

Musik trifft Informatik in Dagstuhl

Meinard Müller

International Audio Laboratories Erlangen
meinard.mueller@audiolabs-erlangen.de

Festkolloquium
32 Jahre Informatik in Schloss Dagstuhl
24. Juni 2022



Meinard Müller: Research Group

- Christof Weiß
- Viora Arifi-Müller
- Sebastian Rosenzweig
- Michael Krause
- Yigitcan Özer
- Simon Schwär
- Peter Meier (external)



Meinard Müller

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



- Senior Researcher (2007-2012)
Max-Planck Institute, Saarland



- Professor Semantic Audio Processing (since 2012)
Erlangen-Nürnberg University

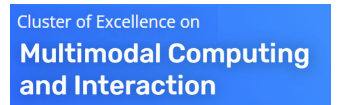


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Multimodal Music Processing



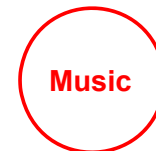
2011, January 23 – 28, Dagstuhl Seminar 11041

Organizers:

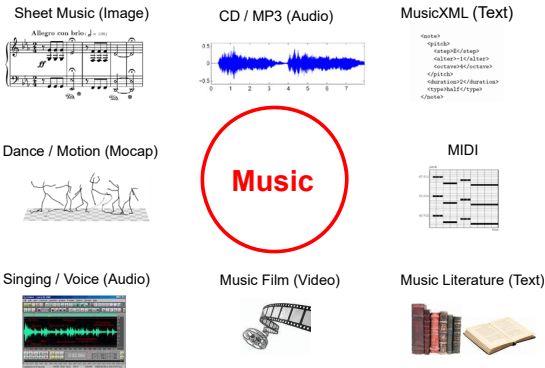
Simon Dixon (Queen Mary University of London, GB)
Masataka Goto (AIST – Ibaraki, JP)
Meinard Müller (MPI Informatik, DE)



