

INTERNATIONAL AUDIO LABORATORIES ERLANGEN
A joint institution of Fraunhofer IIS and Universität Erlangen-Nürnberg



Tutorial T3, EUROGRAPHICS
Saarbrücken, May 8, 2023



Learning with Music Signals: Technology Meets Education

Overview

Meinard Müller

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



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

- Michael Krause
- Yigitcan Özer
- Simon Schwär
- Johannes Zeitler
- Peter Meier (external)
- Christof Weiß
- Sebastian Rosenzweig
- Frank Zalkow
- 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 $\approx 40,000$ students
- Strong Technical Faculty

International Audio Laboratories Erlangen



Audio

International Audio Laboratories Erlangen

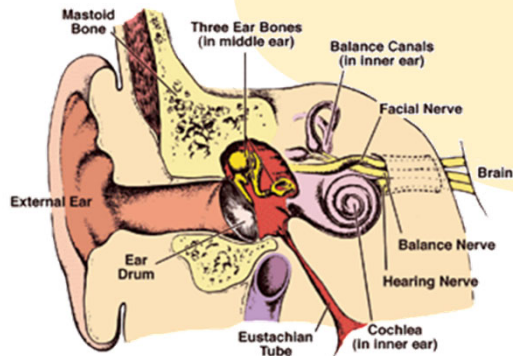
Audio Coding



3D Audio



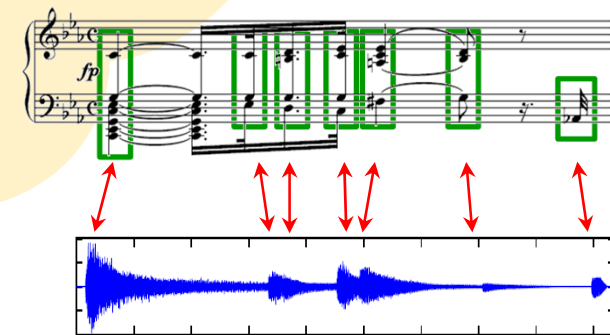
Audio



Psychoacoustics



Internet of Things



Music Processing

AudioLabs – FAU

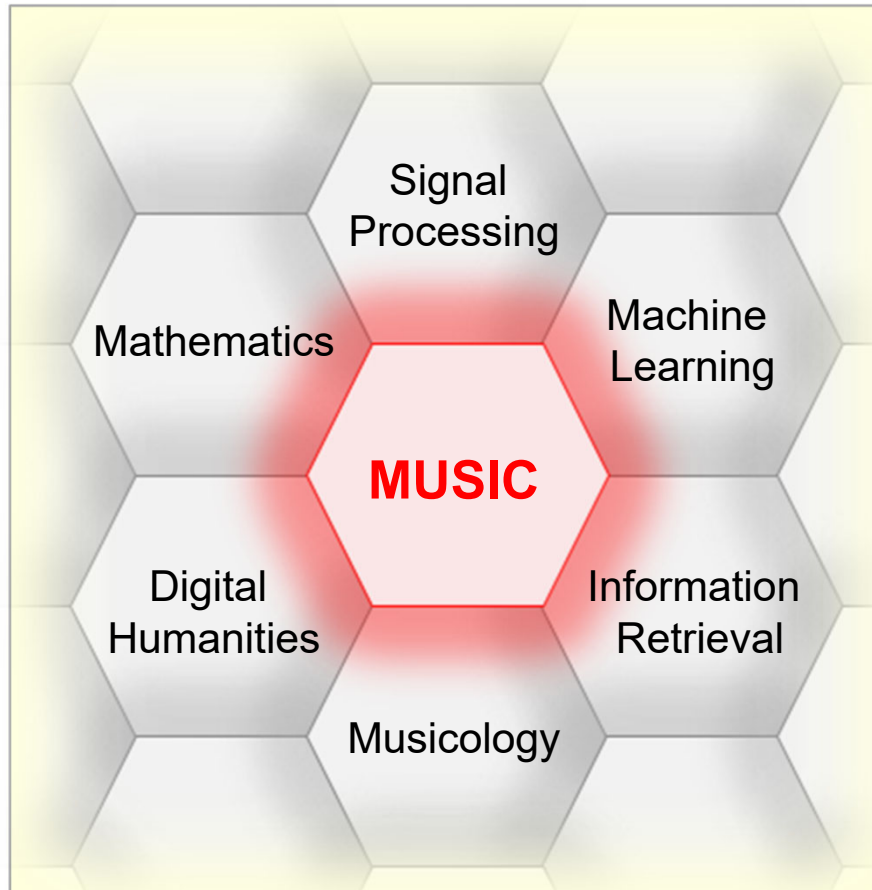
- Prof. Dr. Jürgen Herre
Audio Coding
- Prof. Dr. Bernd Edler
Audio Signal Analysis
- Prof. Dr. Meinard Müller
Semantic Audio Processing
- Prof. Dr. Emanuël Habets
Spatial Audio Signal Processing
- Prof. Dr. Nils Peters
Audio Signal Processing
- Dr. Stefan Turowski
Coordinator AudioLabs-FAU



