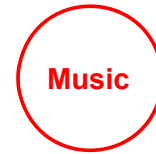


Lecture
Music Processing
Introduction

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meinard.mueller@audiolabs-erlangen.de

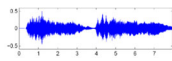


Music Information Retrieval (MIR)

Sheet Music (Image)



CD / MP3 (Audio)



MusicXML (Text)

```
<note>
  <pitch>
    <midi>40</midi>
    <name>G4</name>
    <octave>4</octave>
  </pitch>
  <duration>4</duration>
  <staff>1</staff>
</note>
```

Dance / Motion (Mocap)



MIDI



Singing / Voice (Audio)



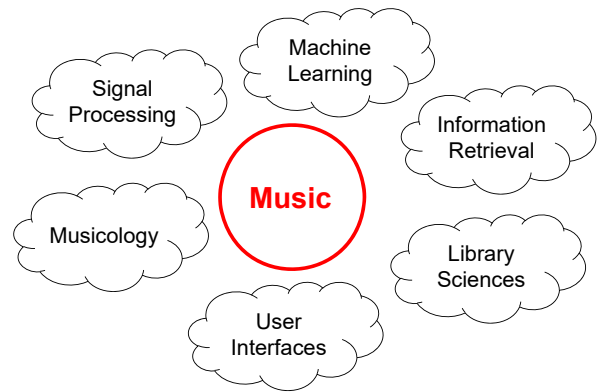
Music Film (Video)



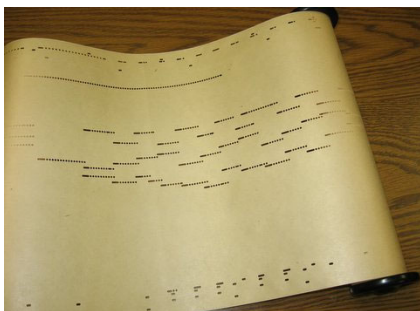
Music Literature (Text)



Music Information Retrieval (MIR)



Piano Roll Representation

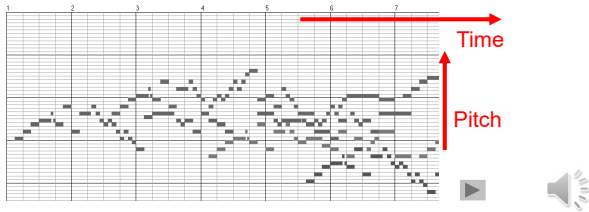


Player Piano (1900)



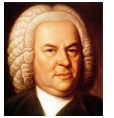
Piano Roll Representation (MIDI)

J.S. Bach, C-Major Fuge
(Well Tempered Piano, BWV 846)

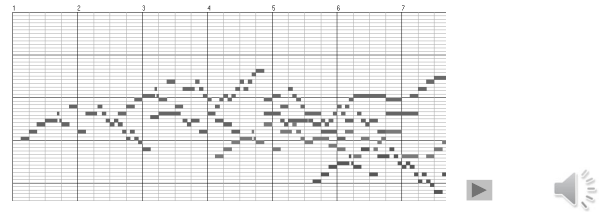


Piano Roll Representation (MIDI)

Query:

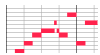


Goal: Find all occurrences of the query



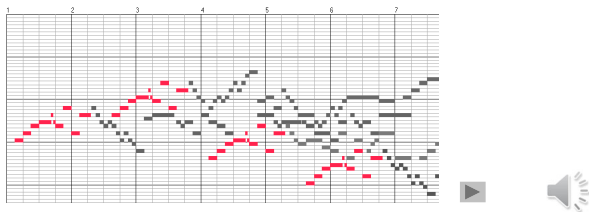
Piano Roll Representation (MIDI)

Query:

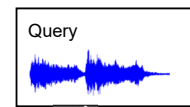


Goal: Find all occurrences of the query

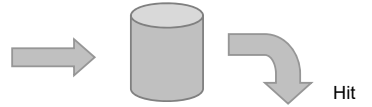
Matches:



Music Retrieval



Database



Audio-ID

Bernstein (1962)
Beethoven, Symphony No. 5

Version-ID

Beethoven, Symphony No. 5:
■ Bernstein (1962)
■ Karajan (1982)
■ Gould (1992)

