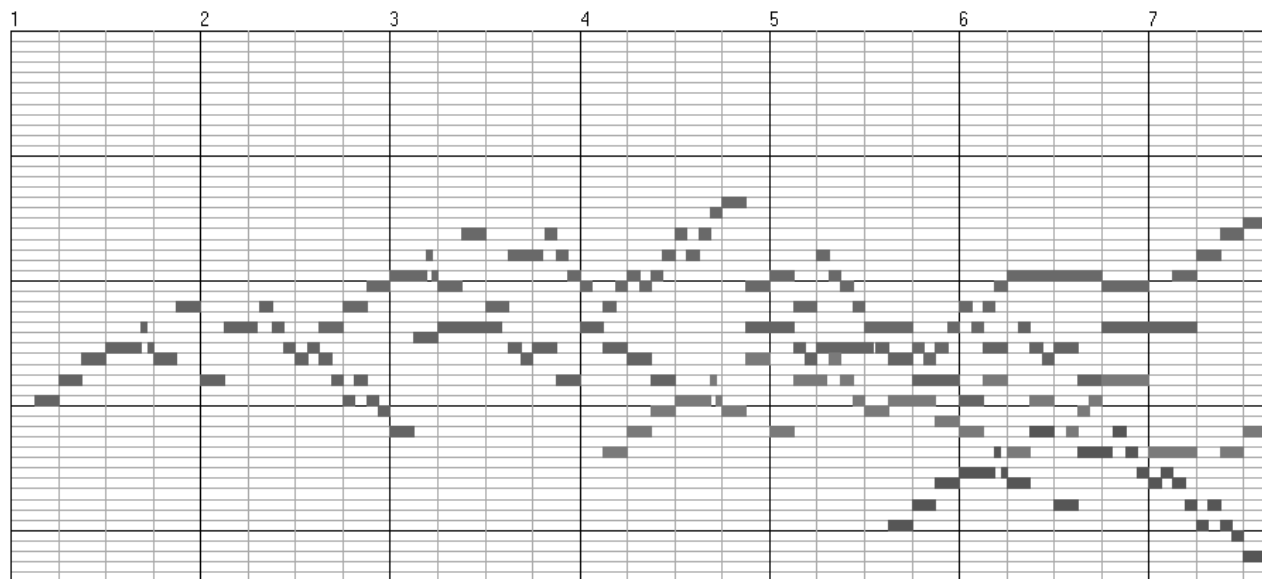
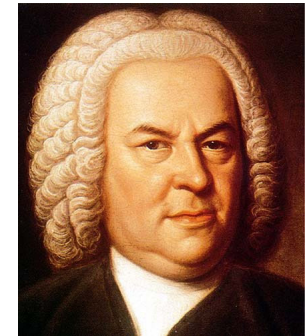


Piano Roll Representation (MIDI)

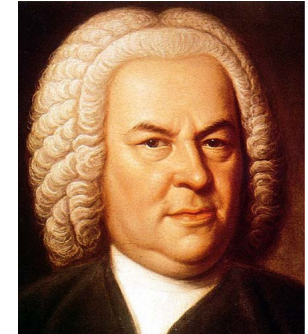
Query:



Goal: Find all occurrences of the query



Piano Roll Representation (MIDI)

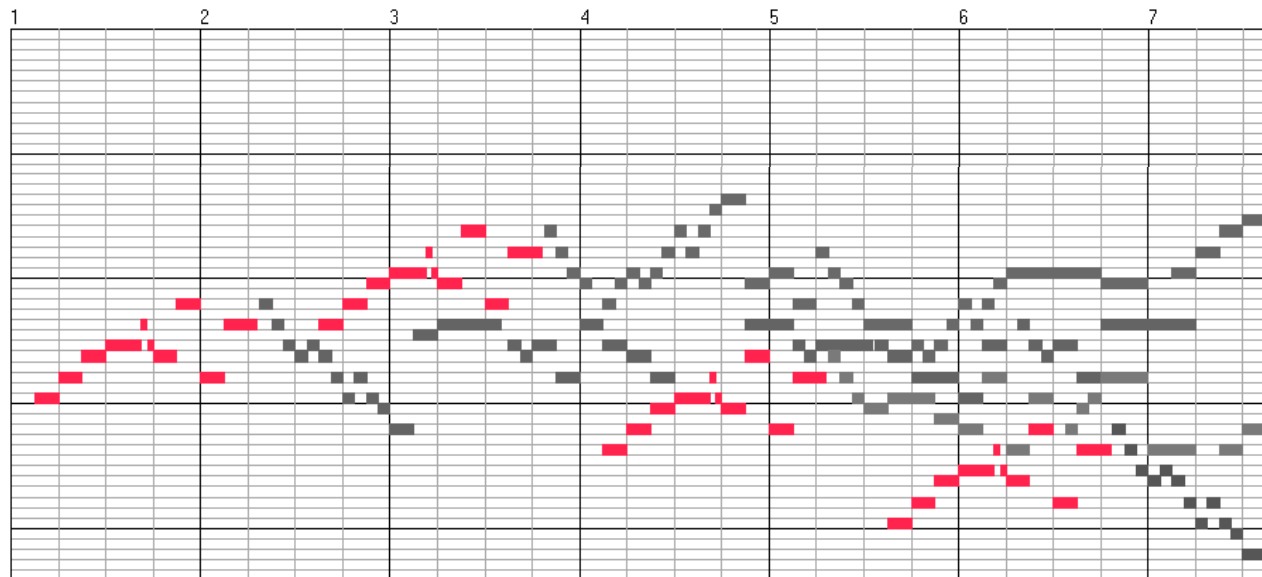


Query:

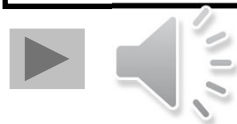
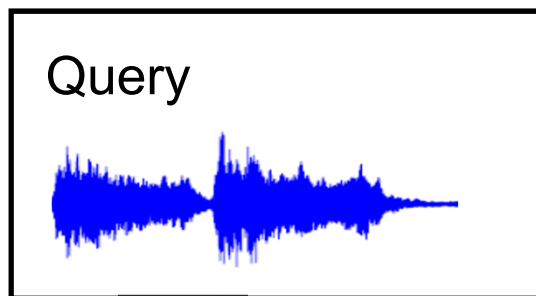


Goal: Find all occurrences of the query

Matches:



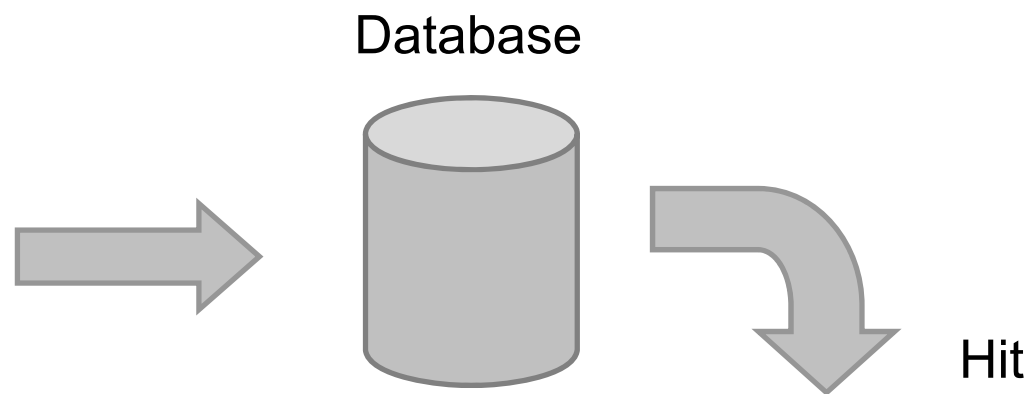
Music Retrieval



Audio-ID

Version-ID

Category-ID



Bernstein (1962)
Beethoven, Symphony No. 5

Beethoven, Symphony No. 5:

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

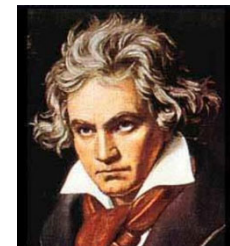


- Beethoven, Symphony No. 9
- Beethoven, Symphony No. 3
- Haydn Symphony No. 94

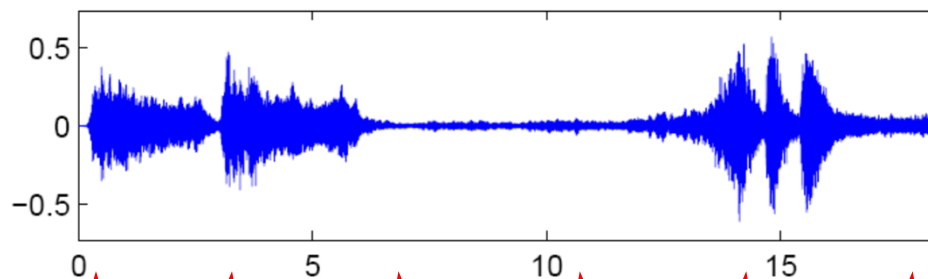


Music Synchronization: Audio-Audio

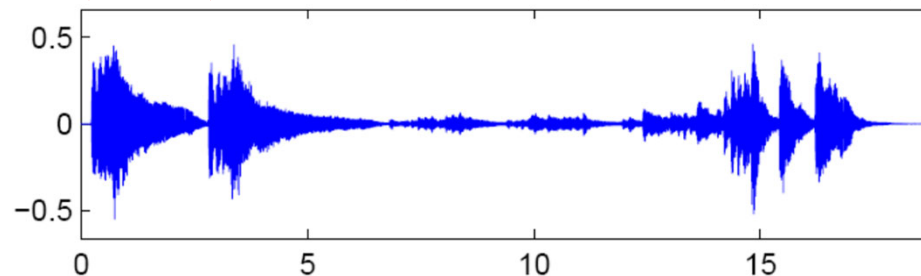
Beethoven's Fifth



Orchester
(Karajan)