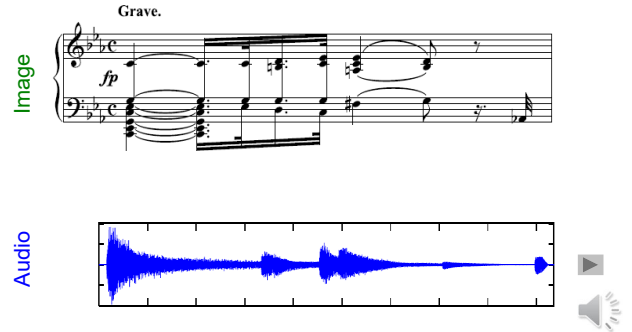
Multimodal Music Processing



Multimodal Music Processing

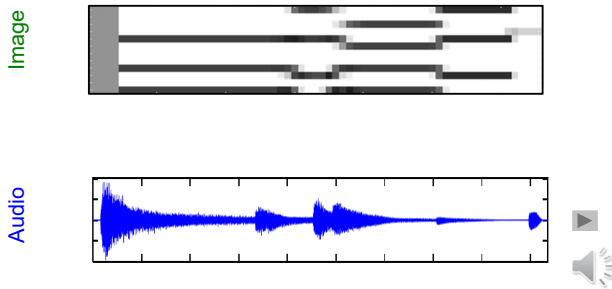


Multimodal Music Processing



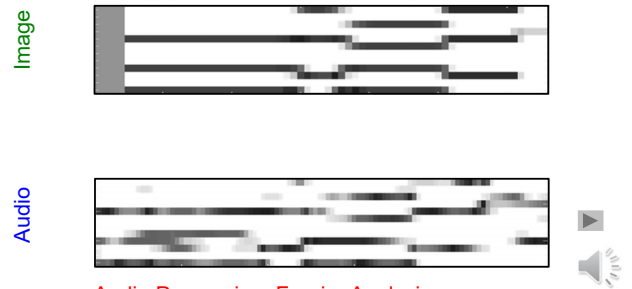
Multimodal Music Processing

Image Processing: Optical Music Recognition



Multimodal Music Processing

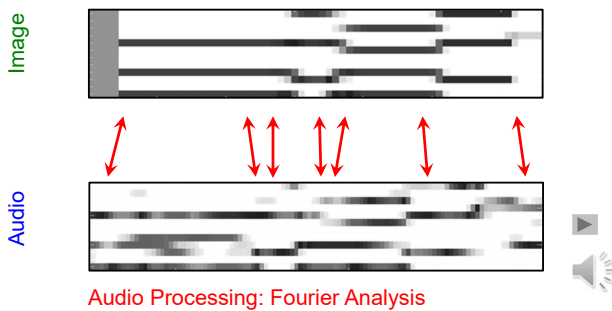
Image Processing: Optical Music Recognition



Audio Processing: Fourier Analysis

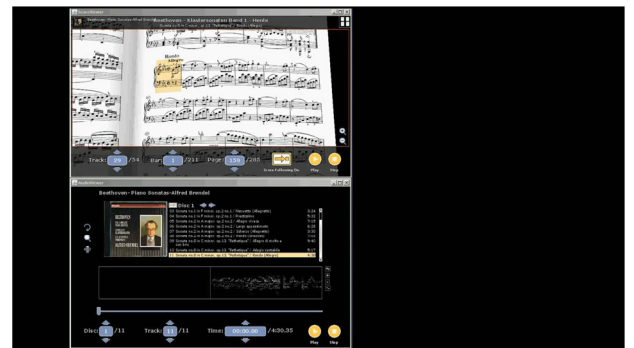
Multimodal Music Processing

Image Processing: Optical Music Recognition

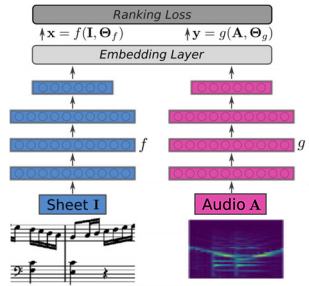


Audio Processing: Fourier Analysis

Multimodal Music Processing



Multimodal Music Processing



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

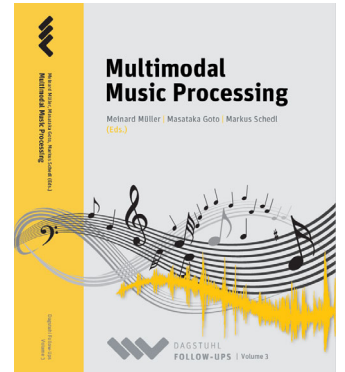
Multimodal Music Processing



Marc Herbstritt

Thank you!

Cluster of Excellence on
**Multimodal Computing
and Interaction**



Computational Audio Analysis



2013, November 3 – 8, Dagstuhl Seminar 13451

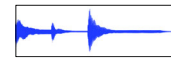
Organizers:

Shrikanth S. Narayanan (USC, US)
Björn Schuller (TU München, DE)
Meinard Müller (FAU, DE)



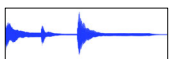
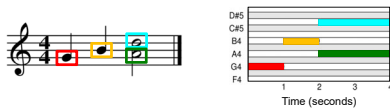
Computational Audio Analysis

Score-informed audio decomposition



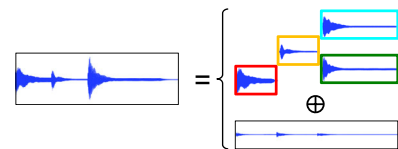
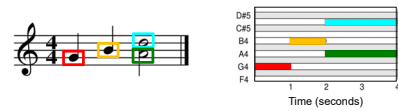
Computational Audio Analysis