Category-ID

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

Music Synchronization: Audio-Audio

Beethoven's Fifth

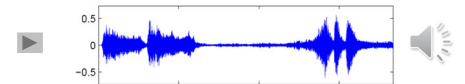


Music Synchronization: Audio-Audio

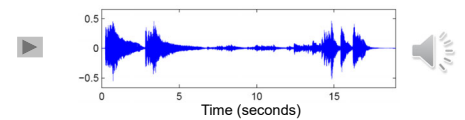
Beethoven's Fifth



Orchester
(Karajan)



Piano
(Scherbakov)

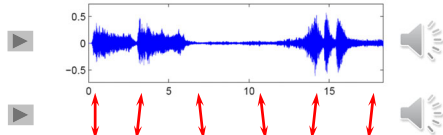


Music Synchronization: Audio-Audio

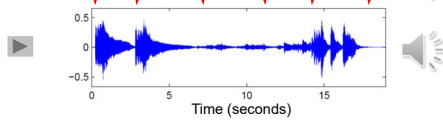
Beethoven's Fifth



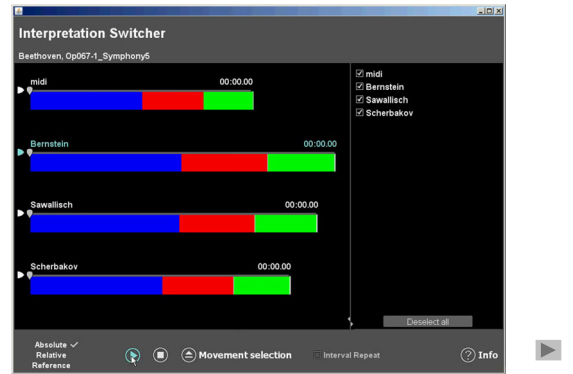
Orchester
(Karajan)



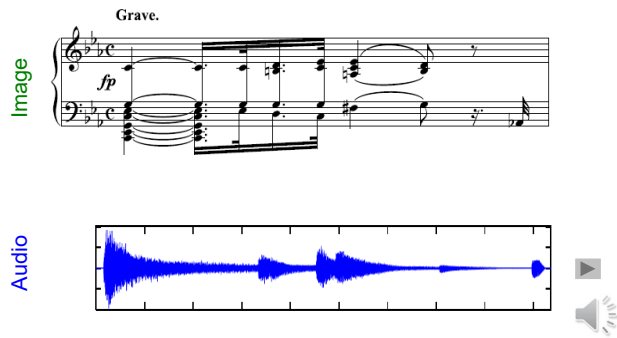
Piano
(Scherbakov)



