25TH INTERNATIONAL SOCIETY FOR MUSIC INFORMATION RETRIEVAL CONFERENCE (ISMIR 2024)
NOVEMBER 10 – 14, 2024
SAN FRANCISCO, CALIFORNIA, USA

ISMIR 2024 Tutorial

Exploring 25 Years of Music Information Retrieval: Perspectives and Insights

Masataka Goto AIST, Japan
Jin Ha Lee University of Washington, USA
Meinard Müller International Audio Laboratories Erlangen, Germany

2024/11/10

Overview

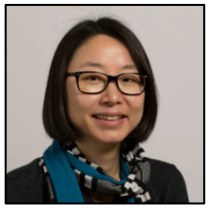
This tutorial reflects on the journey of

Music Information Retrieval (MIR)

over the last 25 years,

offering insights from three distinct perspectives:

research, community, and education

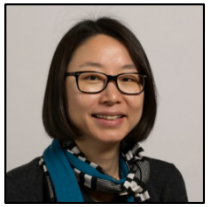

Overview

09:00-09:05 Overview of this tutorial, brief introduction of three speakers

09:05-09:45 **Part 1: Research Perspective** (40 min)
by **Masataka Goto**

discussions (15 min)

10:00-10:40 **Part 2: Community Perspective** (40 min)
by **Jin Ha Lee**



(10:30-11:00: coffee break)

discussions (15 min)

11:25-12:05 **Part 3: Education Perspective** (40 min)
by **Meinard Müller**

discussions (15 min)

12:20-12:30 Conclusions

Part 1: Masataka Goto

- **Senior Principal Researcher, AIST**

  National Institute of Advanced Industrial Science and Technology

- **Working on music information research since 1992**
- **I love ISMIR**
  - 2001-2024: 68 publications since 2001 (including 3 papers this year)
  - 2002-2024: Participation every year since 2002
  - 2007-2024: Program Committee Member (except for 2009/2014/2022)
  - 2009: General Chair (Kobe)
  - 2009-2011: Board Member (Member-at-large)
  - 2014: General Chair (Taipei)
  - 2019: Tutorials Chair (Delft)
  - 2022: Program Chair (Bengaluru)

General Meeting at ISMIR 2009 in Japan

The election results for the very first ISMIR Board of Directors were announced

Part 2: Jin Ha Lee

- **Professor, University of Washington**
- **Working on user-centered MIR, more broadly on organization, access and user behavior related to popular cultural materials**
- **I love ISMIR**
  - 2002-2024: 33 publications since 2002
  - 2009-2015: Secretary, Board of Directors
  - 2014: Program Chair (Taipei)
  - 2020: Program Chair (Montréal)
  - 2021: General Chair (Online)
  - 2024: Program Chair (San Francisco)
  - 2018-2024: Editorial Board Member of TISMIR

GAMER
GAME RESEARCH GROUP

Part 3: Meinard Müller

- **Professor,**
  International Audio Laboratories Erlangen
- **Working on music information research since 2003**
- **I love ISMIR**
  - 2003-2024: 71 publications since 2003 (including 3 papers this year)
  - 2004-2024: Participation every year since 2004
  - 2009-2021: Board Member
  - 2012: Program Chair (Porto)
  - 2015: Program Chair (Malaga)
  - 2020-2021: President of ISMIR
  - Since 2024: Editor in Chief of TISMIR

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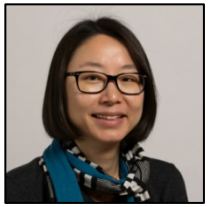

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ISMIR 2024 Tutorial: Exploring 25 Years of MIR

Part 1: Research Perspective

AIST (National Institute of Advanced Industrial Science and Technology)

Masataka Goto

2024/11/10

Research Perspective: Topics

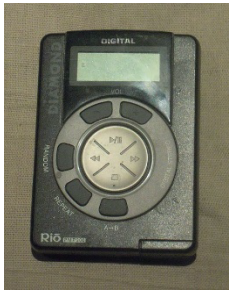
1. Before the Inception of ISMIR
2. Establishing Standard Tasks
3. Datasets and Tools
4. Applications and Interfaces
5. Inherently Interdisciplinary
6. Diverse Approaches
7. Future Challenges

1. Before the Inception of ISMIR

Before the Inception of ISMIR

- **Music compact discs (CDs) appeared in 1982**
  - CD sales in Japan surpassed those of vinyl LPs in 1986
  - CD sales in USA surpassed those of vinyl LPs in 1988

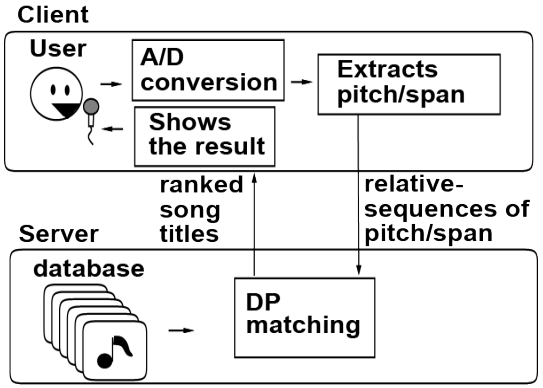
- **MP3 started getting popular since 1995**
  - Expensive special hardware was needed just to extract audio signals from CDs



- **The widespread use of MP3s in the late 1990s led to an increase in music technology research**

Before the Inception of ISMIR

- **Query-by-humming research began in the 1990s**
  - T. Kageyama, K. Mochizuki, and Y. Takashima: Melody retrieval with humming, ICMC 1993
  - A. Ghias et al., Query by humming: Musical information retrieval in an audio database, ACM MM 1995
  - T. Sonoda, M. Goto, and Y. Muraoka: A WWW-based melody retrieval system, ICMC 1998



[Sonoda+, ICMC 1998]

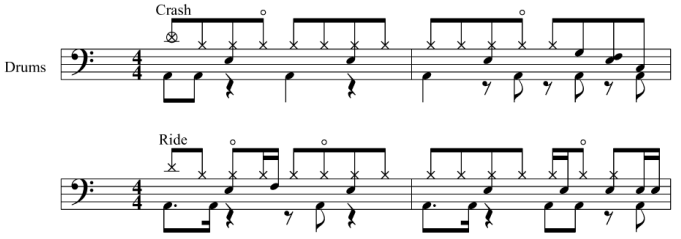
- **Music transcription / sound source separation**
  - [Mont-Reynaud, IJCAI 1985] [Chafe and Jaffe, ICASSP 1986] [Katayose and Inokuchi, ICMPC 1989] [Kashino and Tanaka, ICMC 1993] [Kashino and Murase, ICASSP 1998] [Klapuri, MSc Thesis 1998] etc.
- **Beat tracking**
  - [Allen and Dannenberg, ICMC 1990] [Desain and Honing, ICMC 1994] [Goto and Muraoka, ACM MM 1994 / ICMC 1995,1998] [Scheirer, JASA 1998] etc.
- **Melody and bass estimation** [Goto, CASA 1999 / ICASSP 2000,2001]

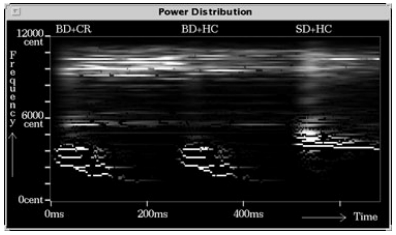
My Personal Story

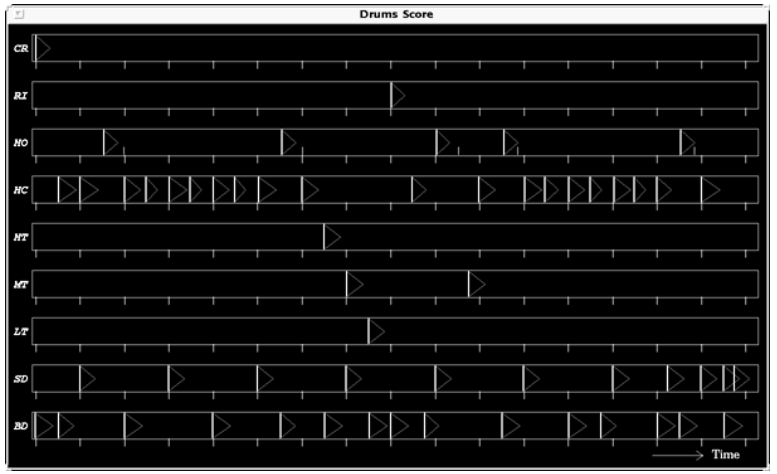
- **In 1992, I started music analysis for polyphonic music**
  - World-first drum detection method for polyphonic drums

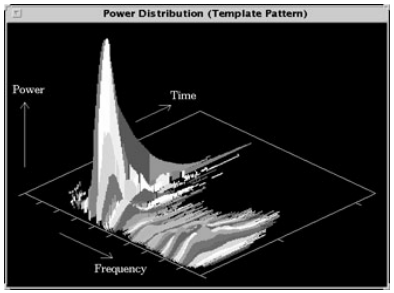
    Input: Sound mixture of **nine kinds of drum instruments**

    Output: Their onset times









Novel template matching
allowing spectral overlaps

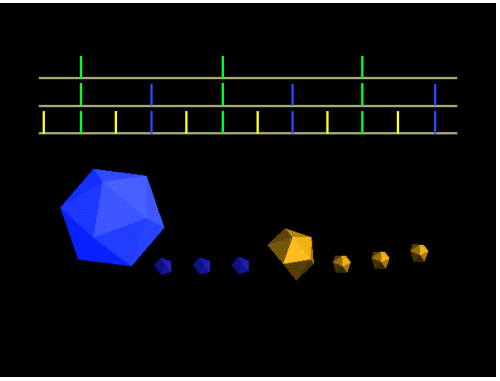
bass drum, snare drum,
low tom, middle tom, high tom,
hihat close, hihat open,
ride cymbal, and crash cymbal

M. Goto and Y. Muraoka: A Sound Source Separation System for Percussion Instruments, IEICE Transactions, Vol.J77-D-II, No.5, pp.901-911, 1994. (in Japanese)

My Personal Story

- **During 1993-1998, I developed a beat tracking system**
  - World-first beat and downbeat detection method for pop music

[Goto and Muraoka, ACM Multimedia 1994 / ICMC 1995,1998]



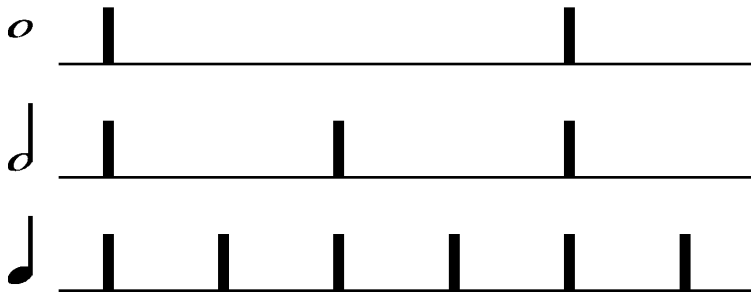
Musical audio signals

Beat structure

Measure level
(measure times)

Half-note level
(half-note times)

Quarter-note level
(beat times)

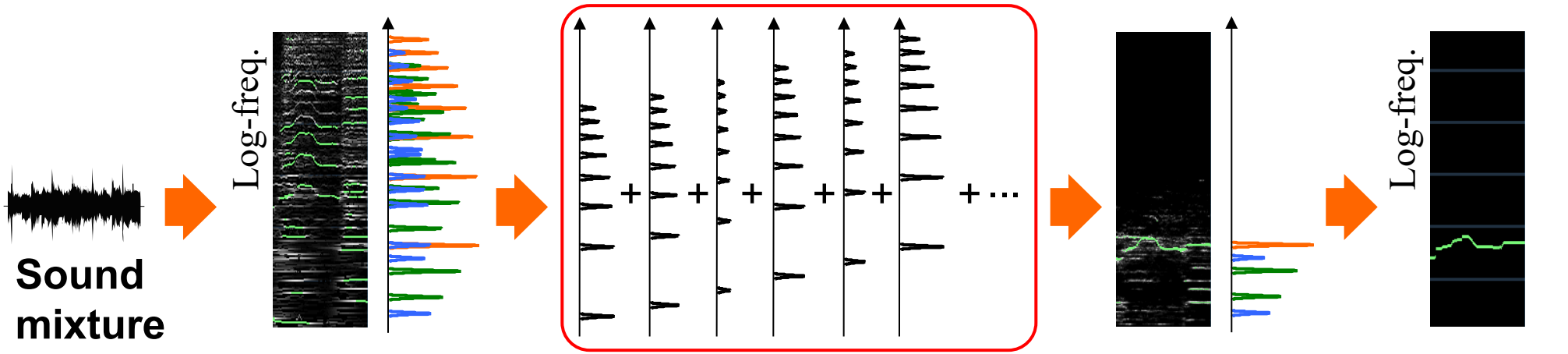


- **Waited one night to get FFT results for full songs**
  - I used a large parallel computer AP1000 with 64 CPUs

My Personal Story

- **In 1998, I started melody and bass estimation**
  - **PreFEst**: World-first melody and bass estimation method

Multirate signal proc. Instantaneous freq.	Mixture density model EM algorithm	Temporal continuity Multiagent model



Sound mixture

PDF of freq. components

Mixture considering all possibilities of F0

F0's PDF

Melody F0

F0: fundamental frequency

M. Goto: A Robust **Predominant-F0 Estimation** Method for Real-time Detection of Melody and Bass Lines in CD Recordings, IEEE ICASSP 2000

And so, the ISMIR conference was launched in 2000

2. Establishing Standard Tasks

Establishing Standard Tasks

- **How to establish standard tasks**
  1. Researchers propose a pioneering research topic
  2. The topic is getting popular because of its importance
  3. The topic gradually becomes a standard task
- **Pioneering research topics of 1990s and early 2000s**
  - Beat and downbeat estimation
  - Melody estimation
  - Genre classification
  - Chord recognition
  - Structure analysis
  - etc.

Standard Tasks

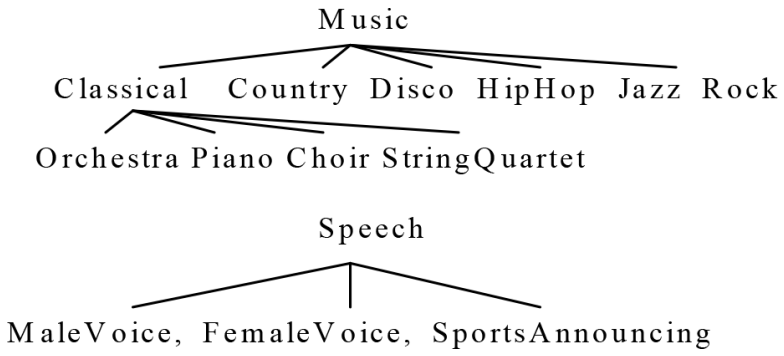
❑ Genre classification

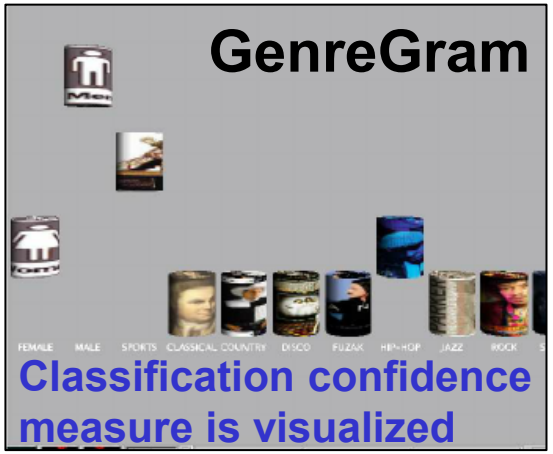
- **ISMIR 2001**: G. Tzanetakis, G. Essl, and P. Cook:
  Automatic Musical Genre Classification of Audio Signals

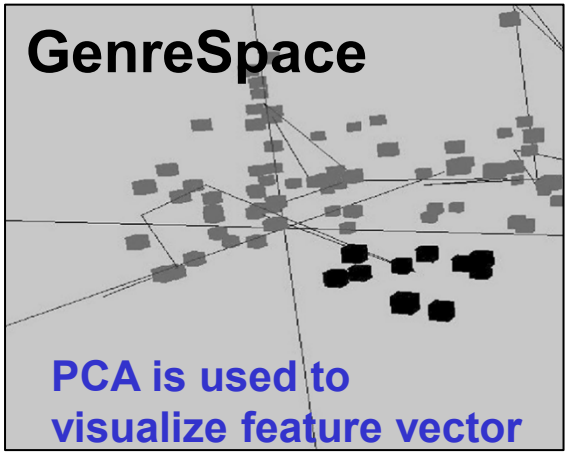
  Feature vector: Centroid, rolloff, flux, low energy, periodicities, etc.