Score-informed audio decomposition



Computational Audio Analysis

Score-informed audio decomposition



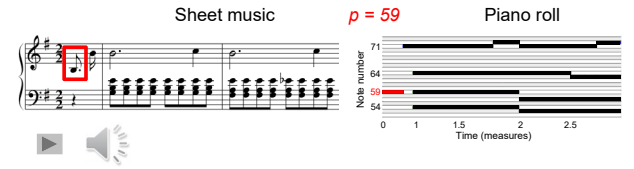
Computational Audio Analysis

Score-informed audio decomposition



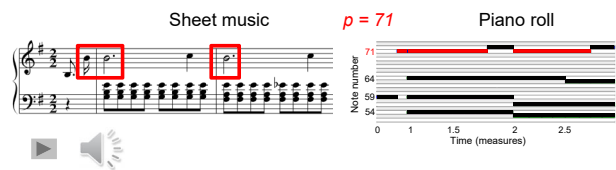
Computational Audio Analysis

Score-informed audio decomposition



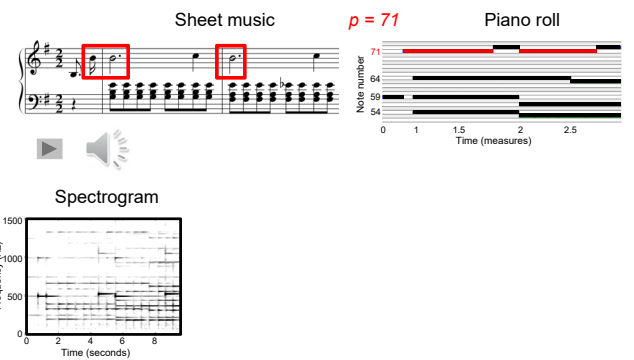
Computational Audio Analysis

Score-informed audio decomposition



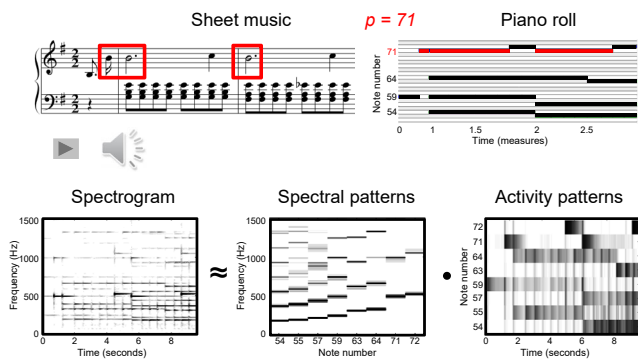
Computational Audio Analysis

Score-informed audio decomposition



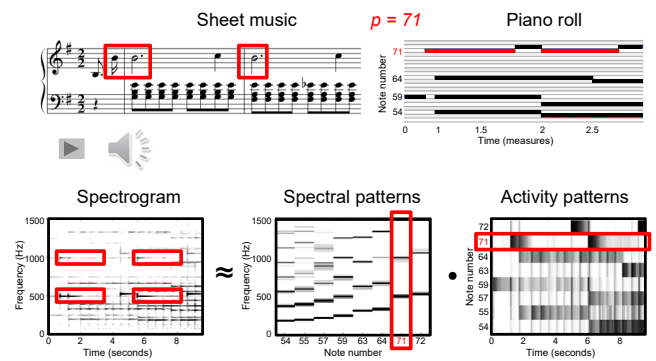
Computational Audio Analysis

Score-informed audio decomposition



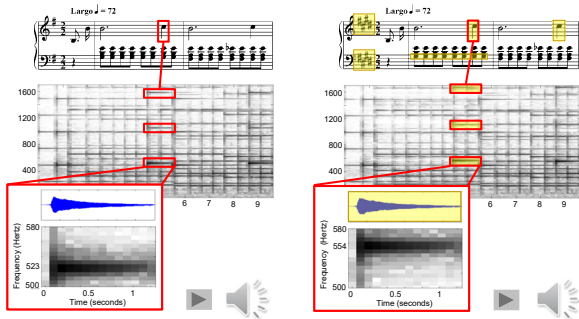
Computational Audio Analysis

Score-informed audio decomposition



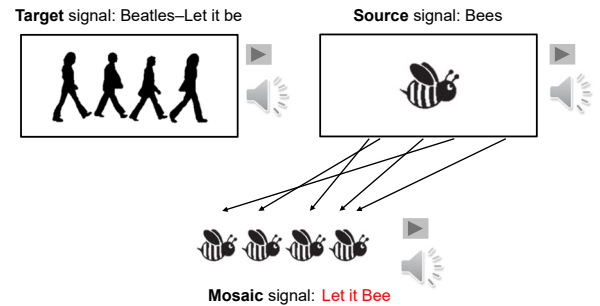
Computational Audio Analysis

Score-informed audio decomposition



Computational Audio Analysis

Audio mosaicing (style transfer)



Computational Audio Analysis

- Decomposing complex audio scenes
- Source separation
- Understanding acoustic, linguistic, or musical properties
- Extracting emotion-related parameters (e.g., stress, confidence, frustration)
- ...