Piano
(Scherbakov)



Time (seconds)

Application: Interpretation Switcher

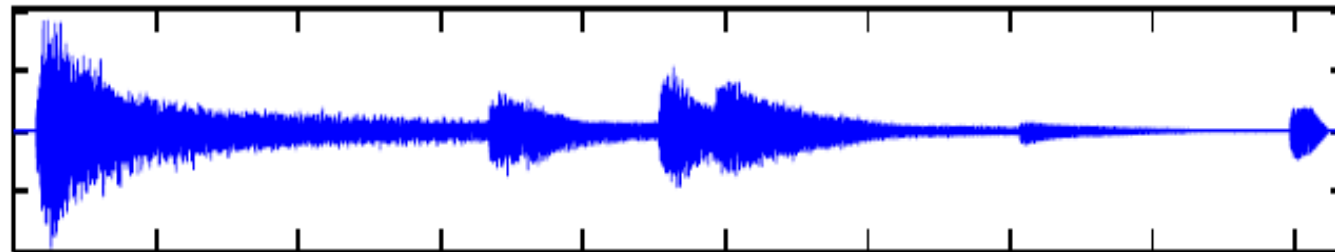


Music Synchronization: Image-Audio

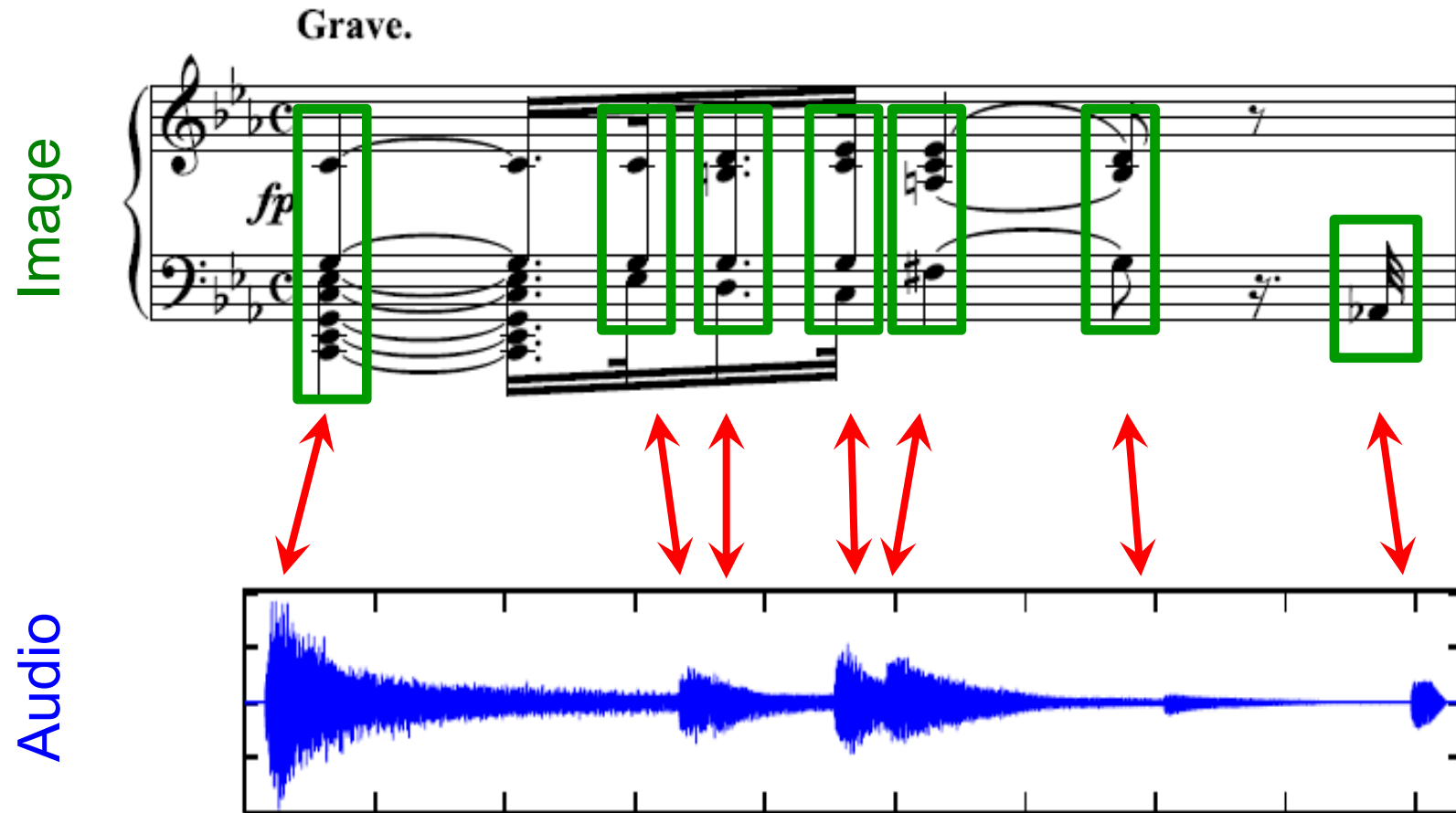
Image



Audio