  Each genre class is represented as a Gaussian distribution

  Two user interfaces





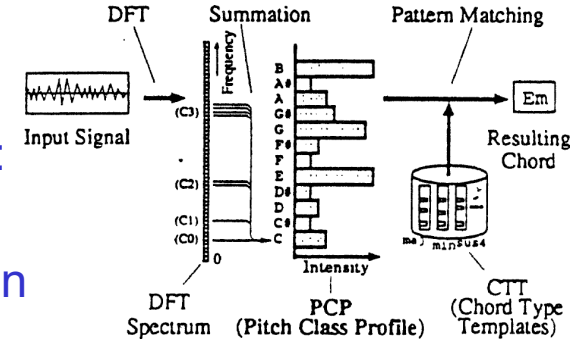


MARSYAS Genre Meter
https://www.youtube.com/watch?v=NDLhrc_WR5Q

Standard Tasks

Chord recognition

- T. Fujishima: Realtime Chord Recognition of Musical Sound: A System Using Common Lisp Music, ICMC 1999
- **ISMIR 2003**: A. Sheh and D. P. W. Ellis: Chord Segmentation and Recognition Using EM-Trained Hidden Markov Models
- **ISMIR 2019**: J. Pauwels, K. O'Hanlon, E. Gomez, M. B. Sandler: 20 Years of Automatic Chord Recognition from Audio



[Fujishima, ICMC 1999]

Structure analysis

- J. Foote: Visualizing Music and Audio Using Self-Similarity, ACM Multimedia 1999
- R. B. Dannenberg and N. Hu: Discovering Musical Structure in Audio Recordings, ICMAI 2002
- **ISMIR 2002**: G. Peeters et al.: Toward Automatic Music Audio Summary Generation from Signal Analysis
- O. Nieto et al.: Audio-Based Music Structure Analysis: Current Trends, Open Challenges, and Applications, **Transactions of ISMIR**, 2020

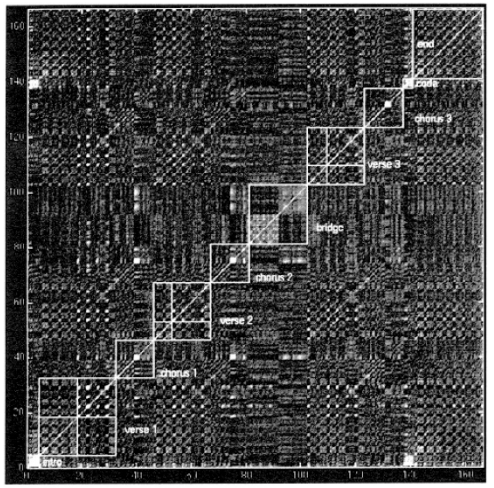


Figure 7. *Day Tripper* by Lennon/McCartney

[Foote, ACM MM 1999]

ADC / MIREX: Standard Tasks

- **ISMIR 2004 Audio Description Contest (ADC)**
  - Genre Classification/Artist Identification
  - Melody Extraction
  - Tempo Induction
  - Rhythm Classification
- **MIREX 2005 (1st Music Information Retrieval Evaluation eXchange)**
  - Audio Artist Identification
  - Audio Drum Detection
  - Audio Genre Classification
  - Audio Key Finding
  - Audio Melody Extraction
  - Audio Onset Detection
  - Audio Tempo Extraction
  - Symbolic Genre Classification
  - Symbolic Melodic Similarity
  - Symbolic Key Finding

Popular Standard Tasks Are Changing

- **MIREX 2014 (10th Music Information Retrieval Evaluation eXchange)**
  - Audio Classical Composer Identification
  - Audio Genre Classification
  - Audio Mood Classification
  - Audio Onset Detection
  - Audio Cover Song Identification
  - Audio Tempo Estimation
  - Audio Key Detection
  - Audio Beat Tracking
  - Audio Downbeat Estimation
  - Audio Chord Estimation
  - Audio Melody Extraction
  - Audio Tag Classification
  - Audio Fingerprinting
  - Audio Music Similarity and Retrieval
  - Music Structure Segmentation
  - Discovery of Repeated Themes & Sections
  - Singing Voice Separation
  - Multiple Fundamental Frequency Estimation & Tracking
  - Query-by-Singing/Humming
  - Query-by-Tapping
  - Real-time Audio to Score Alignment
  - Symbolic Melodic Similarity

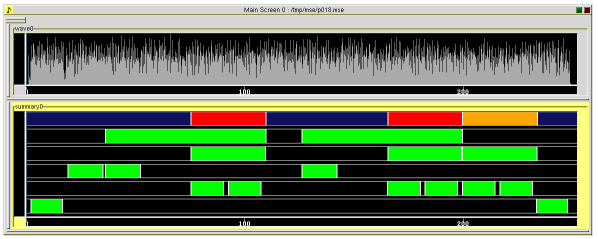
My Personal Story

- **In 2002, I started working on music structure analysis**
  - **RefraiD**: Chorus-section detection method for popular music

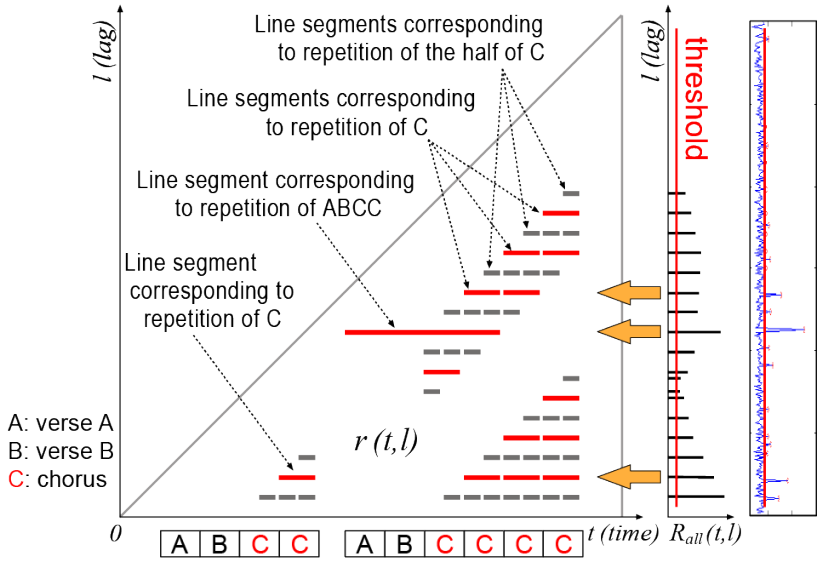
    Detects all the chorus sections in a song

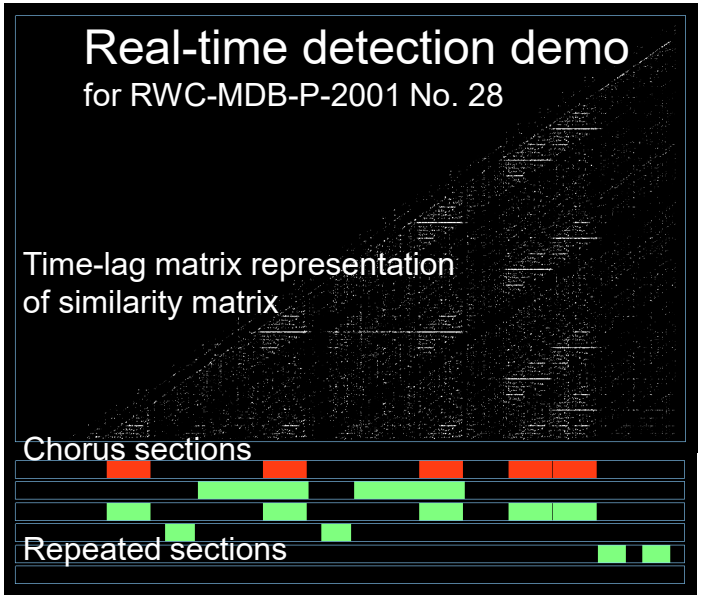
    Detects repetition even after key changes

    Works in real time along the audio input



Find line segments in the similarity $r(t,l)$





M. Goto: A Chorus-Section Detecting Method for Musical Audio Signals, IEEE ICASSP 2003

Establishing Standard Tasks

- **How to establish standard tasks**
  1. Researchers propose a pioneering research topic
  2. The topic is getting popular because of its importance
  3. The topic gradually becomes a standard task

Take-Home Message:

You can also establish a standard task!

Let's propose a brave new idea!

3. Datasets and Tools

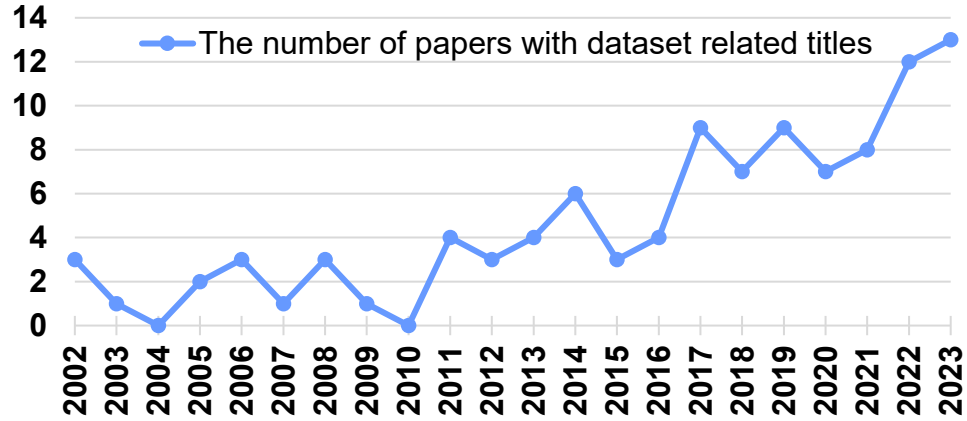
Datasets and Tools

- **Researchers developed music datasets and tools and established the MIR field**
  - Wonderful list of datasets/annotations
    https://www.audiocontentanalysis.org/datasets
  - Wonderful list of tools/software
    https://www.ismir.net/resources/software-tools/
- **Datasets, annotations, and evaluation metrics are important for**
  - **evaluating and comparing research results**
  - **training machine learning models**

Datasets

❑ Datasets

- Very popular in recent years
  for machine learning,
  for evaluation, etc.



* Inexhaustive list (based on grep -i “dataset|database|corpus| corpora” ISMIR_paper_titles.txt)
* There would be other papers that share a dataset without mentioning it in the title

Some early ISMIR papers

- **ISMIR 2002**: M. Goto et al. : **RWC Music Database**: Popular, Classical and Jazz Music Databases
- **ISMIR 2002**: D. Bainbridge and J. R. McPherson: Forming a Corpus of Voice Queries for Music Information Retrieval
- **ISMIR 2002**: T. Noll et al.: Opuscope - Towards a Corpus-Based Music Repository

Excerpts of ISMIR papers (there are too many great datasets to list up all)

- **ISMIR 2009**: E. Law et al.: Evaluation of algorithms using games: the case of music annotation (**MagnaTagATune**)
- **ISMIR 2011**: T. Bertin-Mahieux, D. P. W. Ellis, B. Whitman, and P. Lamere: **The Million Song Dataset**
- **ISMIR 2014**: R. M. Bittner et al.: **MedleyDB**: A Multitrack Dataset for Annotation-Intensive MIR Research
- **ISMIR 2015**: A. Porter et al.: **AcousticBrainz**: A Community Platform for Gathering Music Information Obtained from Audio
- **ISMIR 2017**: E. Fonseca et al.: **Freesound Datasets**: A Platform for the Creation of Open Audio Datasets
- **ISMIR 2018**: G. Meseguer-Brocal, A. Cohen-Hadria and G. Peeters: **DALI**: A Large Dataset of Synchronized Audio, Lyrics and notes, Automatically Created using Teacher-student Machine Learning Paradigm

My Personal Story

- **In 2000-2001, we developed RWC Music Database**
  - Commonly available databases with copyright-cleared music
  - Three main purposes **(not obvious in early 2000s)**
    1. Use databases as a common benchmark

       Compare and evaluate various methods and systems
    2. Accelerate the progress of research depending on databases

       Make use of statistical methods or machine learning methods
    3. Use databases for research publication and presentation

       Demonstrate research w/o conventional copyright restrictions

       Demos can be included in conference videos & CD-ROMs
  - There were no such large-scale databases

ISMIR 2002: M. Goto et al.: RWC Music Database: Popular, Classical, and Jazz Music Databases
ISMIR 2003: M. Goto et al.: RWC Music Database: Music Genre Database and Musical Instrument Sound Database

My Personal Story

- **In 2000-2001, we developed RWC Music Database**
  - Six component DBs: 315 pieces + 50 instruments
    - **Popular Music DB**: 100 pieces
    - **Royalty-Free Music DB**: 15 pieces
    - **Classical Music DB**: 50 pieces
    - **Jazz Music DB**: 50 pieces
    - **Music Genre DB**: 100 pieces
    - **Musical Instrument Sound DB**: 50 instruments (29.1 Gbytes)

  - Audio signals + transcribed SMFs + lyrics text

ISMIR 2002: M. Goto et al.: RWC Music Database: Popular, Classical, and Jazz Music Databases
ISMIR 2003: M. Goto et al.: RWC Music Database: Music Genre Database and Musical Instrument Sound Database

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  - Audio signals + transcribed SMFs + lyrics text

- **In 2001-2006, I developed AIST Annotation**
  - Annotations of beats, melody F0, and chorus sections are distributed

ISMIR 2006: M. Goto: AIST Annotation for the RWC Music Database

Tools

- **Without tools and libraries,**

  we have to implement everything from scratch

  - Advantages of them are tremendous and obvious
  - But we need to be aware of the nature and limitations of them

- **Some popular tools** (there are too many great tools to list up all)

  - **MARSYAS** (software framework for rapid prototyping of audio applications)

    ISMIR 2000: G. Tzanetakis and P. Cook: Audio Information Retrieval (AIR) Tools

  - **librosa** (python package for music and audio analysis)

    B. McFee et al.: librosa: Audio and music signal analysis in python, SciPy 2015

  - **Essentia** (Open-source library and tools for audio and music analysis, description and synthesis)

    ISMIR 2013: D. Bogdanov et al.: Essentia: An Audio Analysis Library for Music Information Retrieval

Datasets and Tools

- **Researchers developed music datasets and tools and established the MIR field**

https://www.audiocontentanalysis.org/datasets

https://www.ismir.net/resources/software-tools/

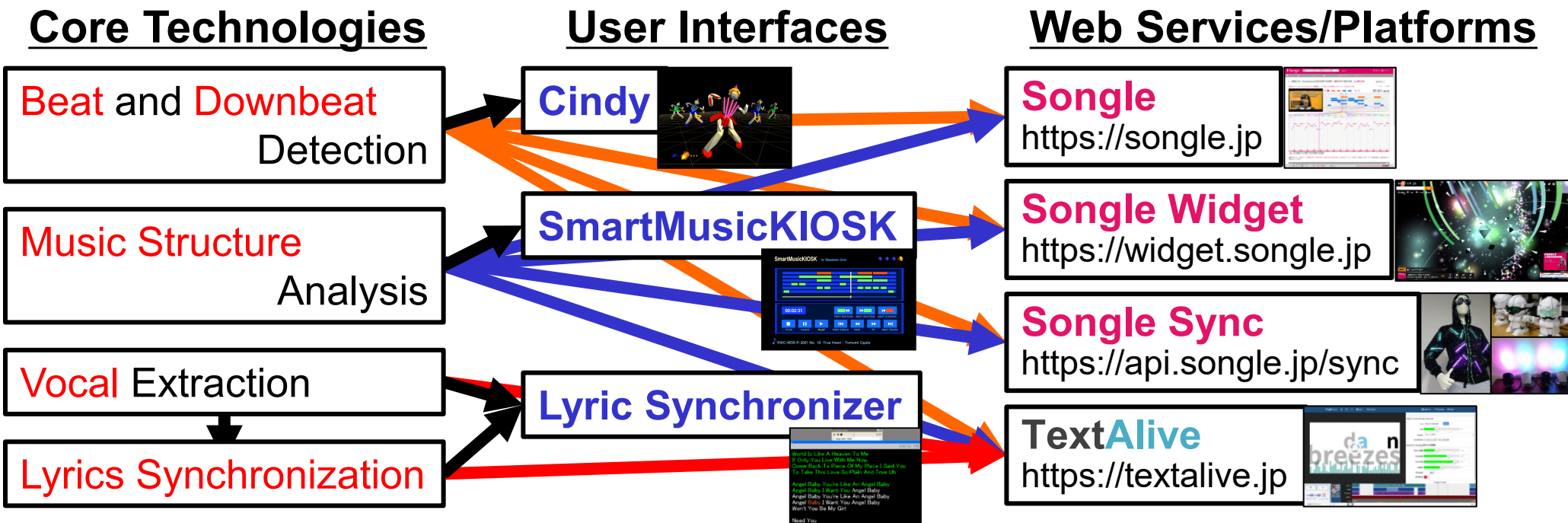
Take-Home Message:

There are still lots of room to contribute by developing your datasets and tools!

4. Applications and Interfaces

My Personal Story

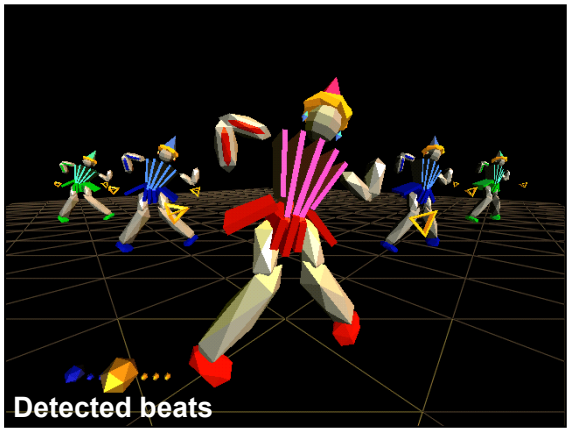
- **In 1990s, people asked me why music technologies are important?**
  - I started thinking how we can enrich music experiences by music technologies and developed music interfaces and applications



My Personal Story

❑ Virtual dancer “Cindy”

- M. Goto: An Audio-based Real-time Beat Tracking System for Music With or Without Drum-sounds, Journal of New Music Research, 30(2), pp.159-171, 2001



Core Technologies

- Beat and Downbeat Detection
- Music Structure Analysis
- Vocal Extraction
- Lyrics Synchronization

User Interfaces

- Cindy
- SmartMusicKIOSK
- Lyric Synchronizer

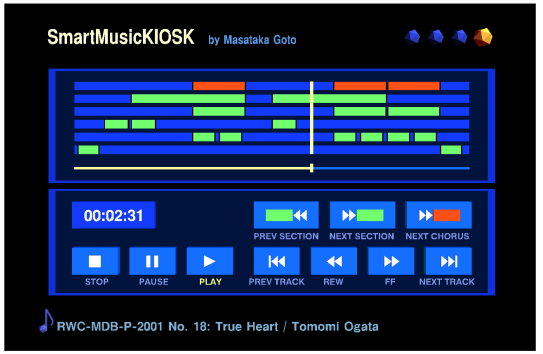
Web Services/Platforms

- Songle https://songle.jp
- Songle Widget https://widget.songle.jp
- Songle Sync https://api.songle.jp/sync
- TextAlive https://textalive.jp

My Personal Story

❑ Music listening station “SmartMusicKIOSK”

- M. Goto: SmartMusicKIOSK: Music Listening Station with Chorus-Search Function, ACM UIST 2003



Core Technologies

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User Interfaces

- Cindy
- SmartMusicKIOSK
- Lyric Synchronizer

Web Services/Platforms

- Songle https://songle.jp
- Songle Widget https://widget.songle.jp
- Songle Sync https://api.songle.jp/sync
- TextAlive https://textalive.jp

My Personal Story

❑ Web platform “Songle Sync”

- J. Kato, M. Ogata, T. Inoue, and M. Goto: Songle Sync: A Large-Scale Web-based Platform for Controlling Various Devices in Synchronization with Music, ACM Multimedia 2018

Core Technologies

- Beat and Downbeat Detection
- Music Structure Analysis
- Vocal Extraction
- Lyrics Synchronization

User Interfaces

- Cindy
- SmartMusicKIOSK
- Lyric Synchronizer

Web Services/Platforms

- **Songle** https://songle.jp
- **Songle Widget** https://widget.songle.jp
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Applications and Interfaces

- **Many researchers and practitioners have put significant effort into developing appealing applications and interfaces**

  (including commercial services and products)

- **Research papers on applications and interfaces have been published in various venues, including ISMIR**
  - Interfaces focusing on a single musical piece
  - Interfaces focusing on collections of music

Applications and Interfaces

❑ Interfaces focusing on a single musical piece

- M. Goto and R. B. Dannenberg: Music Interfaces Based on Automatic Music Signal Analysis: New Ways to Create and Listen to Music, IEEE Signal Processing Magazine, 36(1), pp.74-81, 2019
  1. Content-aware playback navigation
  2. Customization and personalization
  3. Production and performance

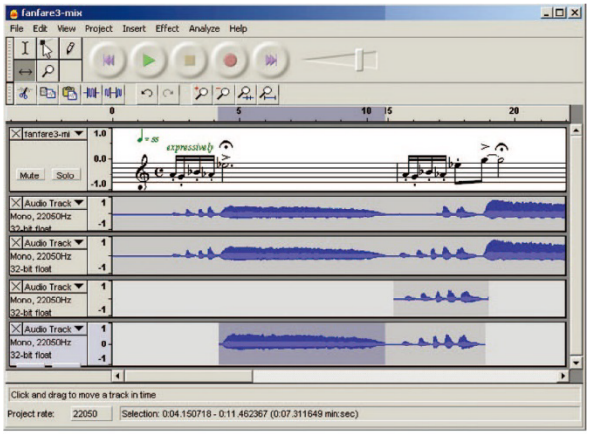


FIGURE 5. The concept design for an intelligent editor that stretches and aligns music notations and audio, which enables users to quickly navigate to, select, and splice together the best "takes" from a recording session [23].