Computational Audio Analysis



Roswitha
Bardohl

SCHLOSS DAGSTUHL
Leibniz-Zentrum für Informatik

Saarbrücken, 23. Oktober 2013
Schloss Dagstuhl: Können Computersysteme Emotionen erkennen?

Thank you!

Deutschlandfunk
Zwischentöne für Computer
06.11.2013

Computational Music Structure Analysis



2016, February 28 – March 4, Dagstuhl Seminar 16092

Organizers:

Juan Pablo Bello (New York University, US)
Elaine Chew (Queen Mary University of London, GB)
Meinard Müller (FAU, DE)



Computational Music Structure Analysis

Example: Carl Maria von Weber: "Der Freischütz"

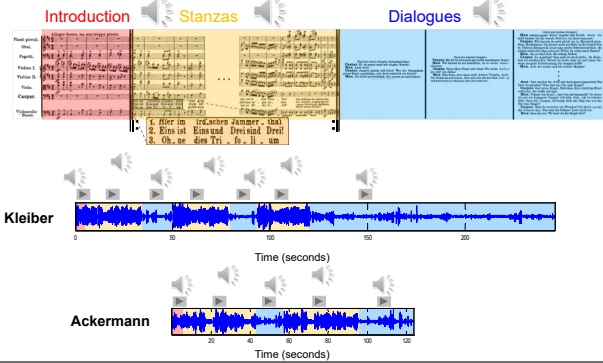


Variations	Performance	
	Kleiber C. , 1973	▶
Tempo	Elmendorff, 1944	▶
Language	Penin (fr.), 1998	▶
Key	Orlov (russ.), 1946	▶
Sound quality	Gui (it.), 1957	▶

Computational Music Structure Analysis



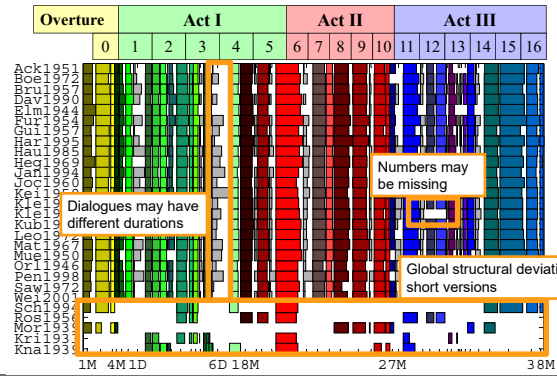
Example: Carl Maria von Weber: "Der Freischütz" (No. 4)



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Festkolloquium 32 Jahre Informatik

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Computational Music Structure Analysis



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Computational Music Structure Analysis

- Extraction of musical form
- Finding (nearly) repeating patterns
- Instrument detection and classification
- Language detection
- Detection of musical keys, chords, ...
- Detection of time signature, tempo, measures, beats, ...
- ...

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Festkolloquium 32 Jahre Informatik

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Computational Music Structure Analysis



Susanne
Bach-
Bernhard



Heike
Clemens



Simone
Schilke



Jutka
Gasiorowski



Michael
Wagner

Thank you!