Music Synchronization: Image-Audio

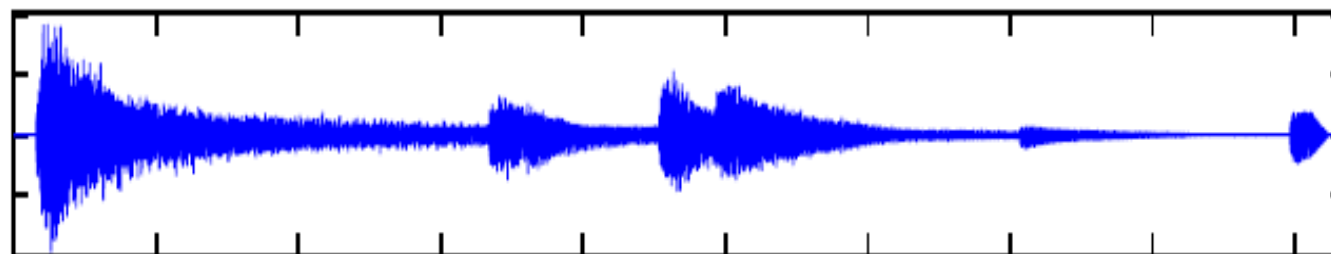


How to make the data comparable?

Image



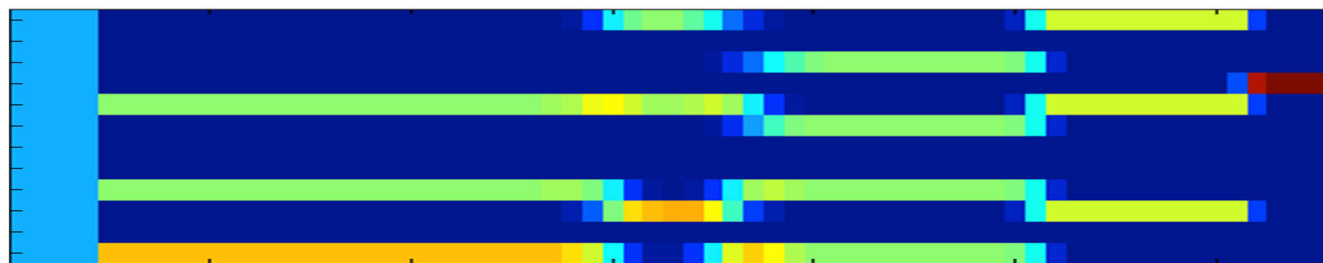
Audio



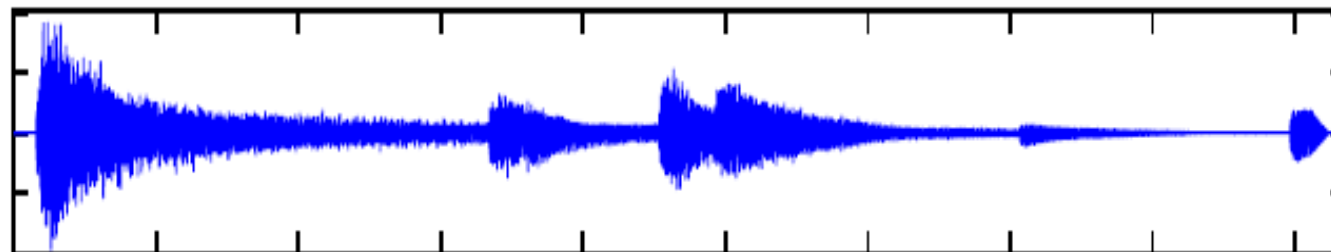
How to make the data comparable?