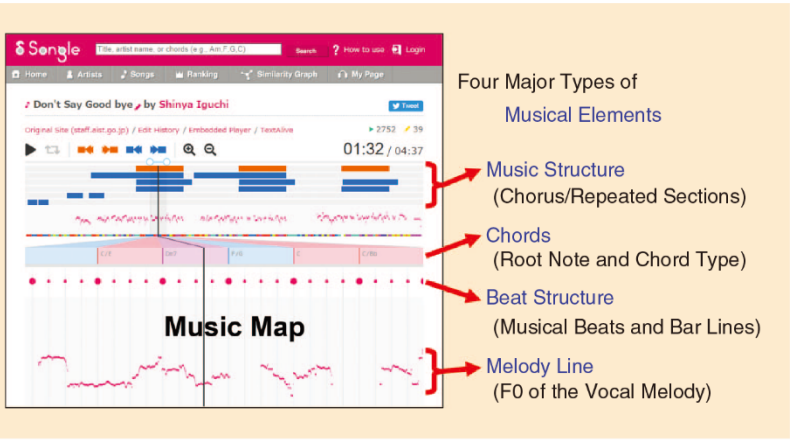


FIGURE 2. An interface of the Songle web service [7]. Songle automatically analyzes songs publicly available on the web and visualizes them with an informative "music map," including four types of musical elements. It is also equipped with the SmartMusicKIOSK interface.

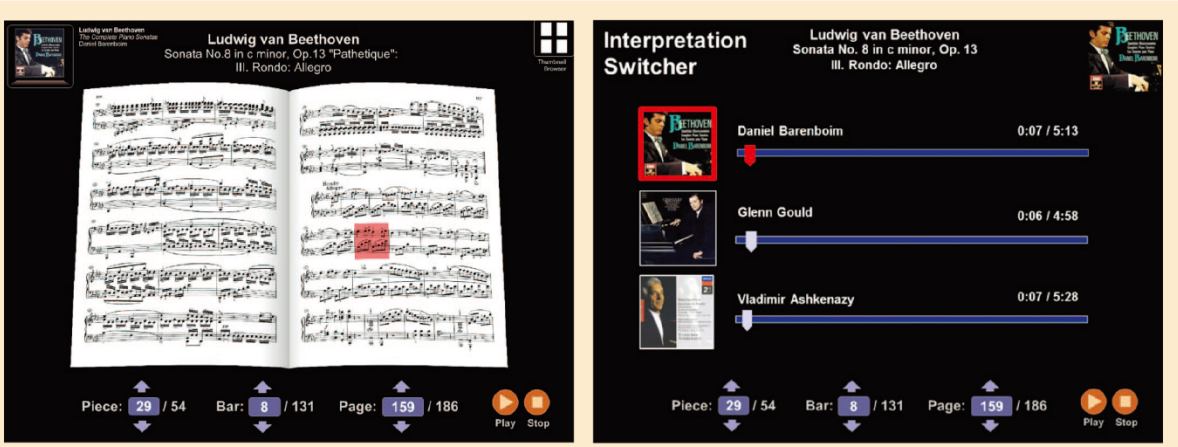


FIGURE 3. (a) The Score Viewer and (b) Interpretation Switcher interfaces. The Score Viewer displays interactive scanned sheet music synchronized with music playback. The Interpretation Switcher enables a user to seamlessly switch to different recordings of the same piece of music [11].

Applications and Interfaces

❑ Interface based on automatic music synchronization

- **ISMIR 2005**: F. Kurth et al.:
  SyncPlayer - An Advanced
  System for Multimodal Music Access

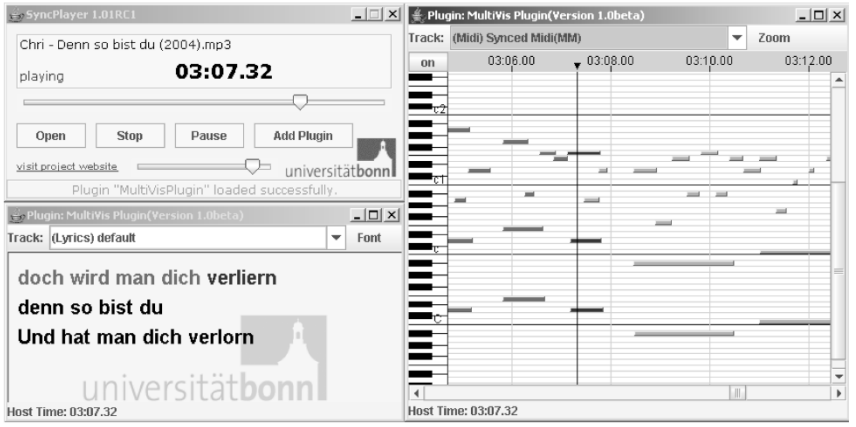
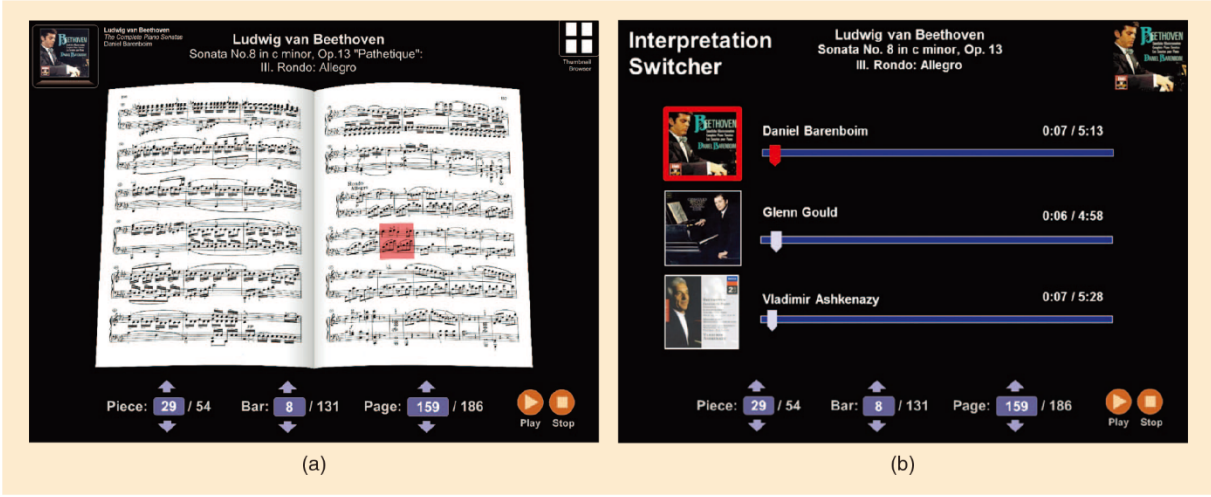


Figure 2: SyncPlayer client interface (left) together with two instances of the MultiVis plug-in, one displaying lyrics metadata, the other showing piano-roll data of an audio recording.



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Applications and Interfaces

❑ Interfaces focusing on collections of music

- P. Knees, M. Schedl, and M. Goto: Intelligent User Interfaces for Music Discovery, **Transactions of ISMIR**, 3(1), pp.165-179, 2020
  1. Content-based music retrieval interfaces
  2. Collaborative and automatic semantic description
  3. Recommender interfaces and continuous streaming

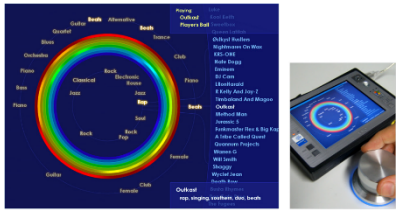
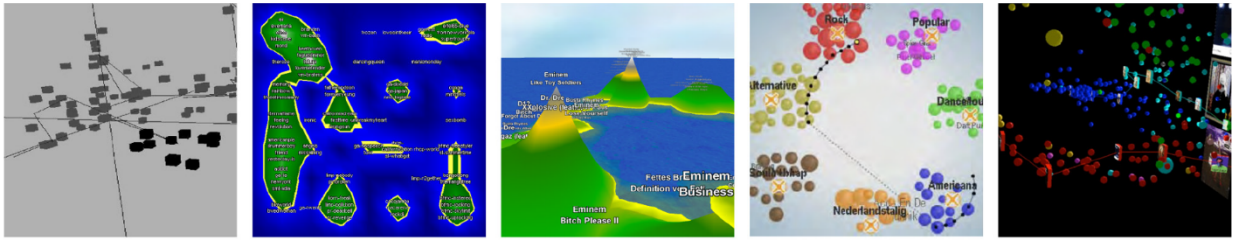
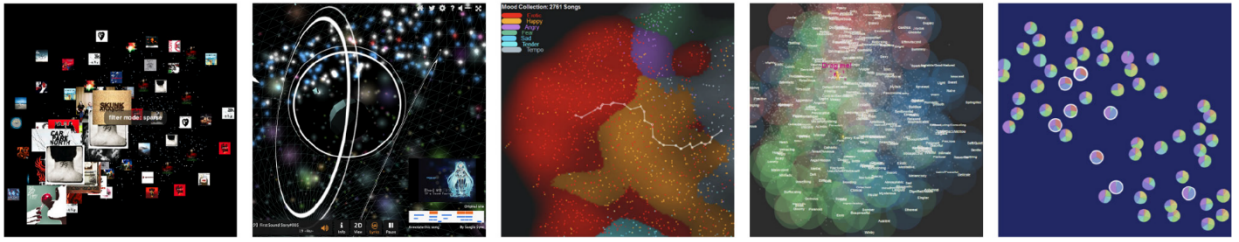


Figure 4: MusicRainbow: An artist discovery interface that enables a user to actively browse a music collection by using audio-based similarity and web-based labeling.

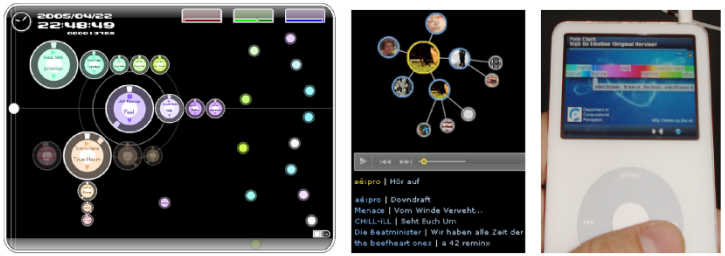


(a) GenreSpace (Tzanetakis et al., 2001) (b) Islands of Music (Pampalk et al., 2004) (c) nepTune (Knees et al., 2006) (d) Artist Map (van Gulik and Vignoli, 2005) (e) Search Inside the Music (Lamere and Eck, 2007)



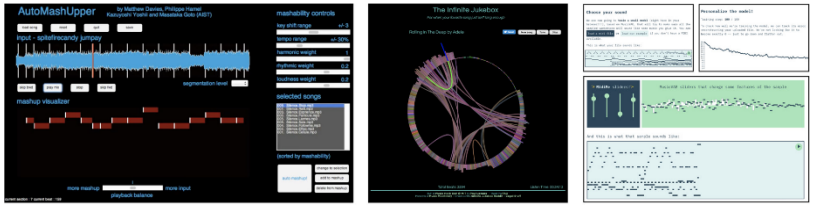
(f) MusicGalaxy (Stober and Nürnberger, 2010) (g) Songrium (Hamasaki et al., 2015) (h) Probabilistic music map (Vad et al., 2015) (i) MoodPlay (Andjelkovic et al., 2019) (j) Instrudive (Takahashi et al., 2018)

Figure 1: Examples of map-based music browsing interfaces based upon dimensionality reduction techniques.



(a) Musicream (Goto and Goto, 2009) (b) FM4 Soundpark Player (Gasser and Flexer, 2009) (c) Intelligent iPod (Schnitzer et al., 2007)

Figure 2: Interfaces for sequential exploration of collections based on content similarity.



(a) AutoMashUpper (Davies et al., 2014) (b) The Infinite Jukebox http://infinitejukebox.playlistmachinery.com (c) MidiMe (Dinculescu et al., 2019)

Figure 7: Interfaces highlighting the confluence of music listening and music (co-)creation.

Applications and Interfaces

ISMIR 2003: Islands of Music

ISMIR 2005: Artist Map

ISMIR 2007: Search Inside the Music

ISMIR 2006: MusicRainbow

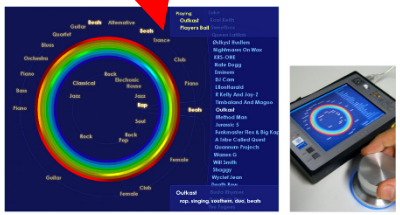
ISMIR 2001: GenreSpace

ISMIR 2015: Probabilistic music map

ISMIR 2018: Instrudive

ISMIR 2013: AutoMashUpper

ISMIR 2005: Musicream



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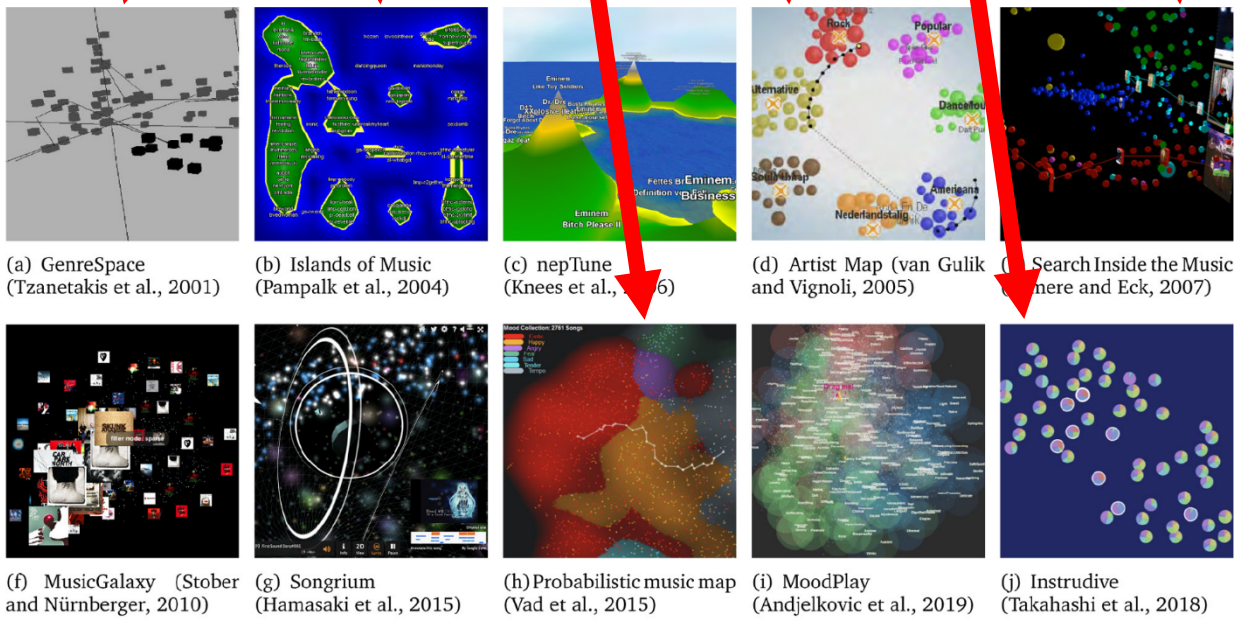

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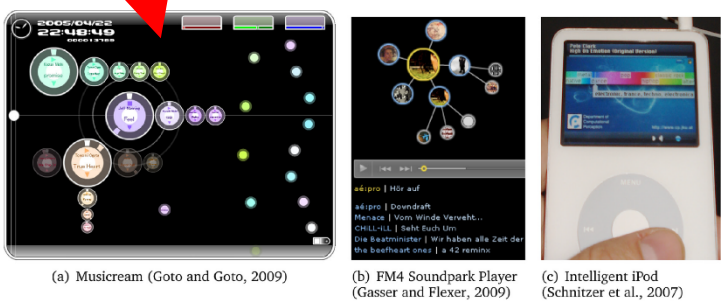

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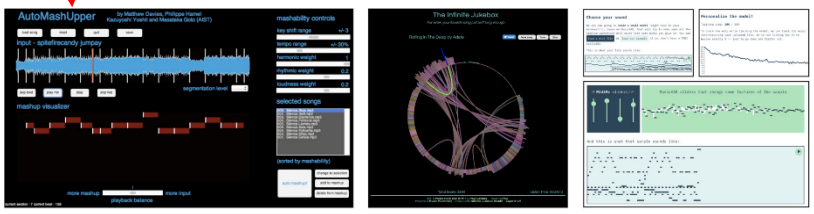

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(b) The Infinite Jukebox http://infinitejukebox.playlistmachinery.com
(c) MidiMe (Dinculescu et al., 2019)

Figure 7: Interfaces highlighting the confluence of music listening and music (co-)creation.

Applications and Interfaces

- **Thanks to the efforts of researchers and practitioners, the importance of MIR research is widely recognized**

Take-Home Message:

It is still important to show

how research results can impact

our daily lives and society!

5. Inherently Interdisciplinary

Inherently Interdisciplinary

- **The main attraction of ISMIR is the gathering of researchers from different backgrounds**
  - Research results in diverse fields are presented
    - Signal processing
    - Symbolic processing
    - Machine learning
    - Human-computer interaction
    - Musicology
    - Library sciences
    - Neuroscience
    - etc.

Inherently Interdisciplinary

- **Interdisciplinarity was emphasized from the start**

Music Information Retrieval (MIR) is a rapidly growing **interdisciplinary research area** encompassing computer science and information retrieval, musicology and music theory, audio engineering and digital signal processing, cognitive science, library science, publishing, and law.

Community	Type of Institution(s)	Typical Research Areas
Computer Science, Information Retrieval	Academic, Commercial	Representation, Indexing, Retrieval, Machine Learning, User Interface Design
Audio Engineering, Digital Signal Processing	Academic, Commercial	Compression, Feature Detection, Pitch Tracking, Machine Learning, Classification, Playlist Generation, Musical Analysis
Musicology, Music Theory	Academic	Representation, Musical Analysis
Library Science	Libraries, Academic	Representation, Metadata, User Studies, Classification, Intellectual Property Rights, User Interface Design
Cognitive Science, Psychology, Philosophy	Academic	Representation, Perception, User Studies, Ontology
Law	Government, Legal Profession, Academic	Intellectual Property Rights

J. Futrelle and J. S. Downie: Interdisciplinary Research Issues in Music Information Retrieval: ISMIR 2000-2002, Journal of New Music Research, 32(2), pp.121-131, 2003

Inherently Interdisciplinary

❑ About ISMIR 2024 (https://ismir2024.ismir.net)

When it comes to **multidisciplinary research** on the processing, analysis, indexing, organizing, and retrieval of music-related data, ISMIR is the largest forum for academics, researchers, practitioners, and industry participants in the field of Music Information Retrieval (MIR).

