Automatische Erschließung von Musikdaten

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Meinard Müller

Mathematics (Diplom/Master, 1997)
Computer Science (PhD, 2001)
Information Retrieval (Habilitation, 2007)

Senior Researcher (2007-2012)
Professor Semantic Audio Processing (since 2012)
Former President of the International Society for Music Information Retrieval (MIR)
IEEE Fellow for contributions to Music Signal Processing

Meinard Müller: Research Group

- Michael Krause
- Yigitcan Özer
- Simon Schwär
- Johannes Zeillier
- Peter Meier (external)
- Christof Weiß
- Sebastian Rosenzweig
- Frank Zalkow
- Christian Dittmar
- Jonathan Driedger
- Thomas Präitzl

International Audio Laboratories Erlangen

- Fraunhofer Institute for Integrated Circuits IIS
  Largest Fraunhofer institute with ≈1000 members
- Applied research for sensor, audio, and media technology
- Friedrich-Alexander Universität Erlangen-Nürnberg (FAU)
  One of Germany’s largest universities with ≈40,000 students
- Strong Technical Faculty

International Audio Laboratories Erlangen

Audio Coding
Psychoacoustics
Internet of Things
Music Processing
3D Audio
Music Information Retrieval (MIR)

- Sheet Music (Image)
- CD / MP3 (Audio)
- MusicXML (Text)
- Dance / Motion (Mocap)
- Singing / Voice (Audio)
- Music Film (Video)
- Music Literature (Text)
- MIDI

Music Film (Video)

Dance / Motion (Mocap)

Singing / Voice (Audio)

Music Literature (Text)

Piano Roll Representation (1900)

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

Query:
Goal: Find all occurrences of the query

Matches:
Music Retrieval

**Query**

Database

- Bernstein (1962)
- Beethoven, Symphony No. 5

**Audio ID**

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

**Version ID**

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

Music Synchronization

**Music Synchronization: Image-Audio**

Image Audio

**Image Processing: Optical Music Recognition**

Audio Processing: Fourier Analysis

**Music Synchronization: Image-Audio**

Image Audio

**Image Processing: Optical Music Recognition**

Audio Processing: Fourier Analysis
Music Synchronization: Image-Audio

- Deep learning
- Embedding techniques
- Music transcription
- Lyrics alignment
- ...

Score-Informed Audio Decomposition

Sheet music

Piano roll

Score-Informed Audio Decomposition

Sheet music

Piano roll

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Score-Informed Audio Decomposition

Audio mosaicing (style transfer)

Target signal: Beatles–Let it be  
Source signal: Bees

Mosaic signal: Let it Bee

Why is Music Processing Challenging?

Example: Chopin, Mazurka Op. 63 No. 3

- Waveform

<table>
<thead>
<tr>
<th>Amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (seconds)</td>
</tr>
</tbody>
</table>

- Waveform / Spectrogram

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (seconds)</td>
</tr>
</tbody>
</table>

Why is Music Processing Challenging?

Example: Chopin, Mazurka Op. 63 No. 3

- Decomposition of audio stream into different sound sources
- Central task in digital signal processing
- "Cocktail party effect"

Source Separation

- Performance
  - Tempo
  - Dynamics
  - Note deviations
  - Sustain pedal
- Polyphony
  - Main Melody
  - Additional melody line
  - Accompaniment
Source Separation

- Decomposition of audio stream into different sound sources
- Central task in digital signal processing
- “Cocktail party effect”
- Several input signals
- Sources are assumed to be statistically independent

Source Separation (Music)

- Main melody, accompaniment, drum track
- Instrumental voices
- Individual note events
- Only mono or stereo
- Sources are often highly dependent

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AI-Based Source Separation

- Understanding modern machine learning techniques
- Critical questioning of artificial intelligence (AI) concepts
- Developing explainable AI models
- Educating next generation of scientists
- …

Music Information Retrieval (MIR)

Fundamentals of Music Processing (FMP)

Meinard Müller
Fundamentals of Music Processing
Audio, Analysis, Algorithms, Applications
Springer, 2015

Accompanying website:
www.music-processing.de