Image Processing: Optical Music Recognition

Image



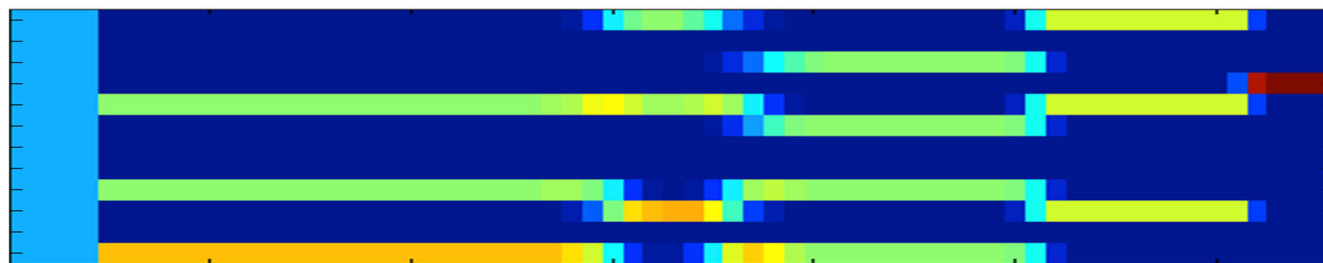
Audio



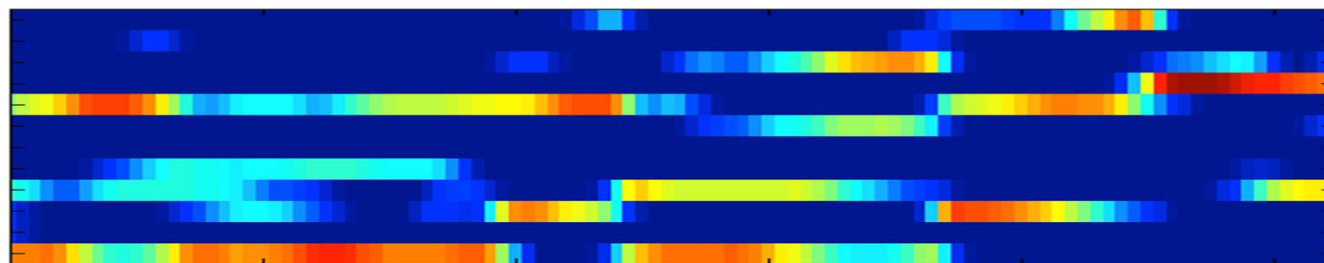
How to make the data comparable?

Image Processing: Optical Music Recognition

Image



Audio

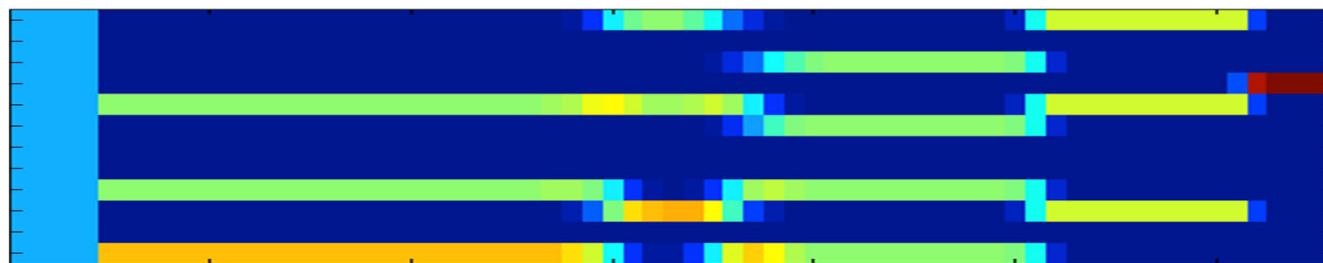


Audio Processing: Fourier Analysis

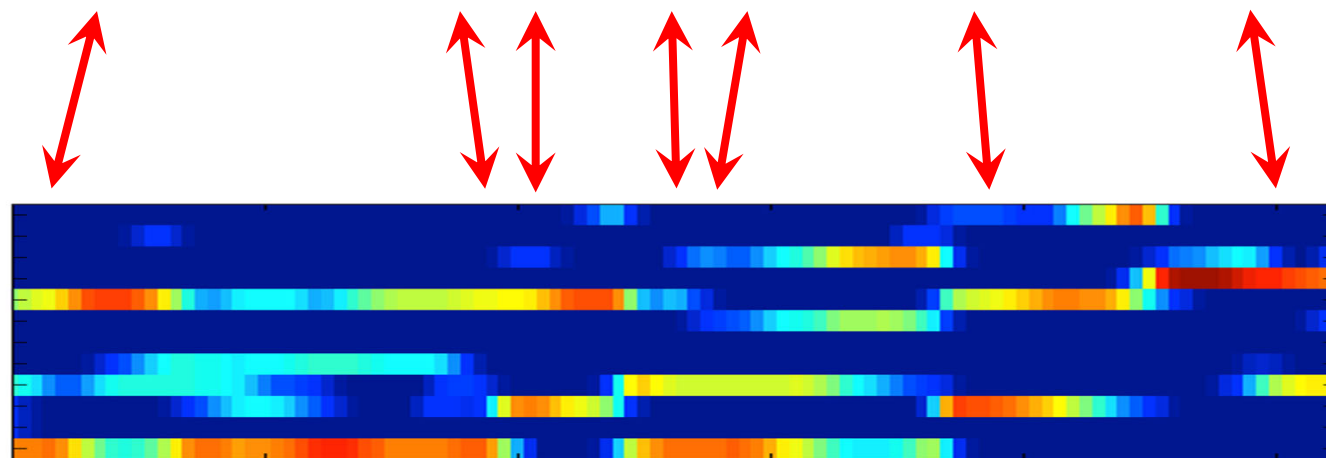
How to make the data comparable?

