

# Tutorial 1

## Tempo, Beat, and Downbeat Estimation

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### Abstract

The highly interrelated topics of tempo, beat, and downbeat estimation from musical audio signals have spanned the entire history of MIR. Along with many MIR topics, the uptake of deep learning has fundamentally altered how these rhythm-oriented tasks have been addressed and has led to a profound increase in performance. This tutorial seeks to position itself within this narrative by providing a high-level understanding of historical signal processing-oriented approaches leading to hands-on practical experience in building, training, and evaluating the most recent state-of-the-art deep learning approaches. Our goal is not only to expose participants to a complete rhythm analysis pipeline, but also to emphasize the importance of technical and musical design choices, the reliability of annotated data, and multidisciplinary. In addition, we seek to provide insight into common pitfalls and discuss future challenges.

The tutorial is targeted towards those in the ISMIR community who wish gain comprehensive insight and practical experience in tempo, beat, and downbeat estimation of musical audio signals. For those new to this area, we seek to provide a hands-on technical and pedagogical guide which can serve as the basis for fostering future research. For those with prior knowledge in the area, we hope to convey a solid understanding of recent advances and current state-of-the-art approaches. As a prerequisite for participation, we would expect some basic experience in the execution of python notebooks.

### Biographies of Presenters

**Matthew E. P. Davies** is a researcher in the Centre for Informatics and Systems of the University of Coimbra (CISUC), Portugal. His research interests include the analysis of rhythm in musical audio signals, evaluation methodology, creative music applications, and reproducible research. His most recent research has addressed the use of compact deep neural networks for the analysis of rhythmic structure, and computational ethnomusicology.

**Sebastian Böck** received his diploma degree in electrical engineering from the Technical University in Munich and his Ph.D. in computer science from the Johannes Kepler University Linz. Within the MIR community he is probably best known for his machine learning-based algorithms and as the principal maintainer of open source python library, madmom. Currently he works as an AI research engineer for enliteAI in Vienna, Austria.

**Magdalena Fuentes** is a Provost's Postdoctoral Fellow at the Music and Audio Research Lab and the Center for Urban Science and Progress of New York University (NYU). She completed her Ph.D. at Université Paris Saclay on multi-scale computational rhythm analysis, with focus on the interaction of microtiming, beats, downbeats and music structure. Her research interests include Machine Listening, Self-Supervised Representation Learning, Computational Rhythm Analysis and Environmental Sound Analysis.