❑ Call for Papers of ISMIR 2024

ISMIR is a truly **interdisciplinary community**, which fosters collaboration between researchers, developers, educators, librarians, students, and professionals from the disciplines involved in Music Information Retrieval, such as musicology, cognitive science, library and information science, computer science, electrical engineering, and many others.

❑ No one can cover all the disciplines related to music

- It is essential to share insights and discuss issues across different disciplines

Inherently Interdisciplinary

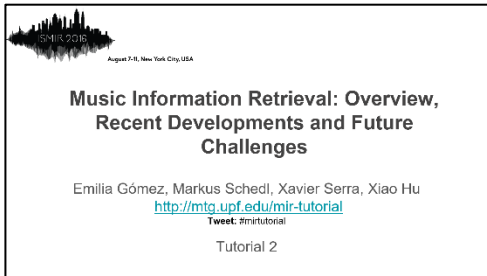
❑ Interdisciplinary research area

- **ISMIR 2016 Tutorial**: E. Gómez, M. Schedl, X. Serra, and X. Hu: Music Information Retrieval: Overview, Recent Developments and Future Challenges
  https://www.upf.edu/web/mtg/mir-overview-recent-developments-future

The online slides of this tutorial are highly recommended

They cover very diverse topics of ISMIR as follows

1. Music content description (Emilia Gómez)
2. Music context description (Markus Schedl)
3. MIR from the user perspective (Xiao Hu)
4. MIR from a cultural perspective (Xavier Serra)



Inherently Interdisciplinary

❑ Before ISMIR 2018

- Each session was given a specific topic

  e.g., “Session D - Corpora and voice”

- This made it easy for attendees to skip sessions on topics they were not familiar with

❑ After ISMIR 2019

- Papers are assigned to sessions randomly, following ISMIR 2018's innovation of making all papers oral presentations
- This allows everyone to stay engaged with all sessions and makes it easier to encounter content from disciplines outside their own expertise
- You can feel like you’ve seen everything at the conference!

Inherently Interdisciplinary

- **The main attraction of ISMIR is the gathering of researchers from different backgrounds**

Take-Home Message:

Let's enjoy papers from disciplines

outside your area of expertise!

6. Diverse Approaches

Diverse Approaches

- There are **diverse approaches** to MIR research

Analysis/Understanding	vs.	**Synthesis/Generation**
Signal processing	vs.	**Symbolic processing**
Real-time/Interactive	vs.	**Non-real-time/Non-interactive**
Creating a system	vs.	**Learning about music/people**
Dealing with one song	vs.	**Dealing with a set of songs**
Professional users	vs.	**Novice/Amateur users**
Automatic	vs.	**Manual/Semiautomatic**
Automating human abilities	vs.	**Augmenting human abilities**
Automatic creation	vs.	**Automatic appreciation**
etc.		**etc.**

M. Goto: Frontiers of Music Information Research Based on Signal Processing, IEEE ICSP 2014 (Keynote Paper)

Recent Approaches

- We here discuss some recent approaches:

  deep learning and creative MIR

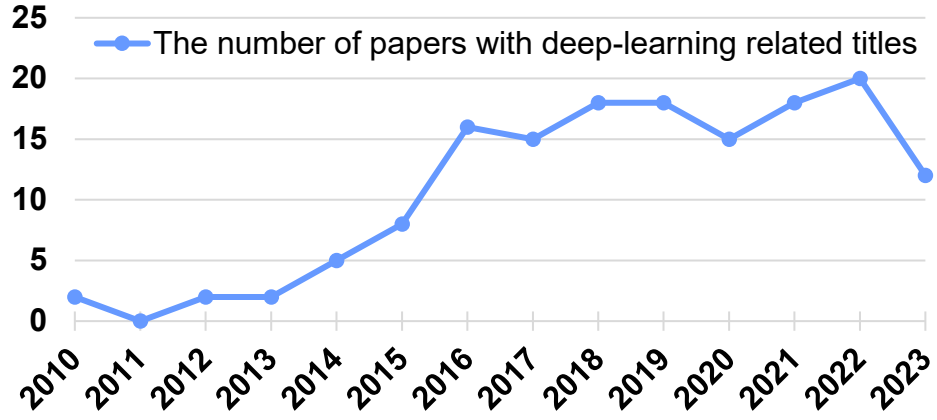
Recent Approaches: Deep Learning

❑ Deep learning approaches

- Very popular in recent years

  Achieve high performances

  Serve essential roles



* Inexhaustive list (based on grep -i "deep|neur|cnn|rnn" ISMIR_paper_titles.txt)
* There are a lot of papers that use deep learning without mentioning it in the title

Some early ISMIR papers

- **ISMIR 2010**: P. Hamel and D. Eck: Learning Features from Music Audio with Deep Belief Networks
- **ISMIR 2010**: F. Eyben, S. Bock, B. W. Schuller, and A. Graves: Universal Onset Detection with Bidirectional Long Short-Term Memory Neural Networks
- **ISMIR 2012**: E. Battenberg and D. Wessel: Analyzing Drum Patterns Using Conditional Deep Belief Networks
- **ISMIR 2012**: E. J. Humphrey, J. Pablo Bello, and Y. LeCun: Moving Beyond Feature Design: Deep Architectures and Automatic Feature Learning in Music Informatics
- **ISMIR 2013**: E. M. Schmidt and Y. Kim: Learning Rhythm and Melody Features With Deep Belief Networks
- **ISMIR 2013**: N. Boulanger-Lewandowski, Y. Bengio, and P. Vincent: Audio Chord Recognition with Recurrent Neural Networks

Some early ISMIR tutorials focusing on deep learning

- **ISMIR 2013**: P. Hamel, E. J. Humphrey, and E. M. Schmidt: Deep Learning in MIR - Demystifying the Dark Art
- **ISMIR 2018**: A. Schindler, T. Lidy, and S. Böck: Deep Learning for MIR
- **ISMIR 2019**: H.-W. Dong and Y.-H. Yang: Generating Music with GANs: An Overview and Case Studies
- **ISMIR 2019**: S. Dieleman, J. Pons, and J. Lee: Waveform-based music processing with deep learning

Reusable Insights

- **ISMIR 2019 started emphasizing reusable insights**
  - **Reviewer guidelines**

    Please note that this year we specially call for submissions that explicitly discuss reusable insights, that is, insights that may go beyond the scope of the paper, domain or application, in order to build up consistent knowledge across the MIR community.
  - **Review form**

    The paper provides reusable insights (i.e. the capacity to gain an accurate and deep understanding). Such insights may go beyond the scope of the paper, domain or application, in order to build up consistent knowledge across the MIR community.

    Please explain your assessment of reusable insights in the paper.

Important improvement by Scientific Program Chairs of ISMIR 2019:
Arthur Flexer, Geoffroy Peeters, Julián Urbano, and Anja Volk

Recent Approaches: Deep Learning

- **Highlight one of many fascinating research topics**
  - Model-based deep learning

    Approaches that combine traditional knowledge-based methods with data-driven techniques based on deep learning

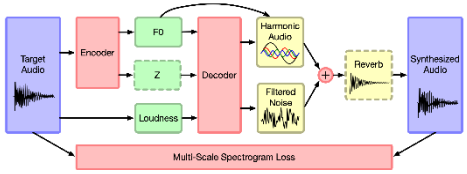
    Prior knowledge related to sound production, music perception, or music composition theory can be incorporated into the design of neural networks and associated loss functions

    G. Richard, V. Lostanlen, Y.-H. Yang, and M. Müller: Model-Based Deep Learning for Music Information Research, IEEE Signal Processing Magazine (in press)

    Differentiable Digital Signal Processing (DDSP) framework

    Integrate traditional DSP elements into deep learning pipelines

    J. Engel, L. Hantrakul, C. Gu, and A. Roberts: DDSP: Differentiable digital signal processing, ICLR 2020



Recent Approaches: Creative MIR

❑ Creative MIR

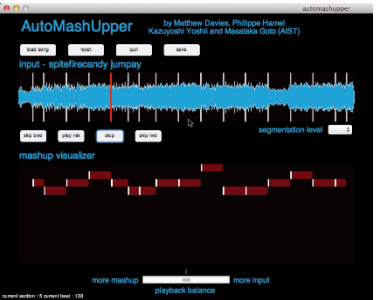
- Music generation was not a popular topic of ISMIR papers!
- Early ISMIR papers proposing Creative MIR

ISMIR 2013 LBD paper: E. J. Humphrey, D. Turnbull, and T. Collins:
A Brief Review of Creative MIR

"creative applications in MIR seems to hold a promising future"

"the earliest efforts in content-based MIR placed a heavy emphasis on retrieval-centric problems"

ISMIR 2013: M. E. P. Davies, P. Hamel, K. Yoshii, and M. Goto:
AutoMashUpper: An Automatic Multi-Song Mashup System



"the emerging field of creative-MIR, where music analysis and transformation techniques are used within real applications"

"the aim of assisting users to become music creators through simple interactions with a user interface"

Recent Approaches: Creative MIR

❑ Creative MIR

- Music generation is now a popular topic of ISMIR papers!

  ISMIR 2017: F. Pachet, A. Papadopoulos, and P. Roy: Sampling Variations of Sequences for Structured Music Generation

  ISMIR 2017: L.-C. Yang, S.-Y. Chou, and Y.-H. Yang: MidiNet: A Convolutional Generative Adversarial Network for Symbolic-Domain Music Generation

  ISMIR 2018: H.-W. Dong and Y.-H. Yang: Convolutional Generative Adversarial Networks with Binary Neurons for Polyphonic Music Generation

  ISMIR 2018: M. Andreux and S. Mallat: Music Generation and Transformation with Moment Matching-Scattering Inverse Networks
  (There are too many papers to list up after 2019)

- Creative MIR and Human-AI Music Creation

  ISMIR 2016: K. Andersen and P. Knees: Conversations with Expert Users in Music Retrieval and Research Challenges for Creative MIR

  ISMIR 2020: C.-Z. A. Huang et al.: Human-AI Co-Creation in Songwriting

  ISMIR 2023: M. Newman, L. Morris, and J. H. Lee: Human-AI Music Creation: Understanding the Perceptions and Experiences of Music Creators for Ethical and Productive Collaboration

Recent Approaches

- **We here discuss some recent approaches:**

  deep learning and creative MIR

Take-Home Message:

Let's be among the first to propose

an approach you believe will

become popular in the future!

7. Future Challenges

Future Challenges

- Over the past 25 years, MIR research and technology have advanced significantly
- But they are not yet mature!
- Let's discuss future challenges!

Challenges Proposed in 2009 (10th ISMIR)

- **Five challenges and opportunities of ISMIR society**

1. Encourage the participation of potential users of MIR systems
   e.g., musicians, musicologists, music educators, and music enthusiasts
2. Dig deeper into the music itself
   Create hybrid audio + symbolic MIR systems
3. Expand its musical horizons
   Work on non-Western music
4. Rebalance the portfolio of music information types
   Unite audio, symbolic, and metadata research
5. Encourage the development and deployment of full-featured, multifaceted, robust, and scalable MIR systems with helpful user-interfaces

J. S. Downie, D. Byrd, and T. Crawford: Ten Years of ISMIR: Reflections on Challenges and Opportunities, ISMIR 2009 (Keynote Talk) [The origins of ISMIR are described in detail]

Grand Challenges Proposed in 2012

- **Five grand challenges in MIR**

1. Provide the best music for each person
   by generating or finding appropriate context-aware music

   People cannot stop using technologies
   that always provide super happiness and joy

2. Predict music trends by predicting hit songs

   Provide reasons why a song is not selling

   Obtain the music playback history of everyone in the world

3. Enrich the relationship between people and music

   Bring about a new music culture
   that is more centered on emotional, touching experiences

M. Goto: Grand Challenges in Music Information Research, Dagstuhl Follow-Ups: Multimodal Music Processing, pp.217-225, 2012

Grand Challenges Proposed in 2012

- **Five grand challenges in MIR**

4. Push new music evolution forward
   by enabling new music representations to emerge

   Do the complexity and tempo of music increase monotonically?

   The faster the tempo and the shorter the songs,
   the more songs people can listen to (i.e., increase "# of songs / hour")

5. Contribute to addressing environmental and energy issues

   Digital music can be the most eco-friendly form of entertainment
   since music can be enjoyed repeatedly

   How can we maximize "happiness per unit of energy" in music?

M. Goto: Grand Challenges in Music Information Research, Dagstuhl Follow-Ups: Multimodal Music Processing, pp.217-225, 2012

Grand Challenges Proposed by M. Goto

- **Ultimate Music Retrieval: Query-by-Brain**
  - Brain state can be used as a query
  - You can listen to music just by thinking about it
- **Ultimate Music Creation: Music Drug**
  - Highly addictive, computer-generated music
  - Once you start listening, you can't stop
  - You might be willing to die for this music
- **Ultimate Music Listening: Direct Digital Music**
  - Music can be delivered directly to the brain
  - No more traditional air-based music (no speakers, no ears needed)
  - Much higher and lower frequencies can be utilized

Intentionally provocative to inspire new ideas!

Future Challenges

- **Ultimate Music ???**

Take-Home Message:

Let's imagine grand challenges!

They can be intentionally provocative

to inspire new ideas!

25TH INTERNATIONAL SOCIETY FOR MUSIC INFORMATION RETRIEVAL CONFERENCE (ISMIR 2024)
NOVEMBER 10 - 14, 2024
SAN FRANCISCO, CALIFORNIA, USA

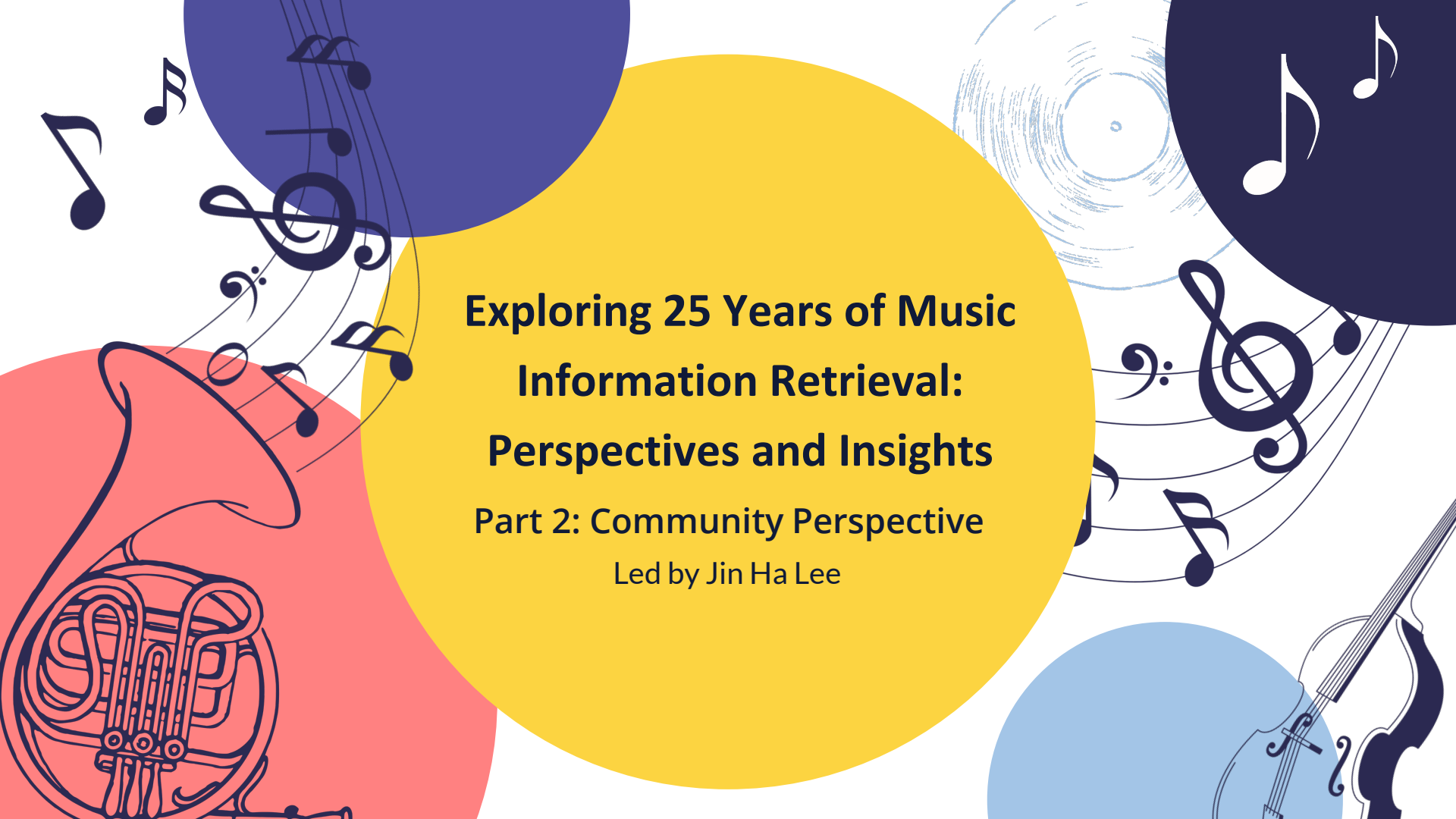
ISMIR 2024 Tutorial: Exploring 25 Years of MIR

Part 2: Community Perspective

University of Washington

Jin Ha Lee

2024/11/10



Exploring 25 Years of Music Information Retrieval: Perspectives and Insights

Part 2: Community Perspective

Led by Jin Ha Lee

Session Goals

- **Examine the community dimensions of ISMIR by tracking the society's growth over time and highlighting the core values that have shaped its development.**
- **Invite the audience to imagine the future of the ISMIR community together.**

Outline

- **The Role and Evolution of ISMIR**
- **Authorship and Collaboration Trends**
- **Evolution of Conference Topics**
- **ISMIR's Strengths and Core Values**
- **Diversity Initiatives, MIREX Overview**
- **Transition to Activities**

The Role and Evolution of ISMIR

Information School
UNIVERSITY of WASHINGTON

ISMIR's Origins and Early Motivations

Motivations: Establish a dedicated MIR conference to bring together researchers from different disciplines and offer a space for knowledge sharing, collaboration, and exploration of emerging challenges and opportunities in MIR (Downie, Byrd, and Crawford, 2009, p. 13).