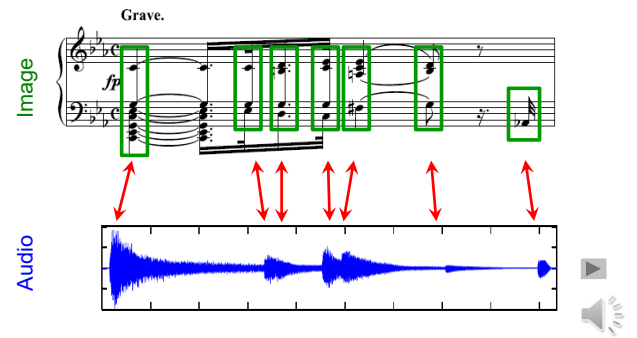
Application: Interpretation Switcher



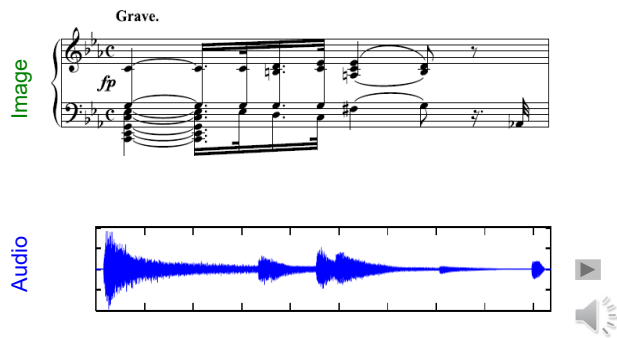
Music Synchronization: Image-Audio



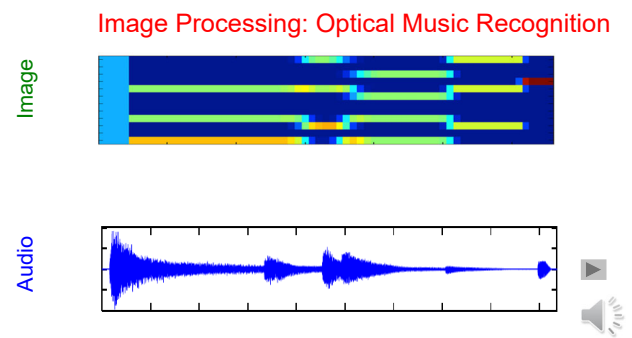
Music Synchronization: Image-Audio



How to make the data comparable?

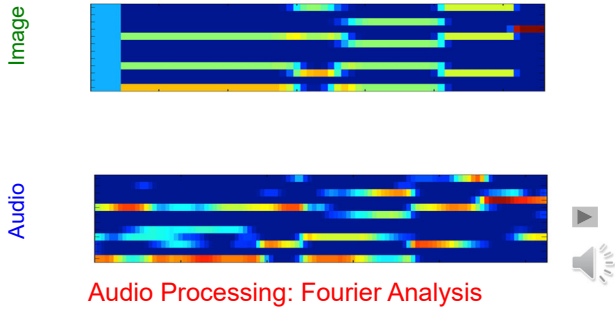


How to make the data comparable?



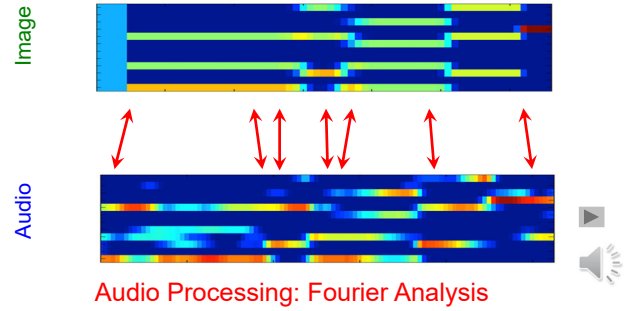
How to make the data comparable?

Image Processing: Optical Music Recognition

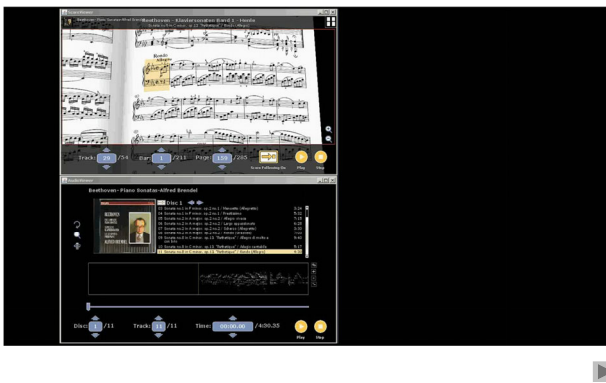


How to make the data comparable?

Image Processing: Optical Music Recognition

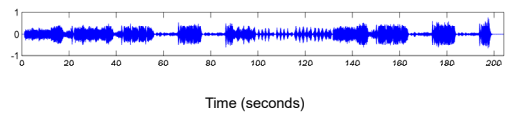


Application: Score Viewer



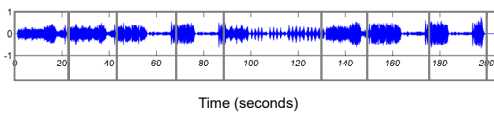
Music Structure Analysis

Example: Brahms Hungarian Dance No. 5 (Ormandy)



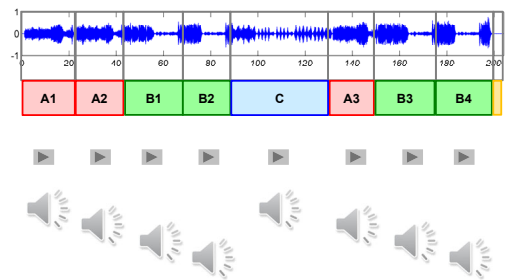
Music Structure Analysis

Example: Brahms Hungarian Dance No. 5 (Ormandy)



