

Tutorial 5, ISMIR
Milan, November 5, 2023



Learning with Music Signals: Technology Meets Education

Overview

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International Audio Laboratories Erlangen
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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 Semantic Audio Processing

- Yigitcan Özer
- Simon Schwär
- Johannes Zeitler
- Peter Meier
- Sebastian Strahl
- Uli Berendes
- Chiu Ching/Sunny
- Vlora Arifi-Müller



- Michael Krause
- Christof Weiß
- Sebastian Rosenzweig
- Frank Zalkow
- Hendrik Schreiber
- Christian Dittmar
- Stefan Balke
- Jonathan Driedger
- Thomas Prätzlich
- ...

International Audio Laboratories Erlangen



- Fraunhofer Institute for Integrated Circuits IIS
- Largest Fraunhofer institute with ≈ 1000 members
- Applied research for sensor, audio, and media technology

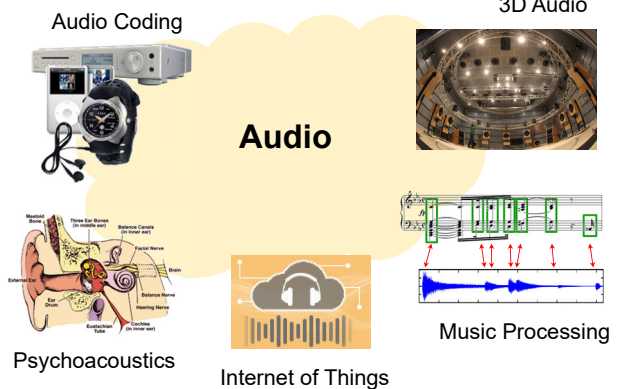


- Friedrich-Alexander Universität Erlangen-Nürnberg (FAU)
- One of Germany's largest universities with ≈ 40,000 students
- Strong Technical Faculty

International Audio Laboratories Erlangen



International Audio Laboratories Erlangen



AudioLabs – FAU

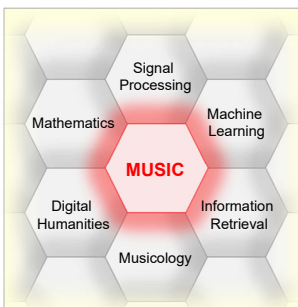
- Prof. Dr. Jürgen Herre
Audio Coding
- Prof. Dr. Bernd Edler
Audio Signal Analysis
- Prof. Dr. Meinard Müller
Semantic Audio Processing
- Prof. Dr. Emanuël Habets
Spatial Audio Signal Processing
- Prof. Dr. Nils Peters
Audio Signal Processing
- Dr. Stefan Turowski
Coordinator AudioLabs-FAU



Music Processing



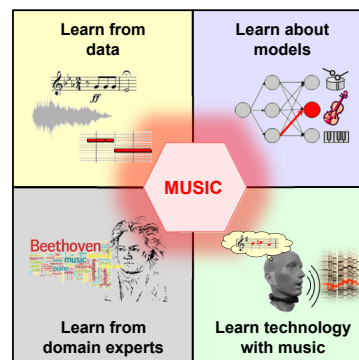
Music Processing: A Multifaceted Research Area



Music ...

- important part of our lives ...
- ... Spotify, Pandora, iTunes, ...
- interdisciplinary research
- intuitive entry point to education

Learning with Music Signals Technology Meets Education



- Machine learning for music signal processing
- Interpretable models and knowledge integration
- Music understanding and applications
- Interactive learning in engineering through music

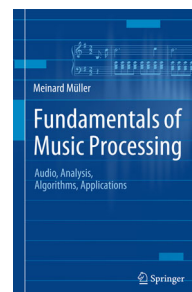
Schedule

- Part 0: Overview
- Part I: Music Retrieval
- Coffee Break**
- Part II: Audio Decomposition
- Part III: FMP Notebooks

Slides/Material:

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

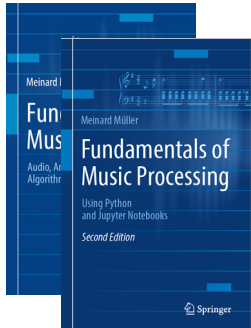
Fundamentals of Music Processing (FMP)



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

Accompanying website:
www.music-processing.de

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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

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FMP Notebooks: Education & Research

FMP Notebooks
Python Notebooks for Fundamentals of Music Processing

The FMP notebooks offer a collection of educational material closely following the textbook [Fundamentals of Music Processing \(FMP\)](https://www.audiolabs-erlangen.de/FMP). This is the starting website, which is opened when calling <https://www.audiolabs-erlangen.de/FMP>. Besides giving an [overview](#), this website provides information on the license, the main contributors, and some links.

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

References (FMP Textbook & Notebooks)

- 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#.YQhEQqzaUk>
- 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>

Resources

- librosa:
<https://librosa.org/>
- madmom:
<https://github.com/CPJKU/madmom>
- Essentia Python tutorial:
https://essentia.upf.edu/essentia_python_tutorial.html
- mirdata:
<https://github.com/mir-dataset-loaders/mirdata>
- open-unmix:
<https://github.com/sigsep/open-unmix-pytorch>
- Open Source Tools & Data for Music Source Separation:
<https://source-separation.github.io/tutorial/landing.html>