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Festkolloquium 32 Jahre Informatik

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Computational Methods for Melody and Voice Processing in Music Recordings



2019, January 27 – February 1, Dagstuhl Seminar 19052

Organizers:

Emilia Gómez (UPF – Barcelona, ES)

Yi-Hsuan Yang (Academica Sinica – Taipei, TW)

Meinard Müller (FAU, DE)



Musik trifft Informatik in Dagstuhl
Festkolloquium 32 Jahre Informatik

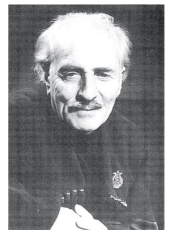
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Computational Methods for Melody and Voice Processing in Music Recordings



Example: Erkomaishvili corpus

- Collection of traditional three-voice Georgian songs
- Performed by the former Georgian master chanter Artem Erkomaishvili (1887-1967)
- Recordings of 100 songs using tape recorders (1966)



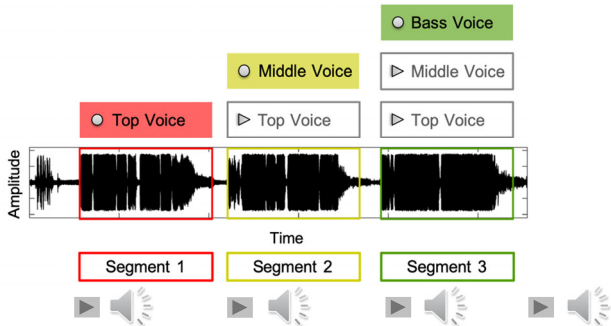
"Original masterpieces of Georgian musical thinking." (Shugliashvili, 2014)

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Festkolloquium 32 Jahre Informatik

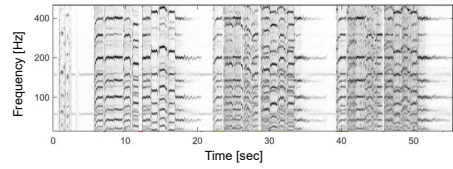
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Computational Methods for Melody and Voice Processing in Music Recordings

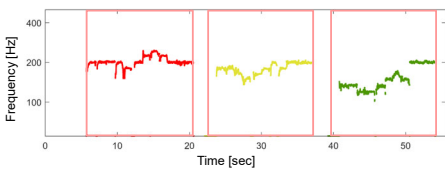
Example: Erkomaishvili corpus



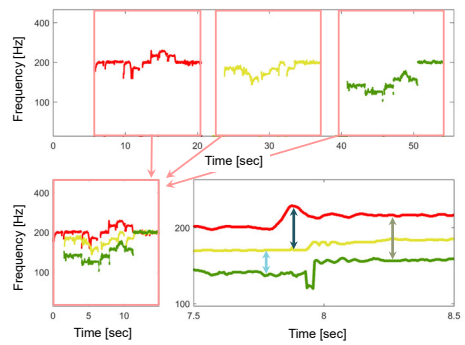
Computational Methods for Melody and Voice Processing in Music Recordings



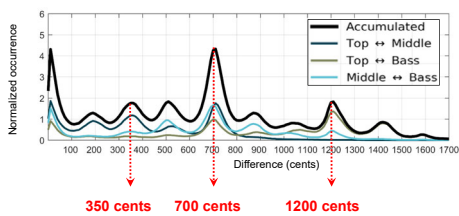
Computational Methods for Melody and Voice Processing in Music Recordings



Computational Methods for Melody and Voice Processing in Music Recordings



Computational Methods for Melody and Voice Processing in Music Recordings



- Peak at 350 cents (between minor and major third)
- Non-western temperament

Computational Methods for Melody and Voice Processing in Music Recordings



Computational Methods for Melody and Voice Processing in Music Recordings



Room
Microphone

Computational Methods for Melody and Voice Processing in Music Recordings

Michael Gerke



Thank you!

Saarbrücken, 25. August 2020
SCHLOSS DAGSTUHL
Leibniz-Zentrum für Informatik

Dagstuhler Gesänge für die Wissenschaft

Forschung und Lehre, 28.08.2020

Chor aus Wissenschaftlern will Beitrag zur KI-Forschung leisten

Internationale Forschende aus Musikwissenschaft und Informatik zeichnen zu Forschungszwecken Gesänge auf. Davon sollen KI-Studien profitieren.