Image Processing: Optical Music Recognition

Image



Audio



Audio Processing: Fourier Analysis



Application: Score Viewer

The screenshot displays two windows from a music application. The top window, titled "ScoreViewer", shows a musical score for "Beethoven - Klaviersonaten Band 1 - Henle". The score is for "Sonata no.8 in C minor, op.13 'Pathétique' / Rondo (Allegro)". The score is displayed in a multi-staff format. The bottom window, titled "AudioViewer", shows a list of tracks 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. The audio player interface includes a progress bar and playback controls.

ScoreViewer

Beethoven - Klaviersonaten Band 1 - Henle
Sonata no.8 in C minor, op.13 "Pathétique" / Rondo (Allegro)

Rondo
Allegro

Track: 29 / 54 Bar: 1 / 211 Page: 159 / 285

Score Following On Play Stop

AudioViewer

Beethoven - Piano Sonatas - Alfred Brendel

Disc 1

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.8 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

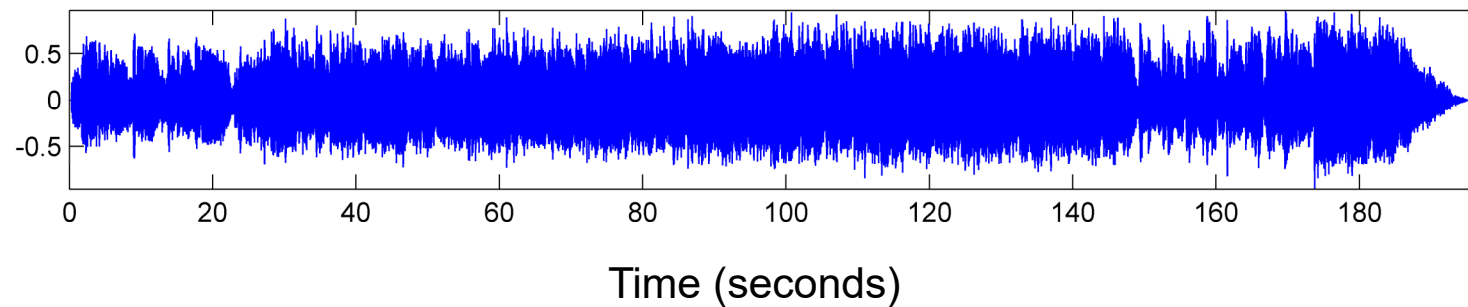
Disc: 1 / 11 Track: 11 / 11 Time: 00:00.00 / 4:30.35

Play Stop



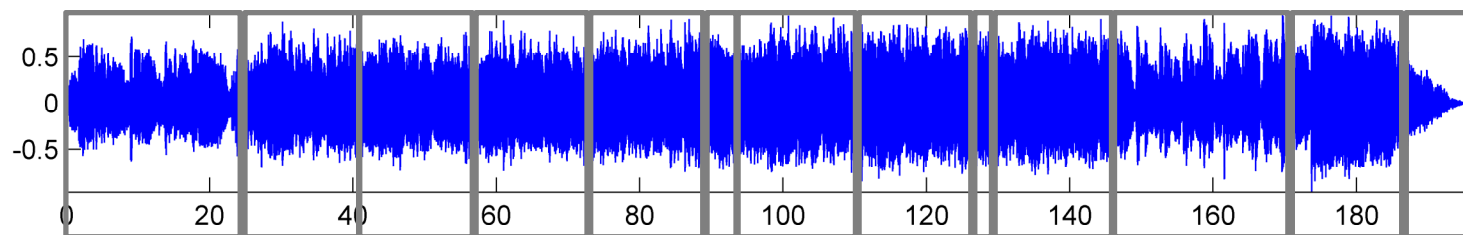
Music Structure Analysis

Example: Zager & Evans “In The Year 2525”

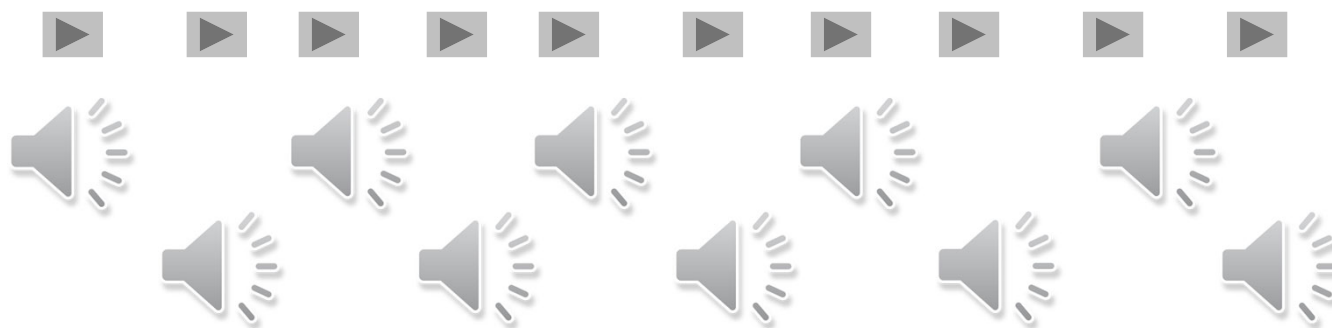


Music Structure Analysis

Example: Zager & Evans “In The Year 2525”