Don Byrd's Obituary: https://www.heraldtimesonline.com/obituaries/psbn0979674

ISMIR's Origins and Early Motivations

- **1999: The idea for ISMIR is born, sparked by the convergence of key individuals and events.**
- **2000: First symposium in Plymouth, MA, with less than 100 attendees**
- **By 2019, the event, held in Delft, Netherlands, had grown to over 500 participants (Flexer et al., 2020, p. 218).**
- **In 2021, there were 1078 registered attendees, 600 of which were students (ISMIR 2021 Conference Report).**

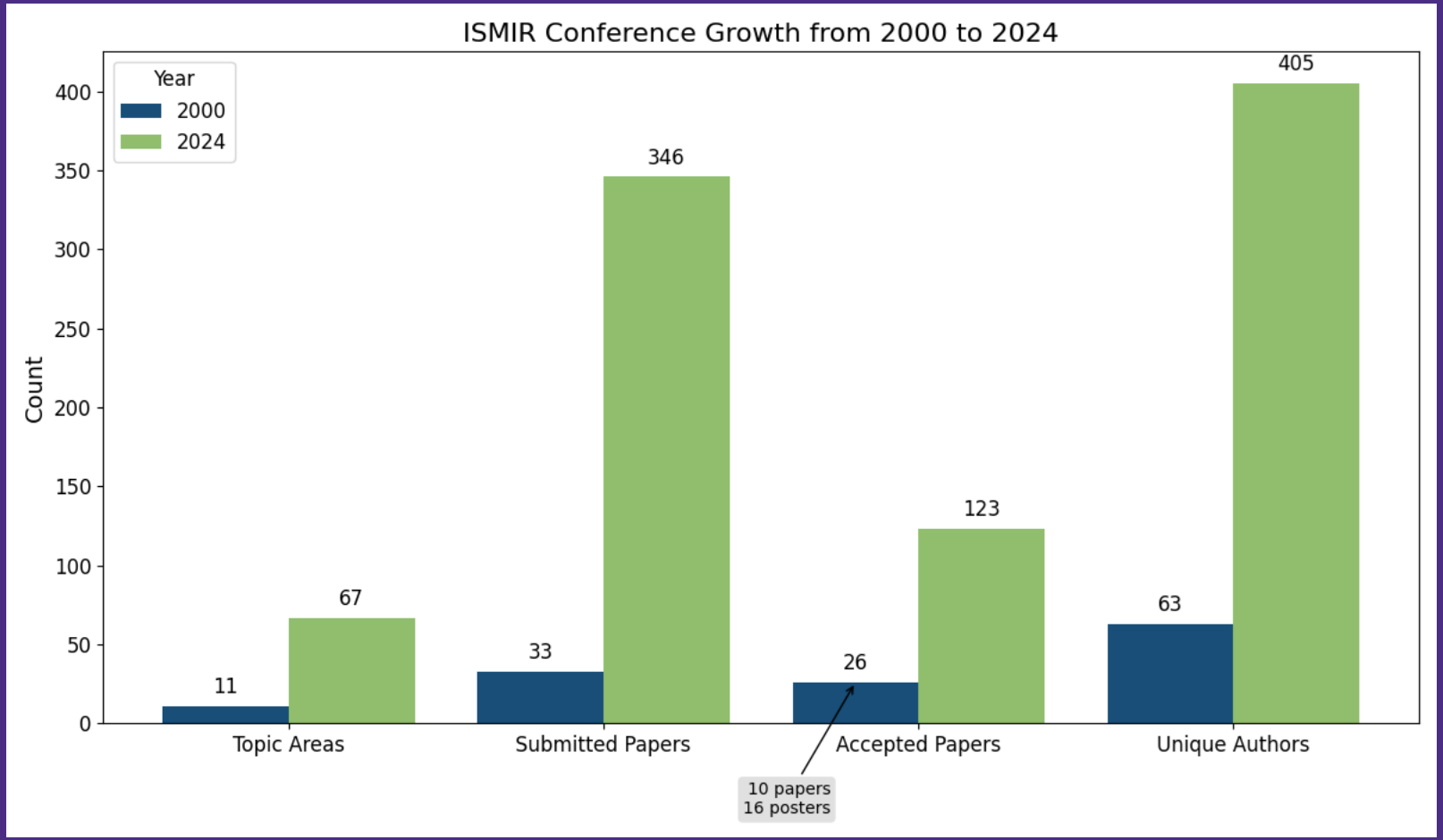
Imagine a world where you walk up to a computer and sing the song fragment that has been plaguing you since breakfast. The computer accepts your off-key singing, corrects your request, and promptly suggests to you that “Camptown Races” is the cause of your irritation. You confirm the computer's suggestion by listening to one of the many MP3 files it has found. Satisfied, you kindly decline the offer to retrieve all extant versions of the song, including a recently released Italian rap rendition and an orchestral score featuring a bagpipe duet.

Does such a system exist today? No. Will it in the future? Yes. Will such a system be easy to produce? Most decidedly not.

From Downie, J.S. (2003), Music information retrieval. Ann. Rev. Info. Sci. Tech., 37: 295-340. https://doi-org.offcampus.lib.washington.edu/10.1002/aris.1440370108

Evolution of ISMIR's Name: From “Symposium” to “Conference” to “Society”

Source: Downie, Byrd, and Crawford (2009)



Data Source: Conference growth data compiled from ISMIR 2000 and 2024 websites, ISMIR 2000 conference report, and ISMIR 2023 proceedings.


ISMIR Conference Locations (2000-2024)
Victoria 2006
San Francisco 2024
Bloomington 2001
Montreal 2020
Plymouth 2000
New York City 2016
Philadelphia 2008
Baltimore 2003
Miami 2011
Utrecht 2010
Delft 2019
London 2005
Paris 2018
Porto 2012
Málaga 2015
Barcelona 2004
Vienna 2007
Milan 2023
Bengaluru 2022
Kobe 2009
Suzhou 2017
Taipei 2014
Curitiba 2013
Virtual Conferences
2021: Online
Marker Legend
Physical Conference
Virtual Conference
Data Source
Conference Data: Data from ISMIR Conference Records
Leaflet | © OpenStreetMap contributors © CARTO

ISMIR Demographics

> MIR is also younger today than ever (60% of the papers accepted in 2019 were written by students) and more diverse (although MIR diversity has now been considered as a major issue for the community).
>
> -- Flexer et al., 2020, p. 218

Authorship and Collaboration Trends

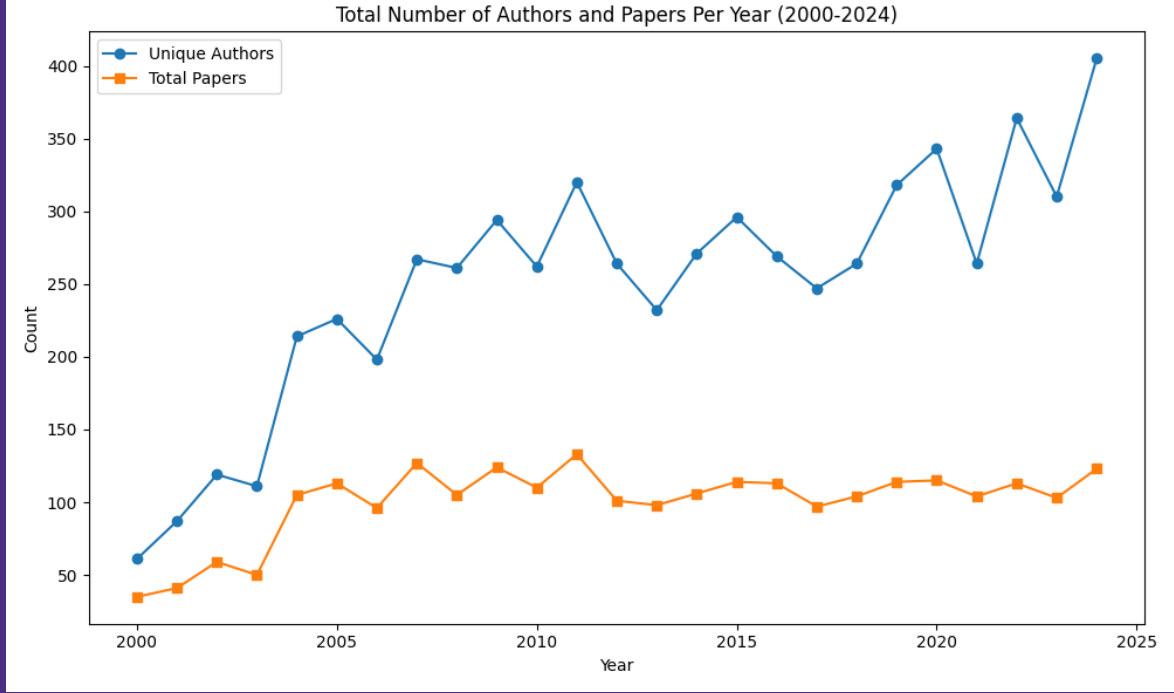
ISMIR Author Analysis

- **Exploring authorship patterns, collaboration trends, and the growth of the community over time.**

Author Analysis - Growth and Development of the Community

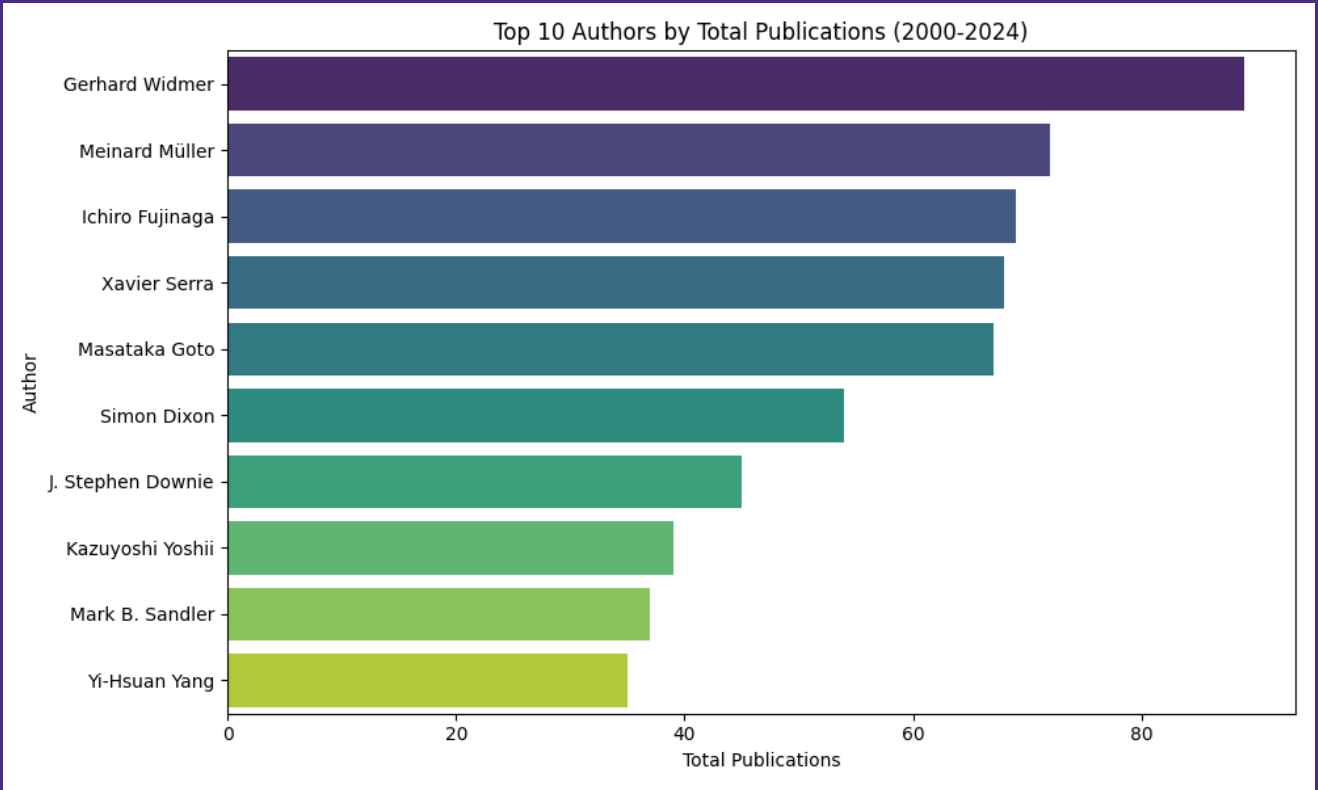
Significant increase in the number of authors and papers over the years.

- **Unique Authors: Grew from 61 in 2000 to 405 in 2024.**
- **Total Papers: Increased from 35 in 2000 to a peak of 133 in 2011.**



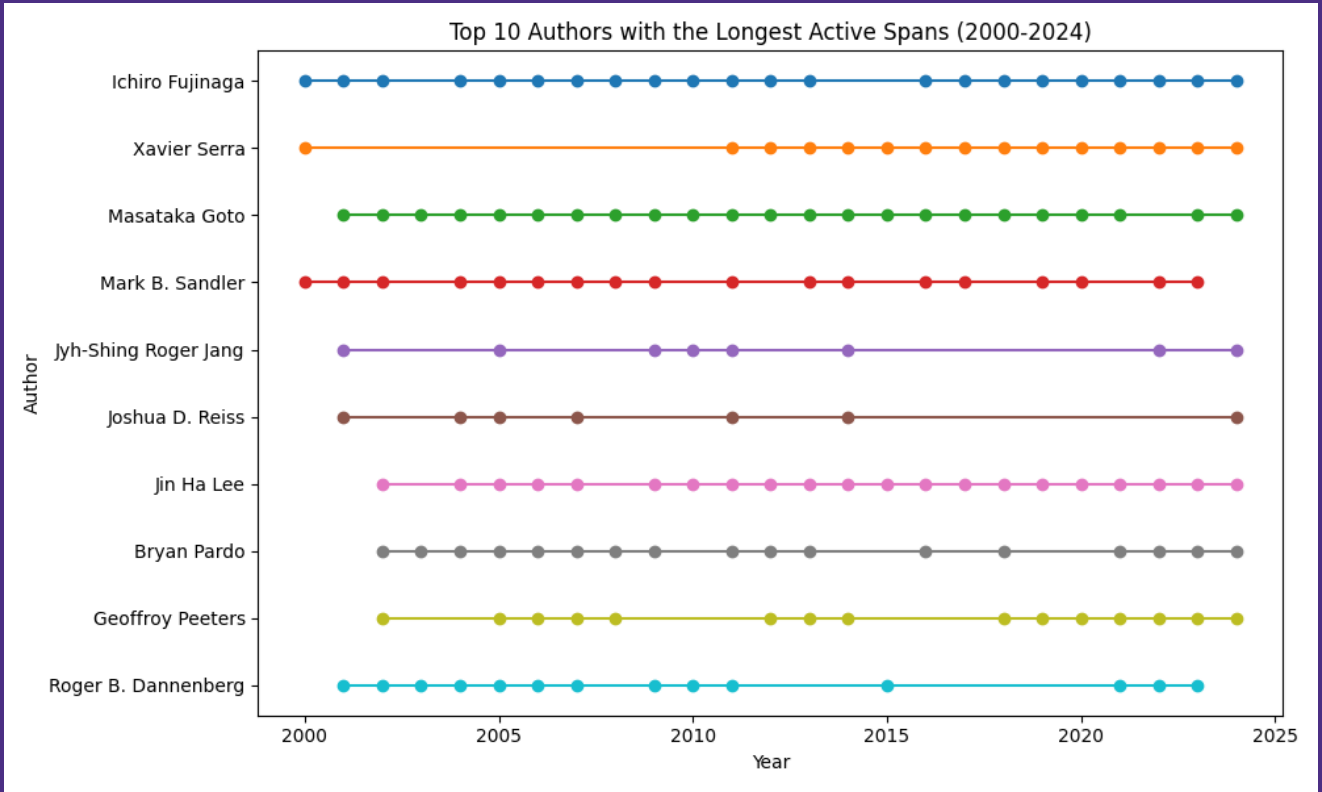
Data Source: Conference Data from ISMIR Conference Records. Data extracted and processed from PDFs using pdfminer.six, GROBID, NLP, and regex techniques.

Author Analysis - Prolific Contributors



Data Source: Conference Data from ISMIR Conference Records. Data extracted and processed from PDFs using pdfminer.six, GROBID, NLP, and regex techniques. See also Top 20 Figure.

Author Analysis - Long-Term Contributors

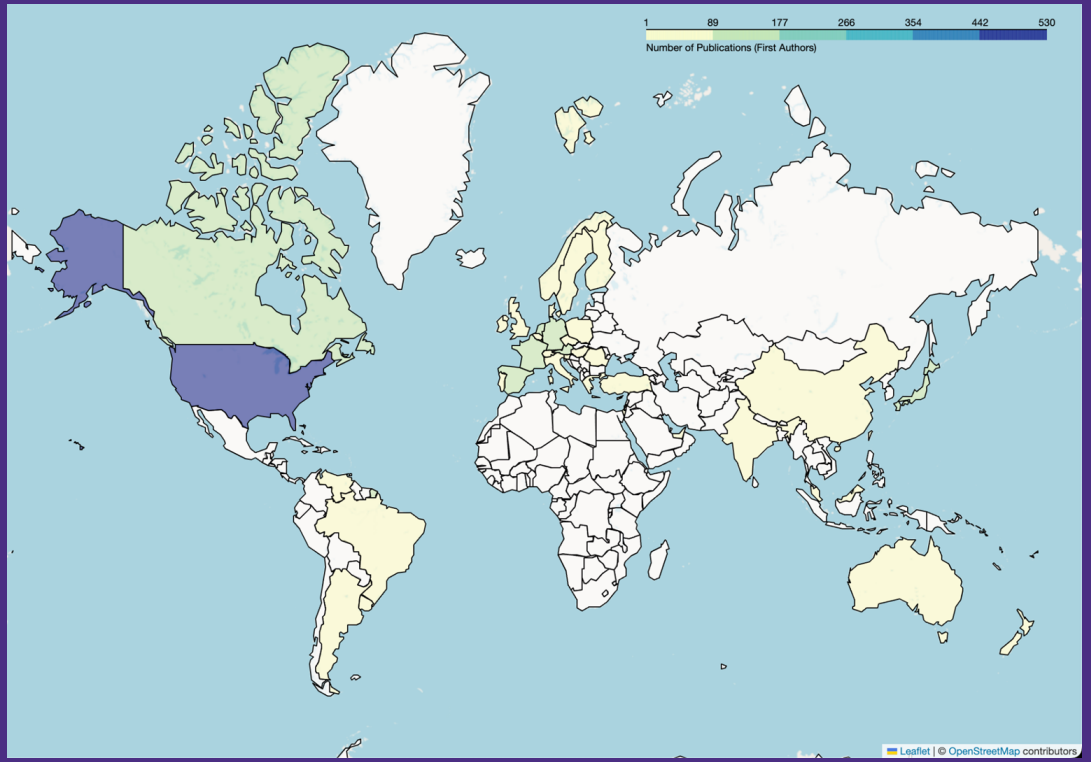


Data Source: Conference Data from ISMIR Conference Records. Data extracted and processed from PDFs using pdfminer.six, GROBID, NLP, and regex techniques.

Choropleth Map Showing Publications by Country (First Authors)

Geographical distribution of authors shows global participation and growth in participation from different regions over time.

Evidence of emerging contributions from countries like Brazil, China, India, and South Korea.