Music Processing



Music Processing: A Multifaceted Research Area

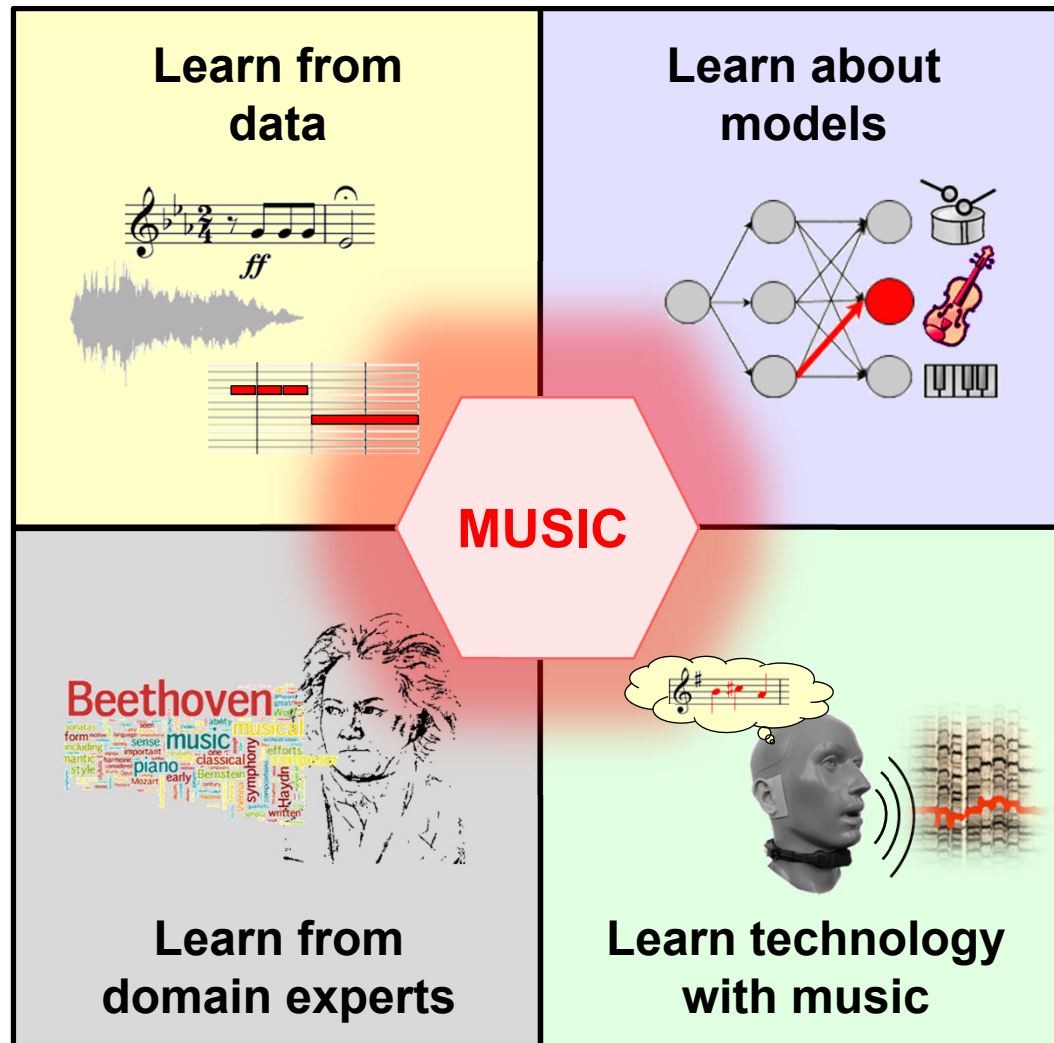


Music ...