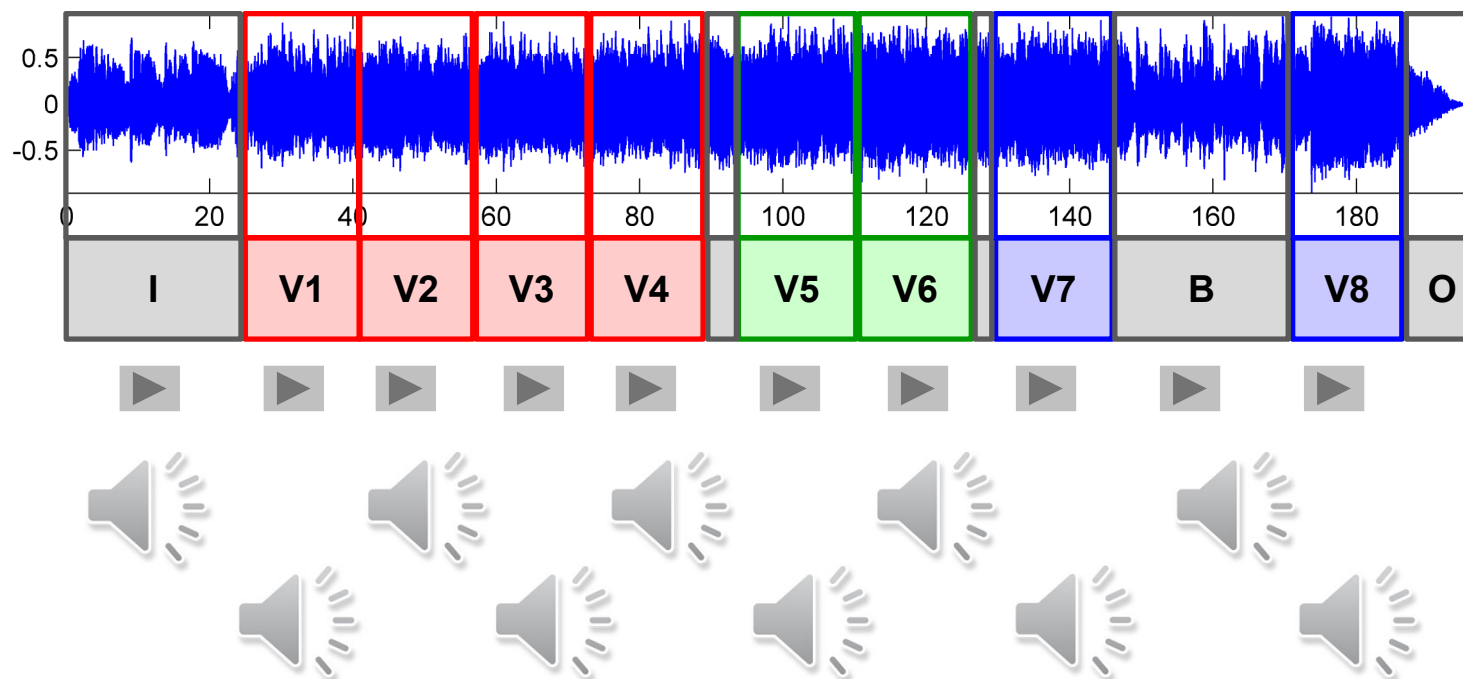


Time (seconds)



Music Structure Analysis

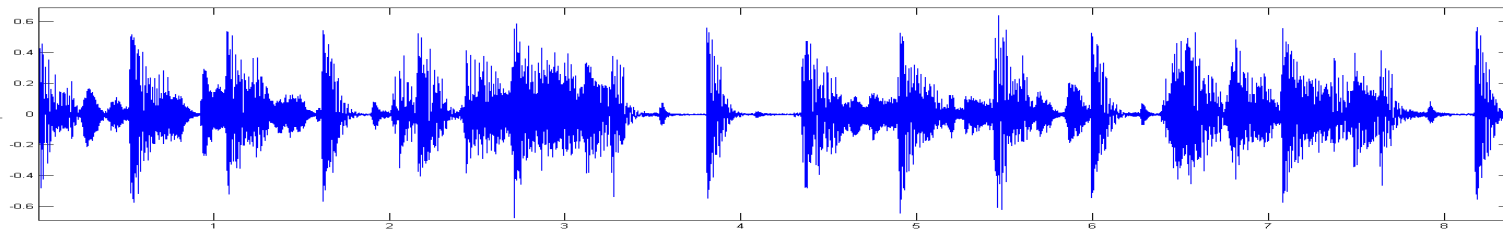
Example: Zager & Evans “In The Year 2525”