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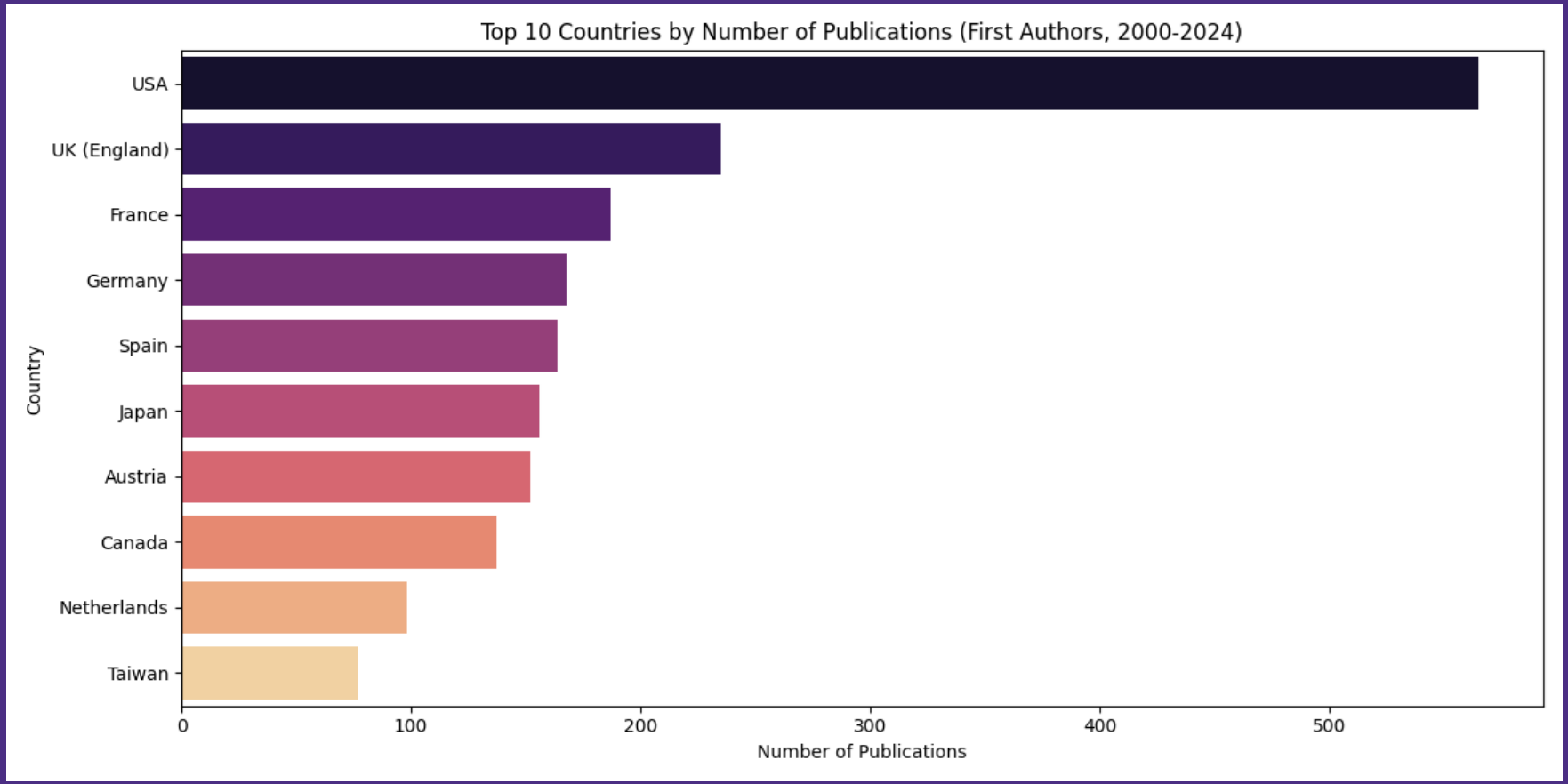
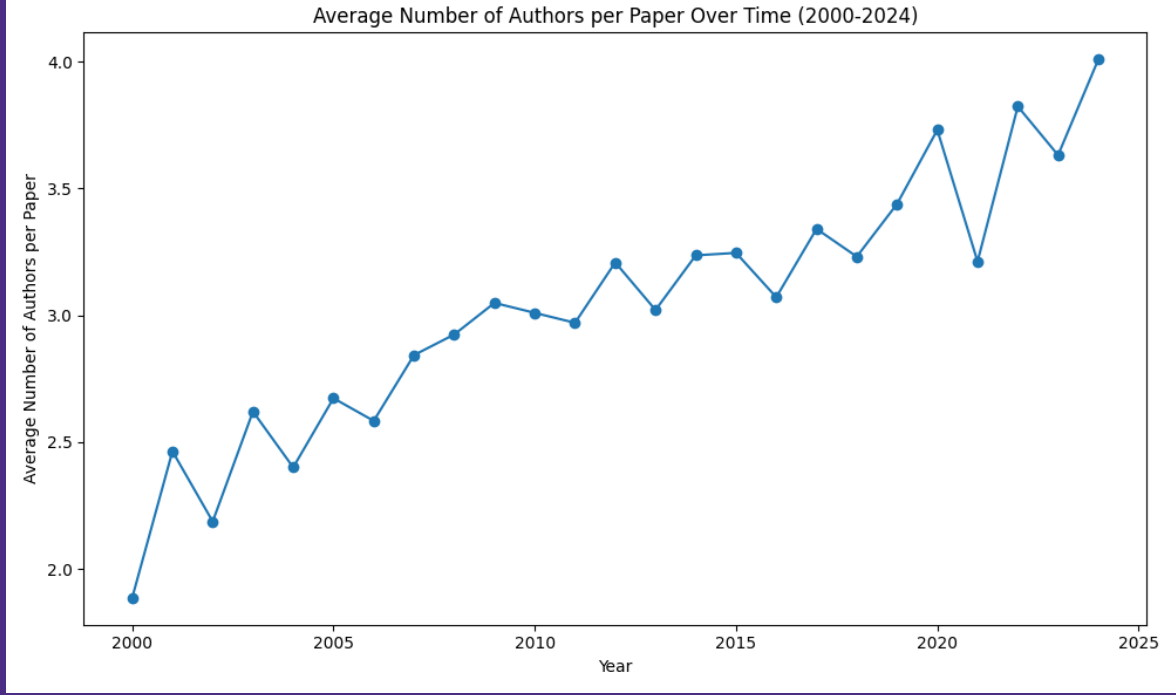


Data Source: Conference Data from ISMIR Conference Records. Data extracted and processed from PDFs using pdfminer.six, GROBID, NLP, and regex techniques.

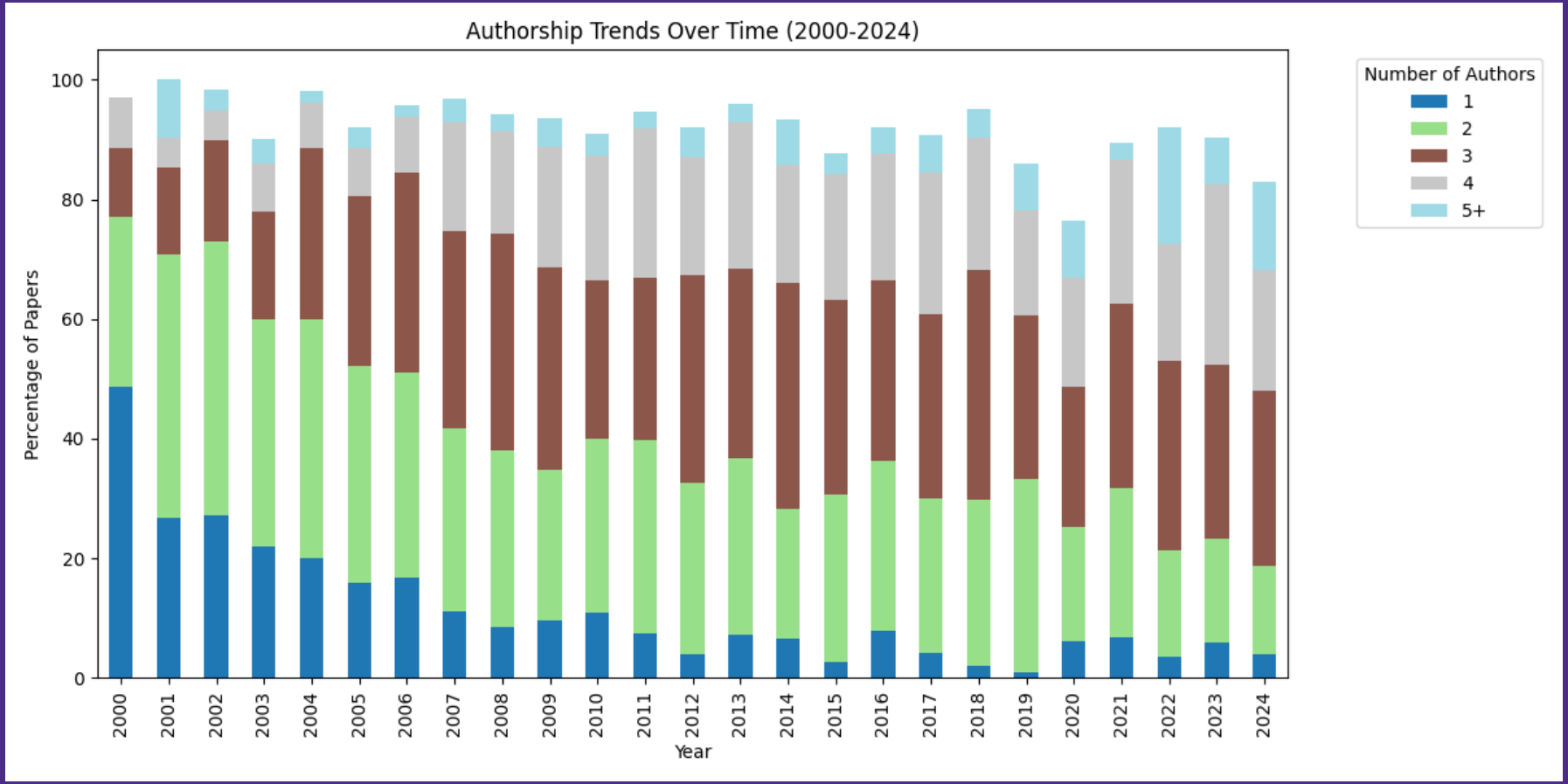
Author Analysis - Increasing Collaboration

The percentage of papers with single authors has decreased significantly.

- **Average Authors per Paper: Data shows the rise from 1.89 in 2000 to 4.0 in 2024 authors per paper.**
- **Authorship Distribution: Increase in papers with 3 or more authors, indicating more collaborative work (figure on next slide).**



Data Source: Conference Data from ISMIR Conference Records. Data extracted and processed from PDFs using pdfminer.six, GROBID, NLP, and regex techniques.



Data Source: Conference Data from ISMIR Conference Records. Data extracted and processed from PDFs using pdfminer.six, GROBID, NLP, and regex techniques.

ISMIR Topic Analysis

- **Analyzing the evolution of conference topics over the years, the addition of new topics and disappearance of others.**
- **What can we discern from the evolving topics focus over the life of the conference?**

Early Years: 2000 Call for Papers - Topics

- **Estimating similarity of melodies and polyphonic music**
- **Music representation and indexing**
- **Problems of recognizing music optically and/or via audio**
- **Routing and filtering for music**
- **Building up music databases**
- **Evaluation of music-IR systems**
- **Intellectual property rights issues**
- **User interfaces for music IR**
- **Issues related to musical styles and genres**
- **Language modeling for music**
- **User needs and expectations**

Early Years: 2001-2002 Proceedings - Topics

2001

- **Systems and Interfaces**
- **Musicology and Extraction of Musical Information**
- **Music Retrieval**
- **Audio and MPEG**

2002

- **Similarity and Recognition**
- **Summarization**
- **Indexation, classification, analysis**
- **Usability**
- **Query By Example**
- **Preprocessing: encoding, segmentation...**
- **Systems**

Topics Analysis: Observations from Early Years

- **The earlier years of the conference had more of a focus on musicology and information retrieval**
- **Emphasis on foundational areas like automatic classification, music similarity metrics, and user needs**
- **Focus on technical areas**

Topics Analysis: Observations from Early Years

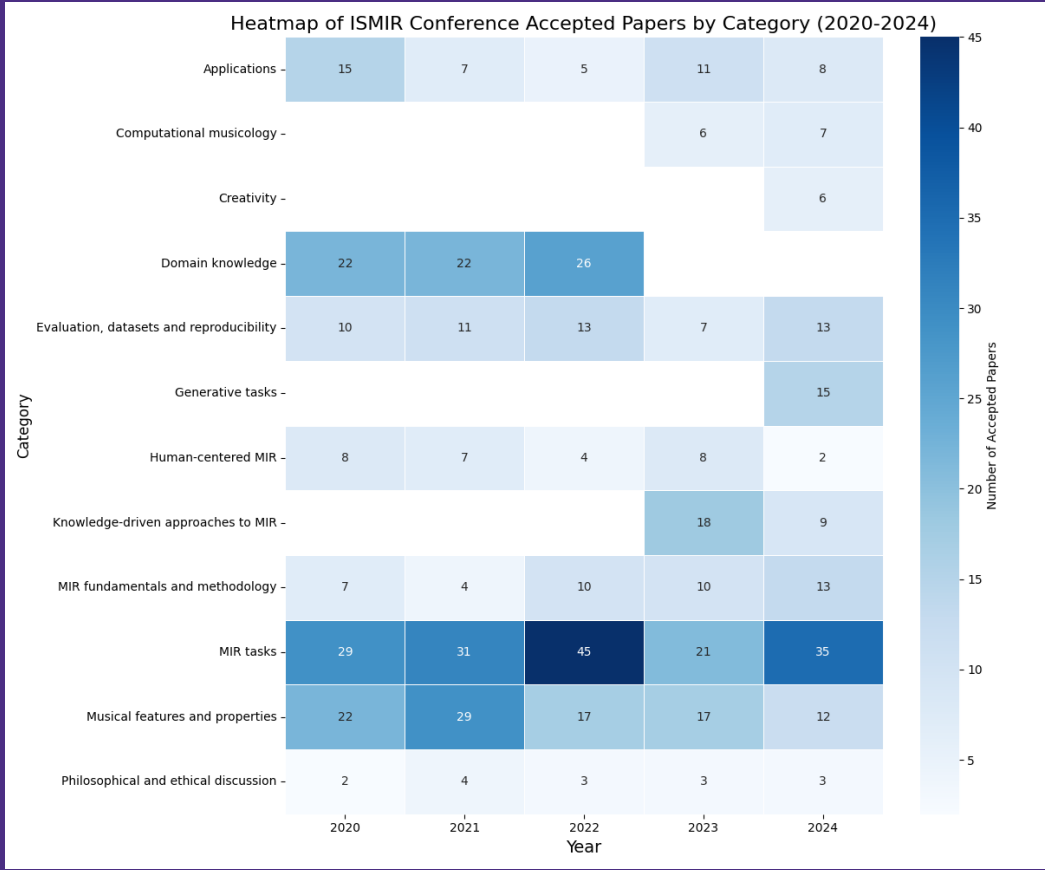
- **User experience, needs, interfaces, etc. were present in the Call for Papers even in early years of the conference, but they don’t begin to appear as proceedings categories until 2004**
- **Machine learning and AI began appearing in the CfP in 2002 and 2003, respectively, but didn’t have a designated track until 2019**

Recent Years: 2024 Call for Papers - Topics

- **MIR fundamentals and methodology**
- **Knowledge-driven approaches to MIR**
- **Musical features and properties**
- **MIR tasks**
- **Generative tasks**
- **Evaluation, datasets, and reproducibility**
- **Philosophical and ethical discussions**
- **Human-centered MIR**
- **Computational musicology**
- **Creativity**
- **Applications**

These topics are larger domains, individual topics can be found here
Mind Map linked here

Recent Years: 2020-2023 Proceedings - Topics



2024 Paper Topics

Subject Area	Reviewed	Accepted	Accepted %
MIR tasks	94	35	37.2
MIR fundamentals and methodology	38	13	34.2
Musical features and properties	36	12	33.3
Evaluation, datasets, and reproducibility	34	13	38.2
Generative Tasks	32	15	46.9
Knowledge-driven approaches to MIR	30	9	30.0
Applications	28	8	28.6
Computational musicology	16	7	43.8
Human-centered MIR	16	2	12.5
Creativity	12	6	50.0
Philosophical and ethical discussions	6	3	50.0
MIR and machine learning for musical acoustics	4	0	0.0
Total	346	123	35.5

Topics Analysis: Observations from Recent Years

- **In later years machine learning/machine learning algorithms and signal processing came to dominate**
- **Natural language processing, text and web mining also began appearing after 2015**
- **The current ISMIR format may be challenging to certain areas like human-centered MIR, esp. for qualitative studies**

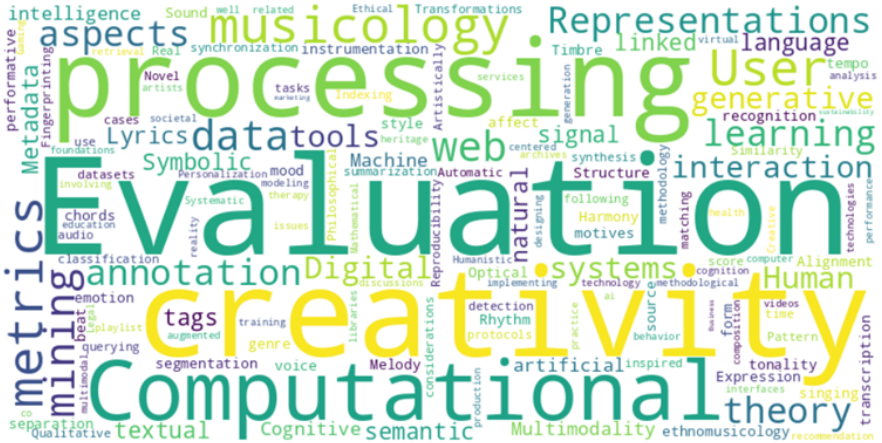
Topics Analysis: Introduction of New Topics

Emerging conference areas:

- **Topics related to gaming began appearing in 2015**
- **Music heritage and sustainability (2022–present)**
- **Music videos, multimodal music systems (2022–present)**

- **Special calls for papers about Cultural Diversity in MIR beginning in 2021**

Word Cloud Comparison of ISMIR CfP Topics: 2000 vs. 2024



Data Source: Conference data pulled from official ISMIR conferences websites for each year.