- 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

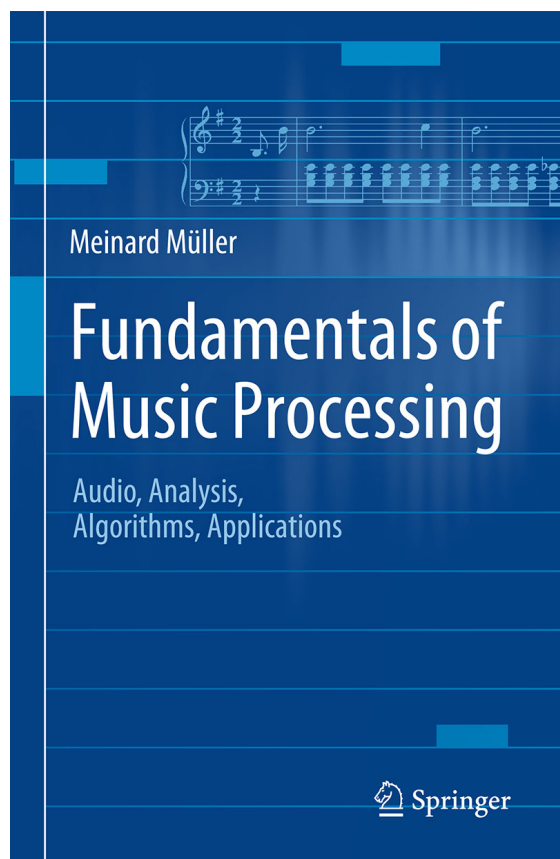
- Part 0: Overview
- Part I: Music Retrieval
- **Coffee Break**
- Part II: Audio Decomposition
- Part III: FMP Notebooks

Slides/Material:

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

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

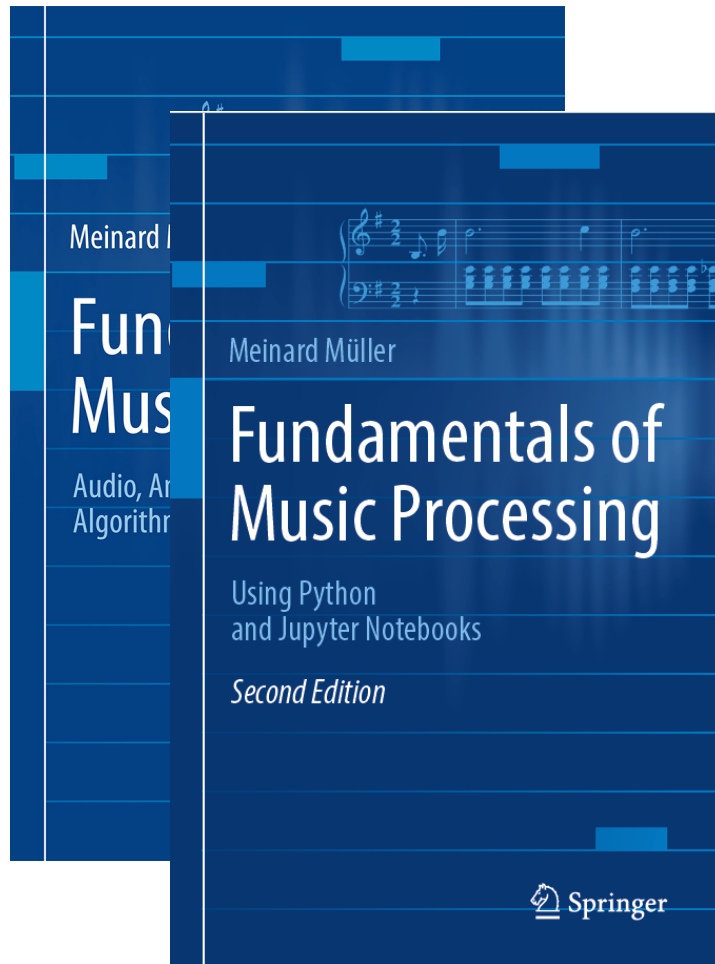
Fundamentals of Music Processing (FMP)



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

Accompanying website:
www.music-processing.de

Fundamentals of Music Processing (FMP)

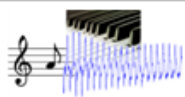

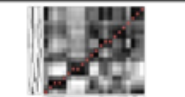
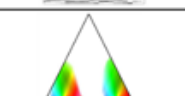

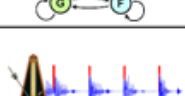




Meinard Müller
Fundamentals of Music Processing
Audio, Analysis, Algorithms, Applications
Springer, 2015

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)