Tempo Estimation and Beat Tracking

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

Example: Queen – Another One Bites The Dust



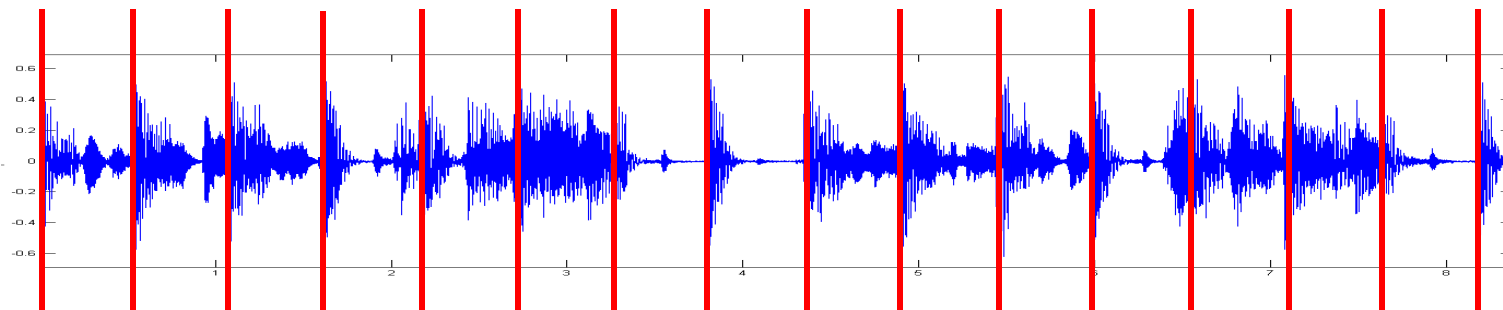
Time (seconds)



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

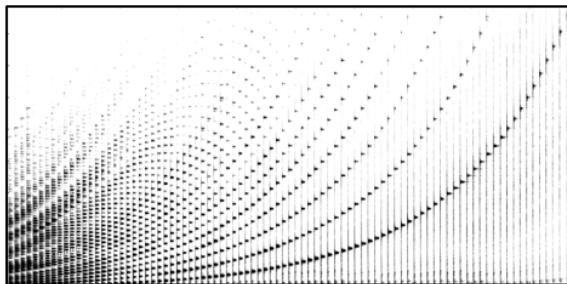
DJ

Audio editing

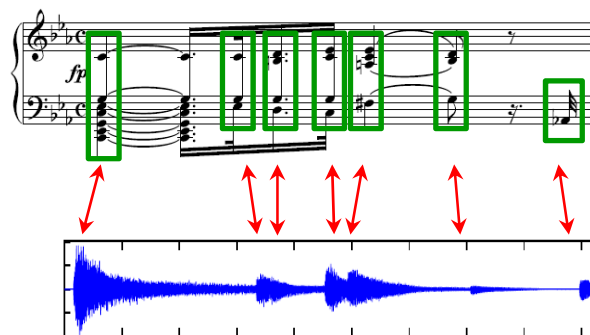


Music Processing

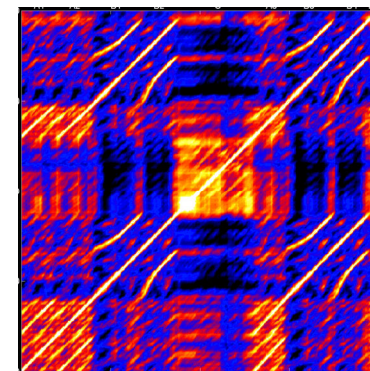
**Fourier Transform
Audio Features**



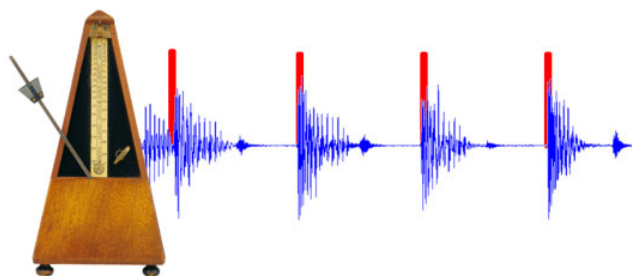
Music Synchronization



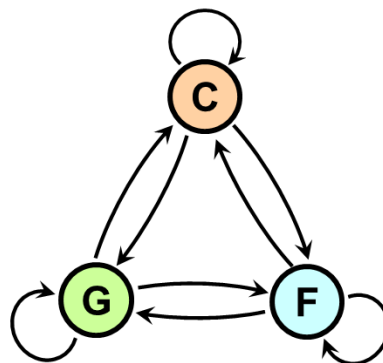
Structure Analysis



Tempo and Beat Tracking



Chord Recognition



Audio Fingerprinting