ISMIR's Strengths and Core Values

Information School
UNIVERSITY of WASHINGTON

Strengths & Core Values of ISMIR

- **Innovation and Scientific Excellence**
- **Interdisciplinary Collaboration**
- **Open Access and Transparency**
- **Inclusivity and Diversity**
- **Supporting and Mentoring**

Innovation and Scientific Excellence

- **ISMIR is dedicated to advancing the MIR field through groundbreaking research, exploration of new ideas across multiple disciplines, and promoting rigor and creativity in addressing MIR challenges**

Interdisciplinary Collaboration

- **ISMIR promotes collaboration across fields like computer science, information science, musicology, psychology, and audio engineering, etc. encouraging the integration of diverse perspectives**
- **Cross-disciplinary engagement is critical to address complex MIR problems as it brings together insights from research on music, technology, human behavior, and culture**

Open Access and Transparency

- **ISMIR papers are publicly accessible without membership barriers**
- **Reproducibility of research is important and thus, sharing dataset and code publicly is encouraged**
- **Open review model is being adopted for increased transparency and accountability**

Inclusivity and Diversity

- **ISMIR seeks to foster an inclusive community by welcoming researchers from varied backgrounds, countries, and disciplines, actively trying to address imbalances in participation and representation.**

Supporting and Mentoring

- **In the early days, ISMIR was dedicated to growing and advancing the field and nurturing emerging researchers**
- **Currently, ISMIR actively supports young scholars by providing resources, mentorship, and networking opportunities to help build their careers which contributes to the field's continued growth**

Recently, Ethics and Societal Impact

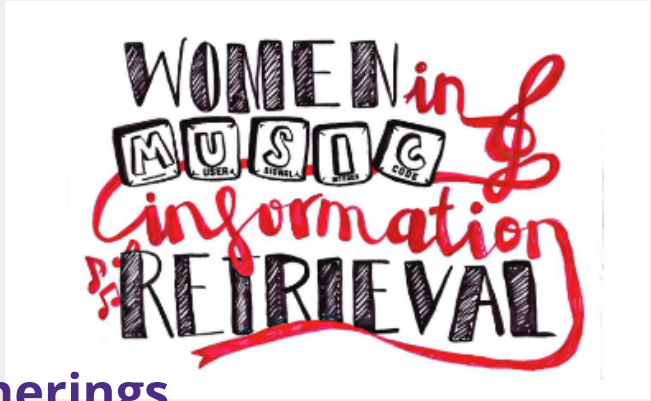
- **ISMIR is starting to place an increasing focus on the ethical and societal implications of MIR research.**
  - **Ethics statement**
  - **Increasing attention on potential biases and ethical impact of MIR work, environmental impact, etc.**

Strengths and Values in Action

Supporting Diversity and Inclusion

- **Later years of the conference included specific calls for papers about cultural diversity**
  - **E.g., A topic emphasis of non-Western music and cross-cultural studies (ISMIR 2021 Proceedings, p. xv)**

WiMIR



- 2011-2013: WiMIR begins as informal gatherings
- 2015: WiMIR included in conference program
- 2016: WiMIR mentoring program launched; receives financial support
- 2017-2019: Continued expansion with mentoring program committees, additional funding from ISMIR Board and local organizations, and travel grants
- 2018: WiMIR workshops commence as satellite events
- 2023: Workshops on hiatus, resuming in 2024.

Supporting Underrepresented Groups

Black in MIR:

- **2020: Fee waivers and keynote speaker representation**
- **First African American keynote speaker in ISMIR history, Dr. Safiya U. Noble[1]**

Queer in MIR:

- **2021: Established to support LGBTQ+ researchers[2]**

Regional Initiatives:

- **MIR in Africa (2022 - Ongoing): Participation in events, future goals[3]**
- **MIR in Latin America (2023 - Ongoing): Launch and community building[4]**

Sources:

1. Cumming et al., 2020, p. xviii
2. Kaneshiro, Smith, Lee, & Lerch, 2021
3. ISMIR Society, 2023, pp. 22-32
4. ISMIR Society, 2023, p. 33

New-to-ISMIR Paper Mentoring (2021-2024)

- **2021: Introduction of a New-to-ISMIR special track during LBD Session**
- **20 student authors participated, with 16 ISMIR reviewers serving as mentors**
- **2022: New-to-ISMIR paper mentoring pilot program begins in 2022**
- **2023-2024: Continued support for the program**

- **Also, 2022- : Newcomer squad!!**

MIREX (Music Information Retrieval Evaluation eXchange)

- **An annual evaluation framework and competition that benchmarks MIR algorithms**
- **MIREX played a pivotal role in the growth and success of the MIR community**
- **During the 10 year period (2005-2015), MIREX evaluated 2,397 algorithms from more than 30 countries (Hu et al., 2015)**

MIREX: Impact on Evaluation Standards

- **Provides a standardized way to evaluate and compare MIR algorithms across various tasks, encouraging reproducibility and advancement in the MIR field**
- **Uses shared datasets and evaluation metrics for fair competition, fostering transparency and objective assessment**
- **Encourages collaboration and promotes community-centered evaluation**

MIREX

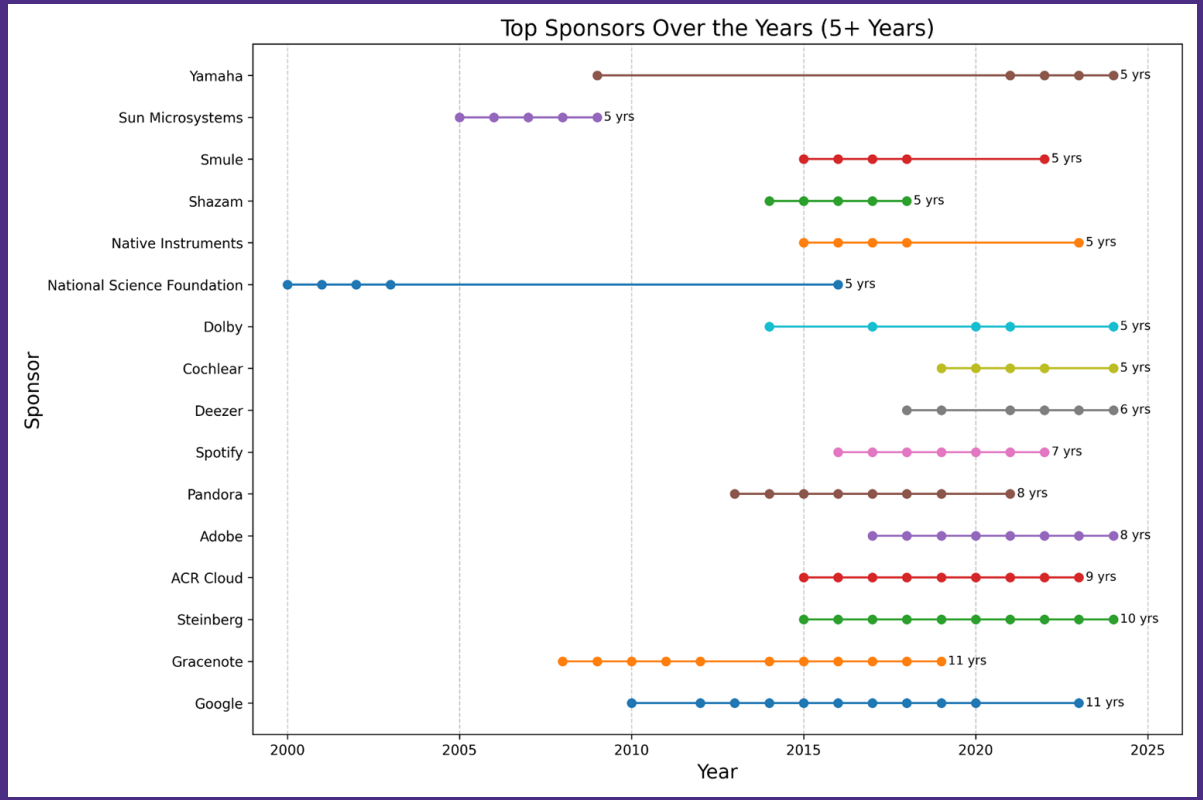
2005-2021

MIREX competition returns beginning 2024!

1999	Music retrieval workshop at SIGIR proposed a range of evaluation scenarios
2000	First ISMIR held at Plymouth with participants holding brainstorming sessions
2001	ISMIR at Indiana University; "Bloomington Manifesto" on evaluation published
2002	Planning grant from the Andrew W. Mellon Foundation awarded
2002	ISMIR at Paris hosted special evaluation workshop
2003	SIGIR at Toronto held Workshop on the Evaluation of Music Information Retrieval Systems
2003	Andrew W. Mellon Foundation and NSF funding awarded
2004	Audio Description Contest run at ISMIR Barcelona
2005	First MIREX plenary session held at ISMIR London
2008	NEMA project funded by the Andrew W. Mellon Foundation
2009	SALAMI funded by the NSF, SSHRC and JISC
2012	MIREX:NG project funded by the Andrew W. Mellon Foundation

Table 1. Important Events in MIREX History

Top ISMIR Sponsors with 5+ Years of Contributions



Data Source: Sponsorship data compiled from ISMIR Conference proceedings and official websites.

Group Activity

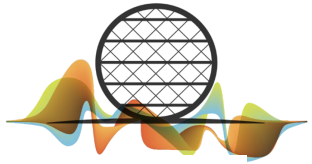
Activity: Core Values Discussion (15 minutes)

- **Goal: Deepen participants' understanding of ISMIR’s core values and inspire creative thinking about new initiatives to support these values**
- **Please share if you have any ideas or suggestions on a new initiative or program that could effectively support ISMIR's core values OR ask any questions about the core values!**


2007


ismir
2009


ISMIR
2019




ISMIR
MTL2020


ISMIR
08


ISMIR 2015
MALAGA


ISMIR
2011 MIAMI


2014
ISMIR
Taipei , Taiwan
Oct 27-31, 2014
The 15th International Society for Musi
Information Retrieval Conference

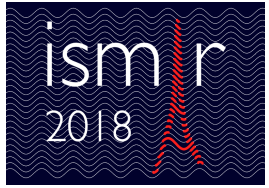

ISMIR2021


ISMIR 2016


2024
ISMIR
SAN FRANCISCO


ISMIR 2023
Milan, Italy
Nov. 5-9,
2023


ISMIR 2022
BENGALURU


ismir
2018


ismir
2010 UTRECHT
11th International Society for Music
Information Retrieval Conference


ISMIR
2012
PORTO


ISMIR
2017, SUZHOU, CHINA


ismir
CURITIBA • BRAZIL

References

Link to full reference list here

25TH INTERNATIONAL SOCIETY FOR MUSIC INFORMATION RETRIEVAL CONFERENCE (ISMIR 2024)
NOVEMBER 10 - 14, 2024
SAN FRANCISCO, CALIFORNIA, USA

ISMIR 2024 Tutorial: Exploring 25 Years of MIR

Part 3: Education Perspective

International Audio Laboratories Erlangen

Meinard Müller

2024/11/10

AUDIO LABS

Tutorial 2, ISMIR

San Francisco, November 10, 2024

Exploring 25 Years of Music Information Retrieval

Part 3: Education Perspective

Meinard Müller

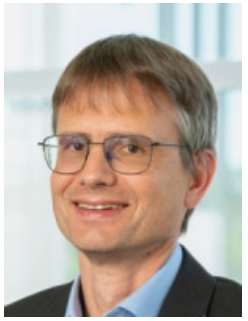
International Audio Laboratories Erlangen

meinard.mueller@audiolabs-erlangen.de

Friedrich-Alexander-Universität Erlangen-Nürnberg

Fraunhofer IIS

Meinard Müller



- Academic Background
  - 1997: Master (Mathematics)
  - 2001: PhD (Computer Science)
  - 2007: Habilitation (Information Retrieval)
  - 2012: Professor (Semantic Audio Processing)

FAU

- Personal MIR History
  - 2003: First ISMIR paper as co-author
  - 2012 & 2015: Scientific program chair
  - 2009-2021: Member of ISMIR Board
  - 2020/2021: President of ISMIR
  - 2024: Editor-in-chief of TISMIR

ISMIR

- IEEE Fellow (Music Signal Processing)

IEEE

- ACM Senior Member

acm

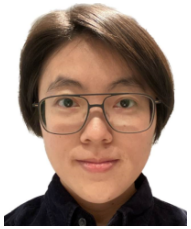
Meinard Müller: Research Group

- Ben Maman
- Simon Schwär
- Johannes Zeitler
- Peter Meier
- Sebastian Strahl
- Uli Berendes
- Ching-Yu Chiu (Sunny)
- Vlora Arifi-Müller
- Stefan Balke
- Yigitcan Özer
- Michael Krause
- Christof Weiß
- Sebastian Rosenzweig
- Frank Zalkow
- Hendrik Schreiber
- Christian Dittmar
- Stefan Balke
- Jonathan Driedger
- Thomas Prätzlich
- …













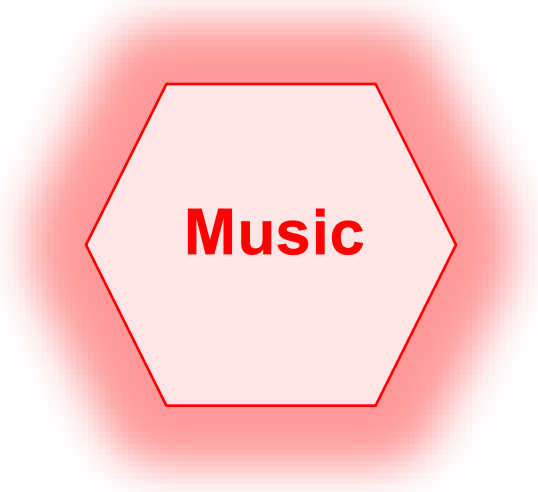






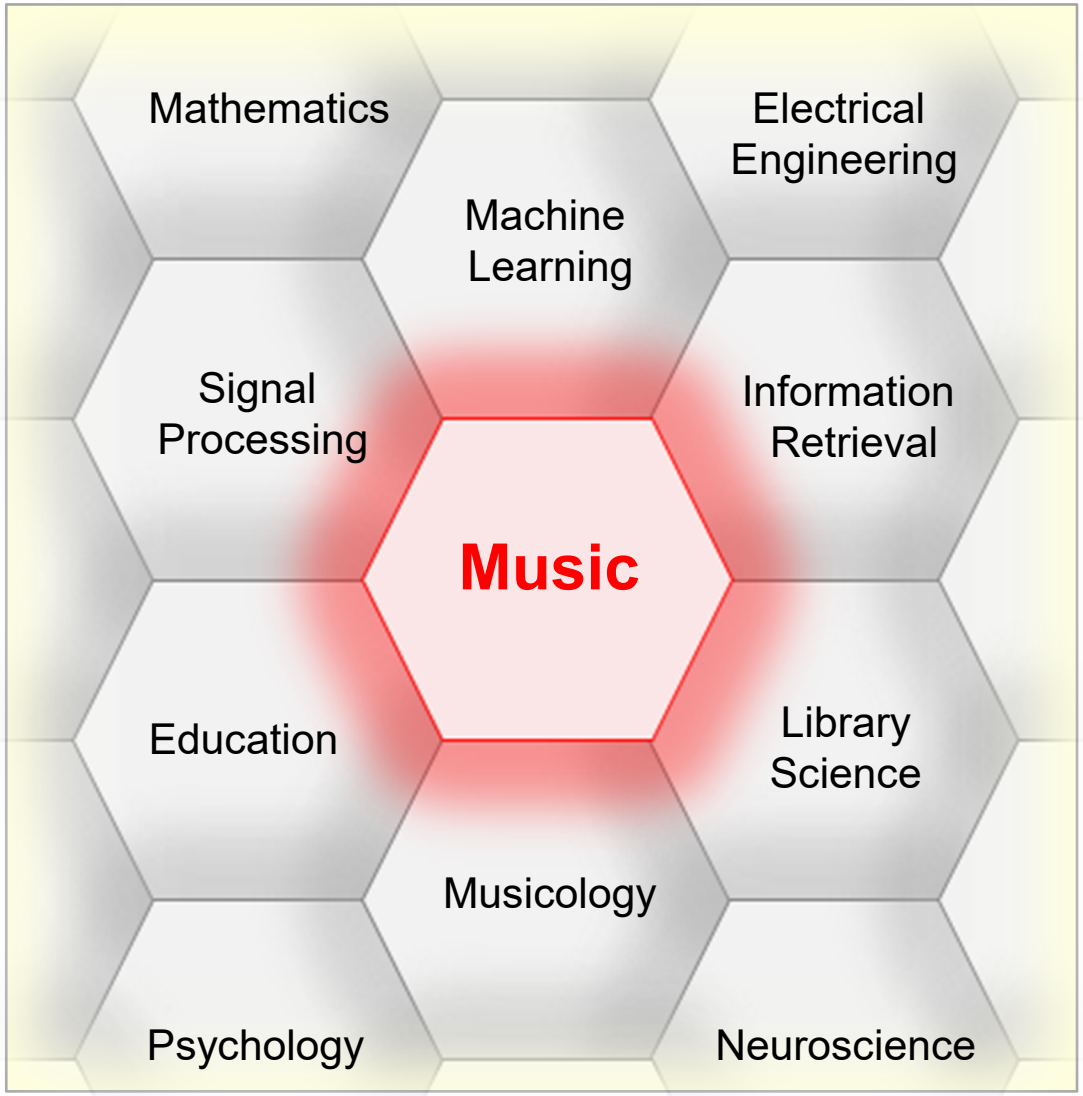
What is MIR?

- Research of computational systems to help humans understand music-related data



What is MIR?