Deep Learning and Knowledge Integration for Music Audio Analysis



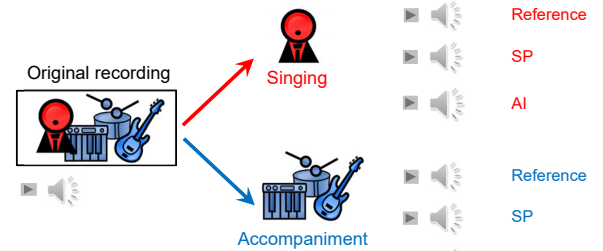
2022, February 20 – 25, Dagstuhl Seminar 22082

Organizers:

Rachel Bittner (Spotify – Paris, FR)
Juhan Nam (KAIST – Daejeon, KR)
Meinard Müller (FAU, DE)



Deep Learning and Knowledge Integration for Music Audio Analysis



- Reference: Best possible result
- SP: Using traditional signal processing
- AI: Using data-driven approach

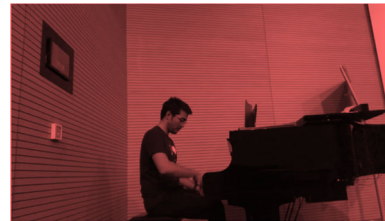
Deep Learning and Knowledge Integration for Music Audio Analysis

- Yigitcan Özer
- PhD student in engineering
- Pianist



Deep Learning and Knowledge Integration for Music Audio Analysis

- Yigitcan Özer
- PhD student in engineering
- Pianist



Only Piano!



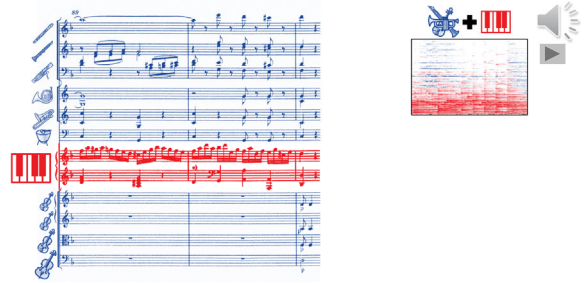
Where is the orchestra?



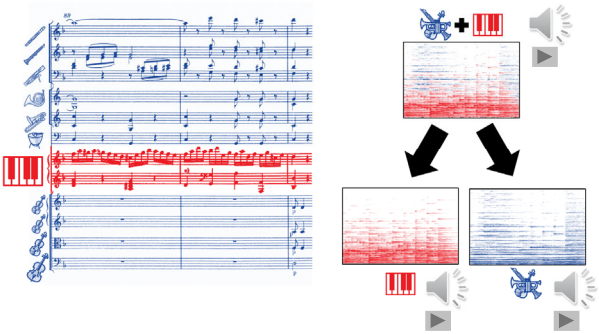
Deep Learning and Knowledge Integration for Music Audio Analysis



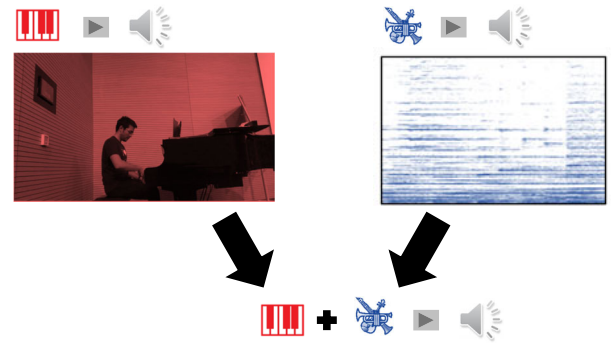
Deep Learning and Knowledge Integration for Music Audio Analysis



Deep Learning and Knowledge Integration for Music Audio Analysis



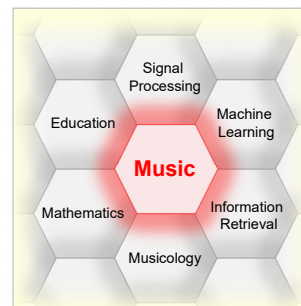
Deep Learning and Knowledge Integration for Music Audio Analysis



Deep Learning and Knowledge Integration for Music Audio Analysis

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

Musik trifft Informatik in Dagstuhl



- Music is a ubiquitous and vital part of our lives
- Digital music services: Spotify, Pandora, iTunes, ...
- Music yields intuitive entry point to support and motivate education in technical disciplines
- Music bridges the gap between engineering, computer science, mathematics, and the humanities

Musik trifft Informatik in Dagstuhl



Reinhard Wilhelm



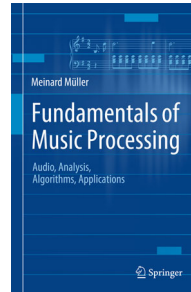
Raimund Seidel



SCHLOSS DAGSTUHL
Leibniz-Zentrum für Informatik

Thank you!