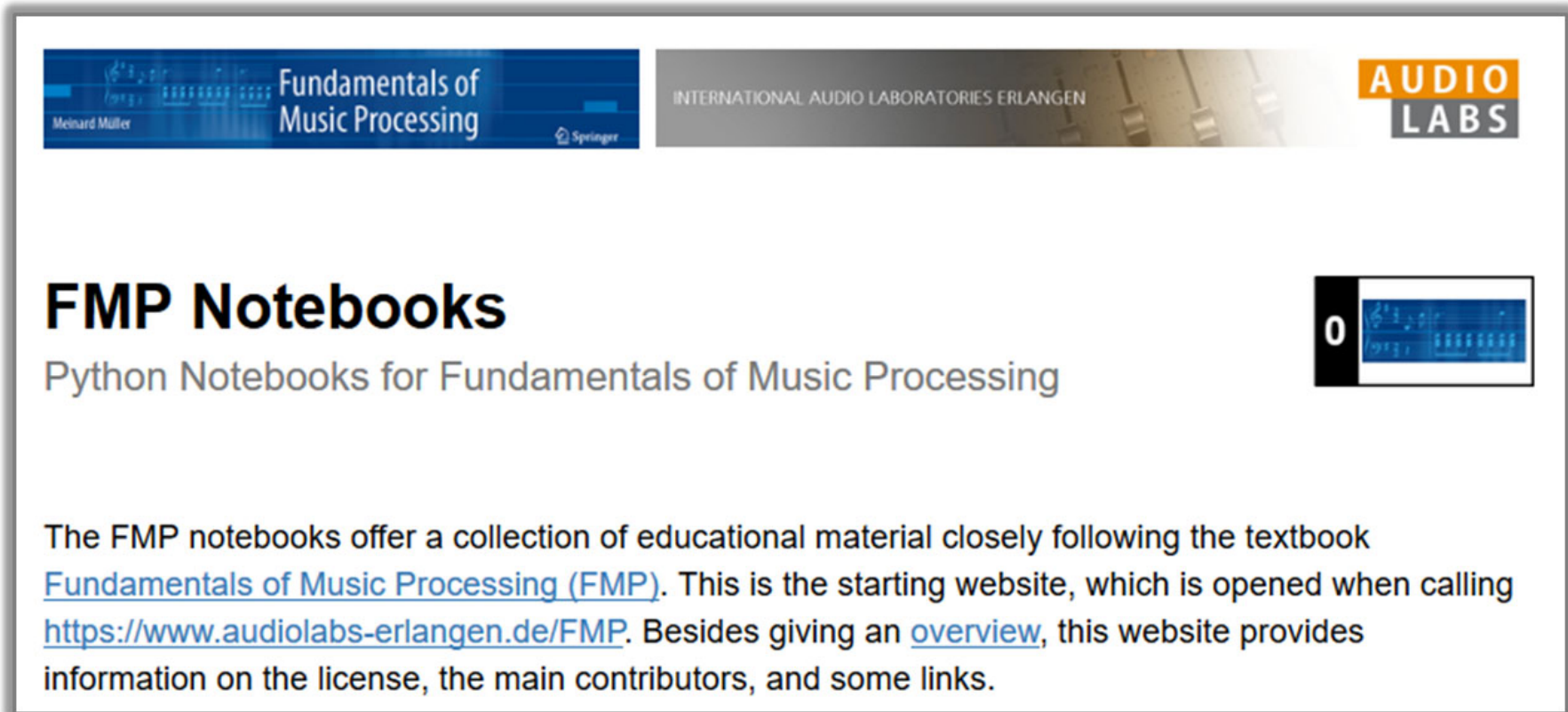
Chapter	Music Processing Scenario
1	 Music Representations
2	 Fourier Analysis of Signals
3	 Music Synchronization
4	 Music Structure Analysis
5	 Chord Recognition
6	 Tempo and Beat Tracking
7	 Content-Based Audio Retrieval
8	 Musically Informed Audio Decomposition

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Audio, Analysis, Algorithms, Applications
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Using Python and Jupyter Notebooks
Springer, 2021

FMP Notebooks: Education & Research



The screenshot shows the top of a website. On the left is the cover of the book 'Fundamentals of Music Processing' by Meinard Müller, published by Springer. To the right of the book cover is the text 'INTERNATIONAL AUDIO LABORATORIES ERLANGEN' and the 'AUDIO LABS' logo. Below this is the main heading 'FMP Notebooks' and the subtitle 'Python Notebooks for Fundamentals of Music Processing'. To the right of the subtitle is a small icon of a notebook with a '0' on it. Below the heading and subtitle is a paragraph of text: 'The FMP notebooks offer a collection of educational material closely following the textbook [Fundamentals of Music Processing \(FMP\)](#). 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#.YOhEQOgzaUk>
- 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>