Music Structure Analysis

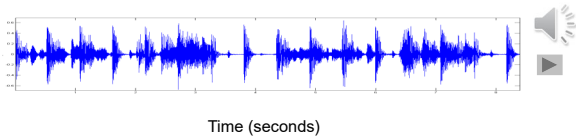
Example: Brahms Hungarian Dance No. 5 (Ormandy)



Tempo Estimation and Beat Tracking

Basic task: "Tapping the foot when listening to music"

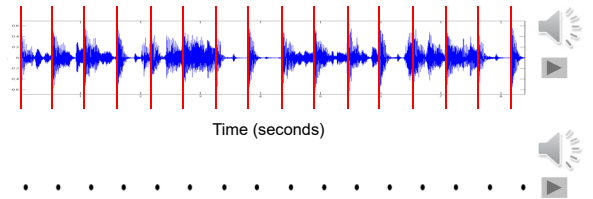
Example: Queen – Another One Bites The Dust



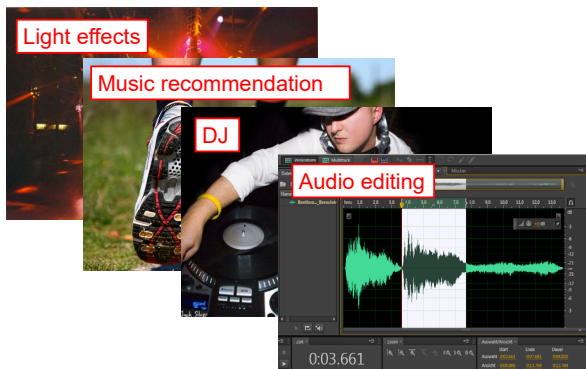
Tempo Estimation and Beat Tracking

Basic task: "Tapping the foot when listening to music"

Example: Queen – Another One Bites The Dust



Tempo Estimation and Beat Tracking



Why is Music Processing Challenging?

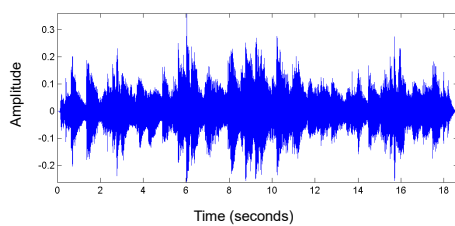
Example: Chopin, Mazurka Op. 63 No. 3



Why is Music Processing Challenging?

Example: Chopin, Mazurka Op. 63 No. 3

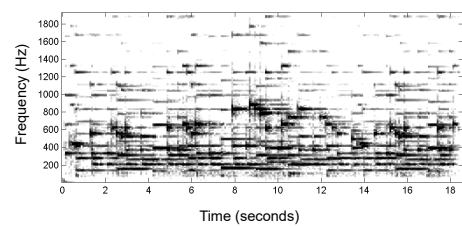
- Waveform



Why is Music Processing Challenging?

Example: Chopin, Mazurka Op. 63 No. 3

- Waveform / Spectrogram



Why is Music Processing Challenging?

Example: Chopin, Mazurka Op. 63 No. 3

- Waveform / Spectrogram
- Performance
 - Tempo
 - Dynamics
 - Note deviations
 - Sustain pedal

Why is Music Processing Challenging?

Example: Chopin, Mazurka Op. 63 No. 3

- Waveform / Spectrogram

- Performance
 - Tempo
 - Dynamics
 - Note deviations
 - Sustain pedal

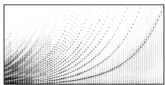


- Polyphony

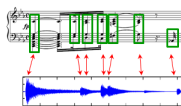
- █ Main Melody
- █ Additional melody line
- █ Accompaniment

Music Processing

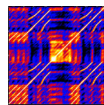
**Fourier Transform
Audio Features**



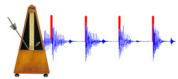
Music Synchronization



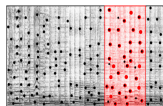
Structure Analysis



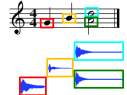
Tempo and Beat Tracking



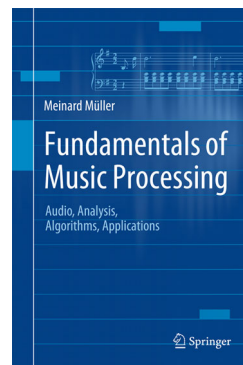
Audio Identification



Audio Decomposition



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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