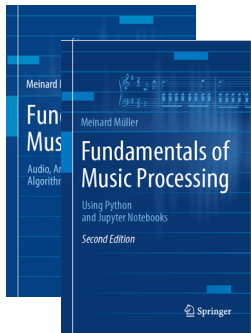
Fundamentals of Music Processing (FMP)



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

Accompanying website:
www.music-processing.de

Fundamentals of Music Processing (FMP)



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

Accompanying website:
www.music-processing.de

2nd edition
Meinard Müller
Fundamentals of Music Processing
Using Python and Jupyter Notebooks
Springer, 2021

Fundamentals of Music Processing (FMP)

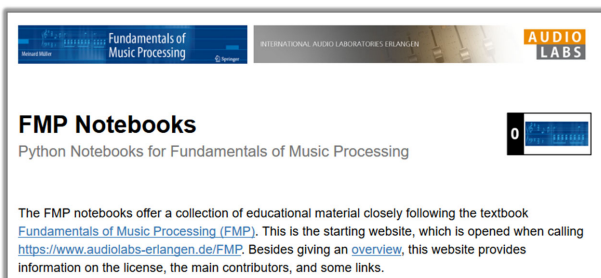
Chapter	Music Processing Scenario
1	Music Representations
2	Fourier Analysis of Signals
3	Music Synchronization
4	Music Structure Analysis
5	Chord Recognition
6	Tempo and Beat Tracking
7	Content-Based Audio Retrieval
8	Musically Informed Audio Decomposition

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

Accompanying website:
www.music-processing.de

2nd edition
Meinard Müller
Fundamentals of Music Processing
Using Python and Jupyter Notebooks
Springer, 2021

FMP Notebooks: Education & Research



<https://www.audiolabs-erlangen.de/FMP>

References

- Meinard Müller: Fundamentals of Music Processing – Using Python and Jupyter Notebooks. 2nd Edition, Springer, 2021.
<https://www.springer.com/gp/book/9783030698072>
- Meinard Müller and Frank Zalkow: libfmp: A Python Package for Fundamentals of Music Processing. Journal of Open Source Software (JOSS), 6(63): 1–5, 2021.
<https://joss.theoj.org/papers/10.21105/joss.03326>
- Meinard Müller: An Educational Guide Through the FMP Notebooks for Teaching and Learning Fundamentals of Music Processing. Signals, 2(2): 245–285, 2021.
<https://www.mdpi.com/2624-6120/2/2/18>
- Meinard Müller and Frank Zalkow: FMP Notebooks: Educational Material for Teaching and Learning Fundamentals of Music Processing. Proc. International Society for Music Information Retrieval Conference (ISMIR): 573–580, 2019.
<https://zenodo.org/record/3527872#.Y0hEQOqzaUk>
- Meinard Müller, Brian McFee, and Katherine Kinnaird: Interactive Learning of Signal Processing Through Music: Making Fourier Analysis Concrete for Students. IEEE Signal Processing Magazine, 38(3): 73–84, 2021.
<https://ieeexplore.ieee.org/document/9418542>

Resources (Group Meinard Müller)

- FMP Notebooks:

<https://www.audiolabs-erlangen.de/FMP>

- libfmp:

<https://github.com/meinardmueller/libfmp>

- synctoolbox:

<https://github.com/meinardmueller/synctoolbox>

- libtsm:

<https://github.com/meinardmueller/libtsm>

- Preparation Course Python (PCP) Notebooks:

<https://www.audiolabs-erlangen.de/resources/MIR/PCP/PCP.html>

<https://github.com/meinardmueller/PCP>