- Research of computational systems to help humans understand music-related data
- Multifaceted area drawing from a diverse set of disciplines

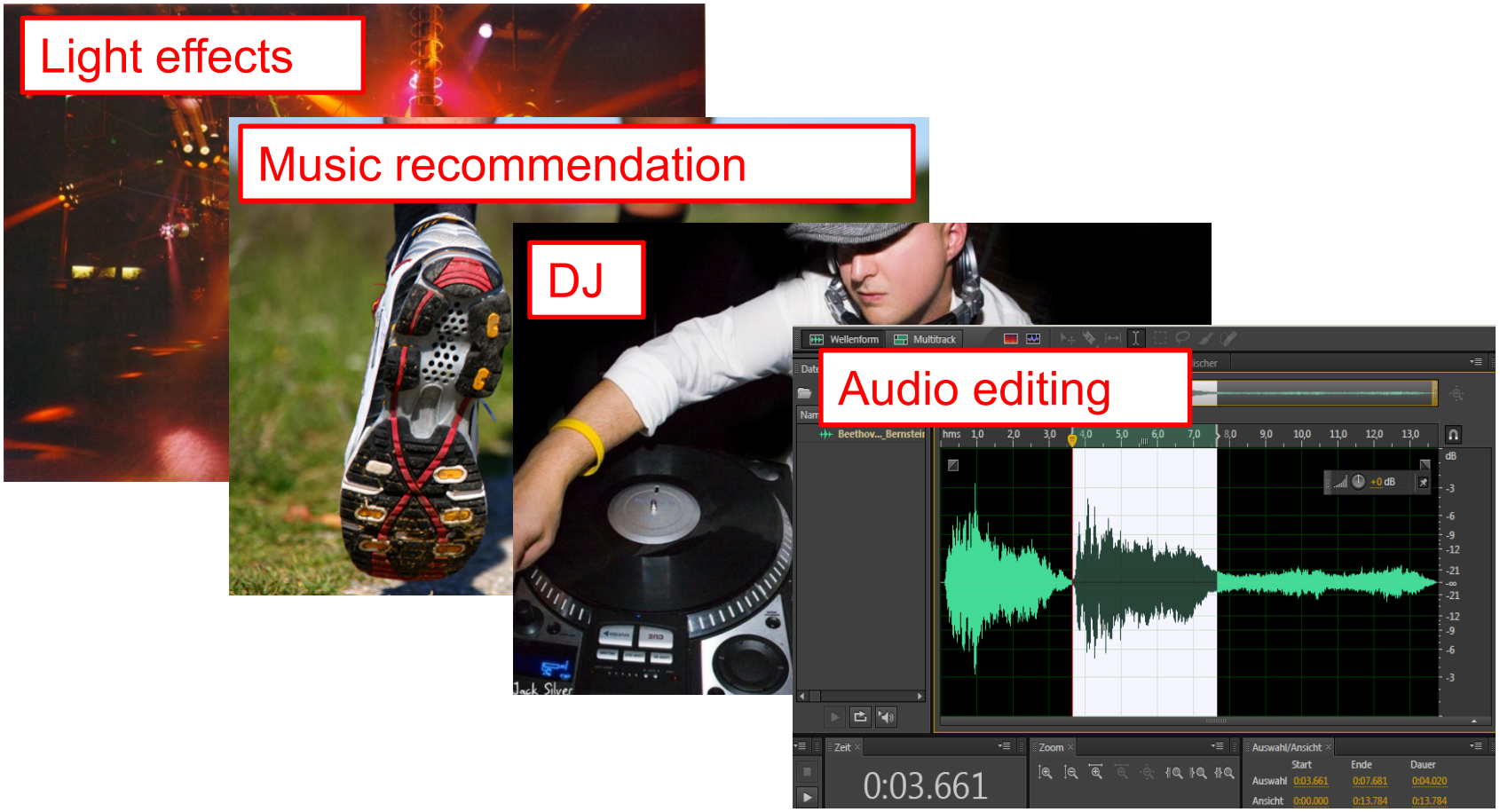


Education Perspective on MIR

- Music as an educational domain
- Insights in MIR research
- Doing a PhD in MIR
- Writing and reviewing for MIR
- Educational resources and TISMIR

Tempo and Beat Tracking

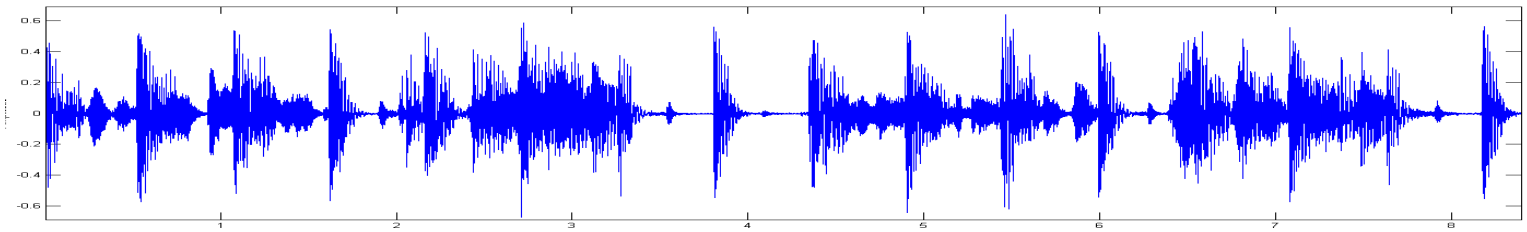
Basic task: “Tapping the foot when listening to music”



Tempo and Beat Tracking

Basic task: “Tapping the foot when listening to music”

Example: Queen – Another One Bites The Dust



Time (seconds)

Tempo and Beat Tracking

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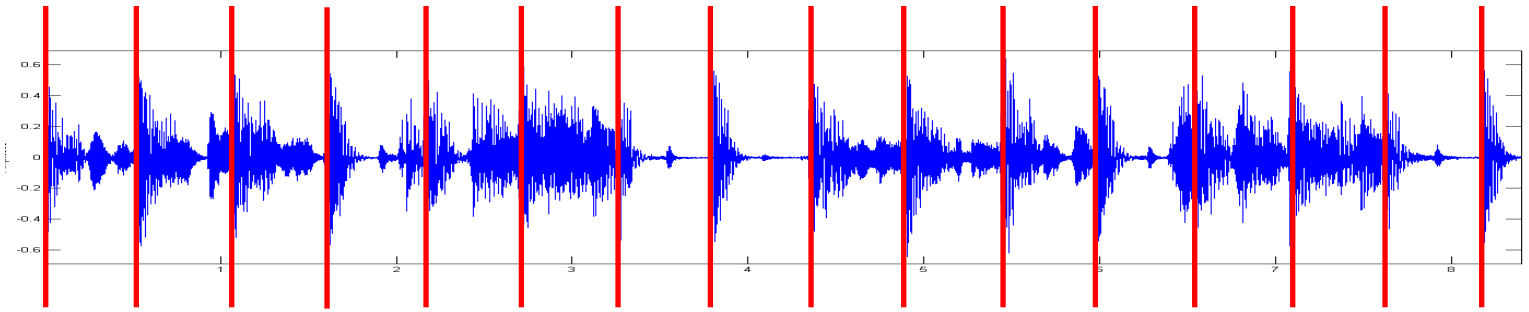

Time (seconds)

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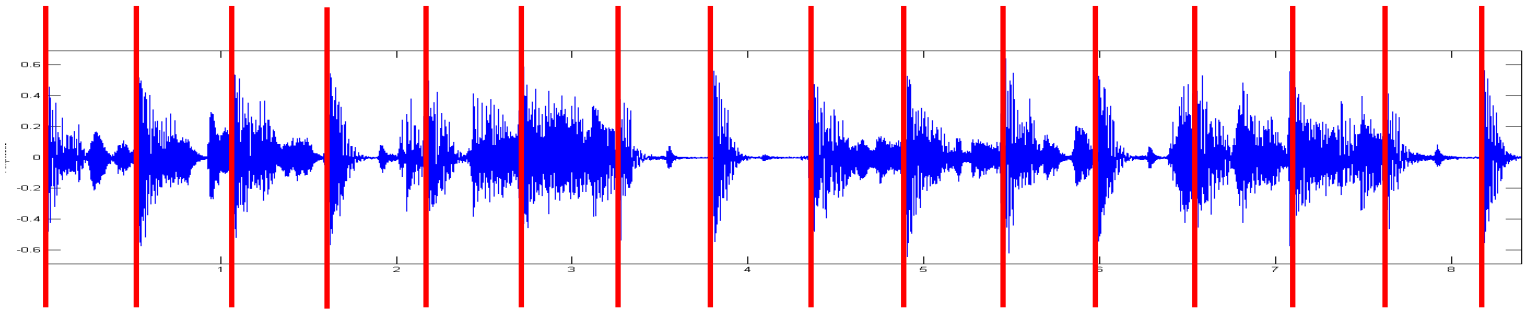
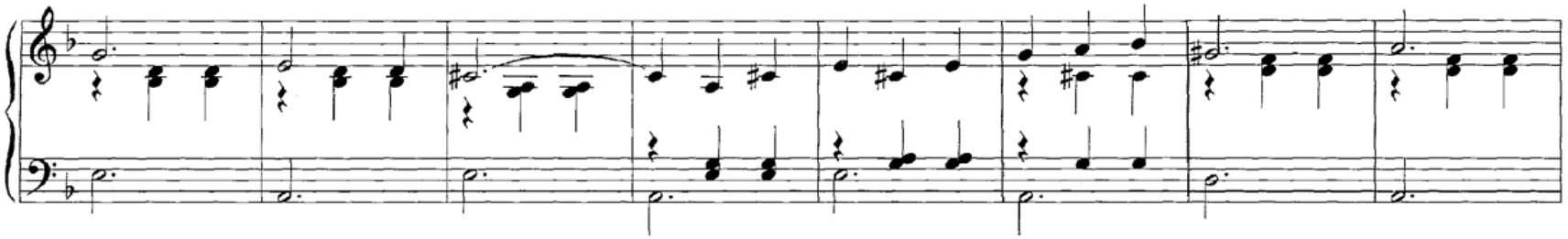


Time (seconds)

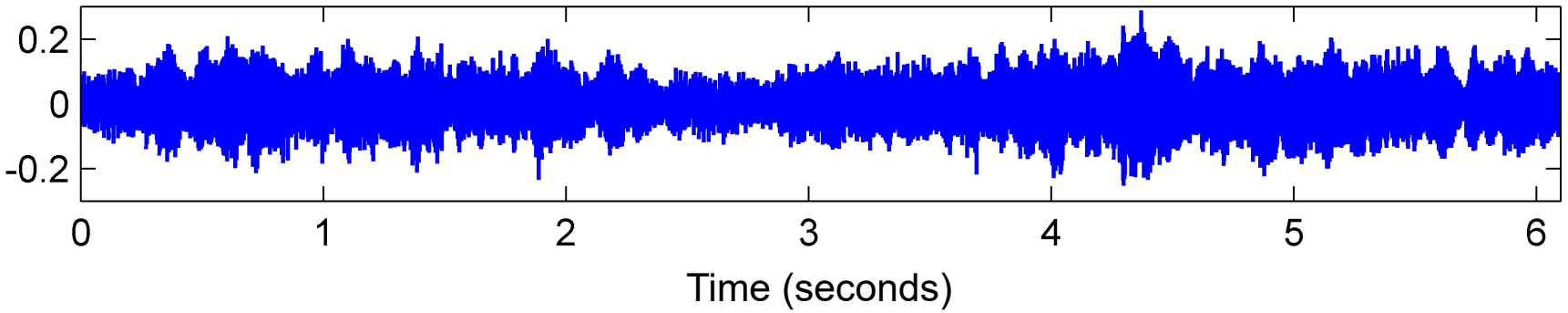
Assumptions

- Beat positions go along with onsets
- Beats are periodically spaced

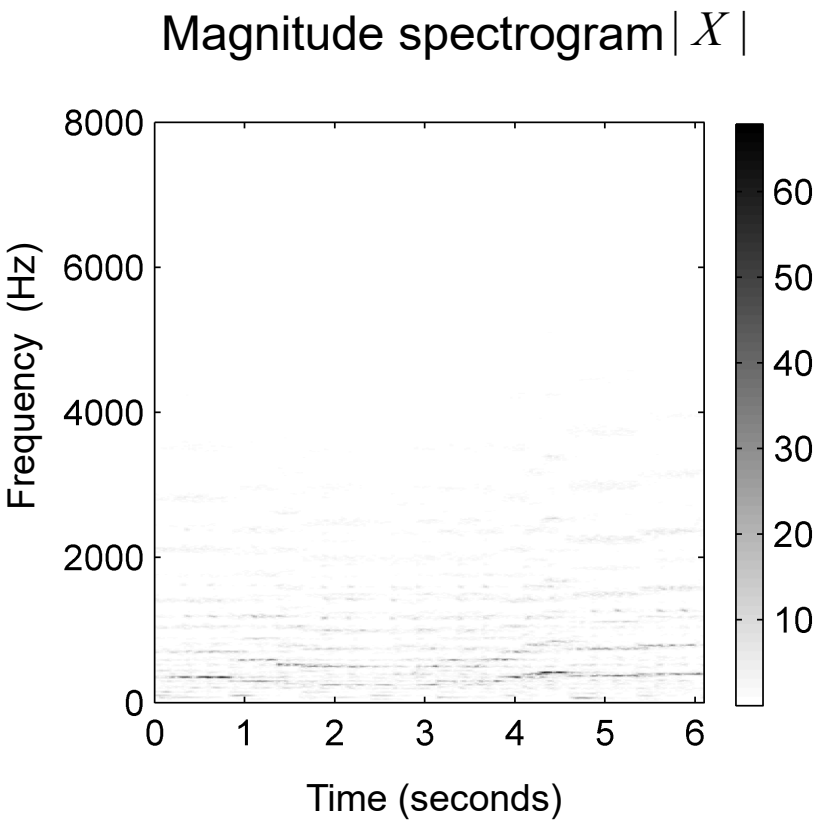
Onset Detection (Spectral Flux)



Audio recording



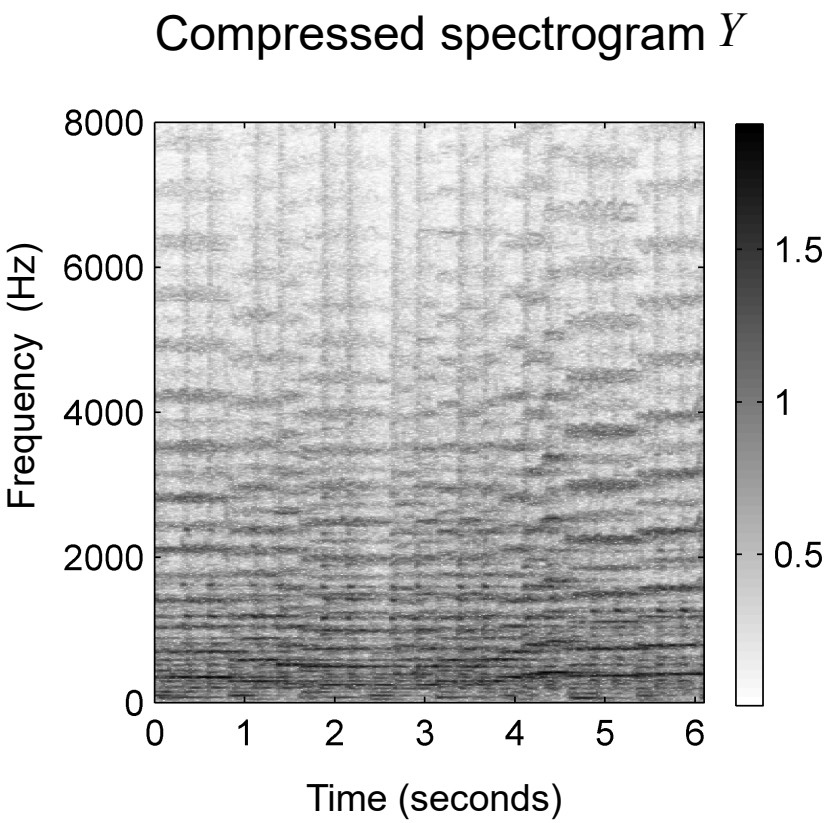
Onset Detection (Spectral Flux)



Steps:

1. Spectrogram

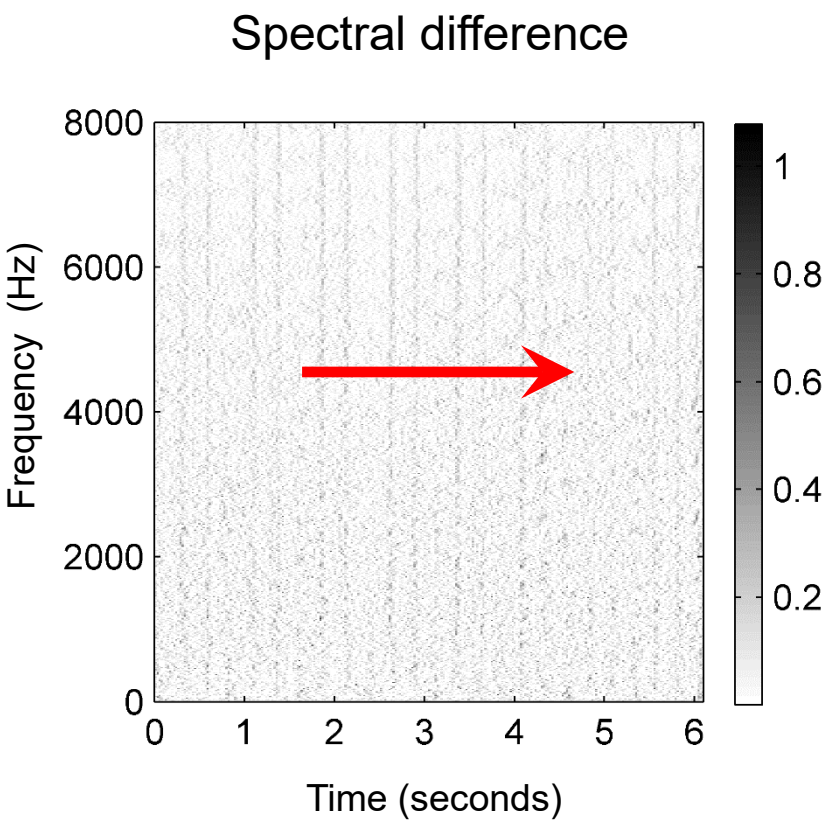
Onset Detection (Spectral Flux)



Steps:

1. Spectrogram
2. Logarithmic compression

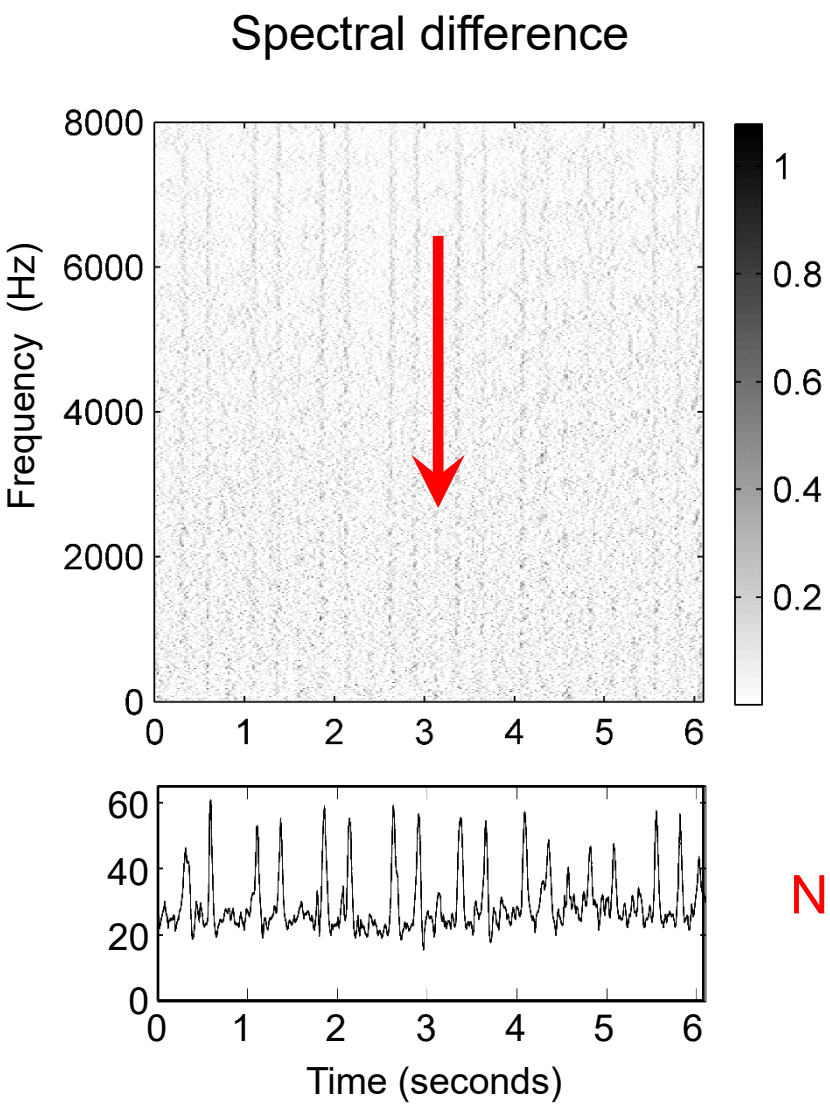
Onset Detection (Spectral Flux)



Steps:

1. Spectrogram
2. Logarithmic compression
3. Differentiation & half wave rectification

Onset Detection (Spectral Flux)



Steps:

1. Spectrogram
2. Logarithmic compression
3. Differentiation & half wave rectification
4. Accumulation

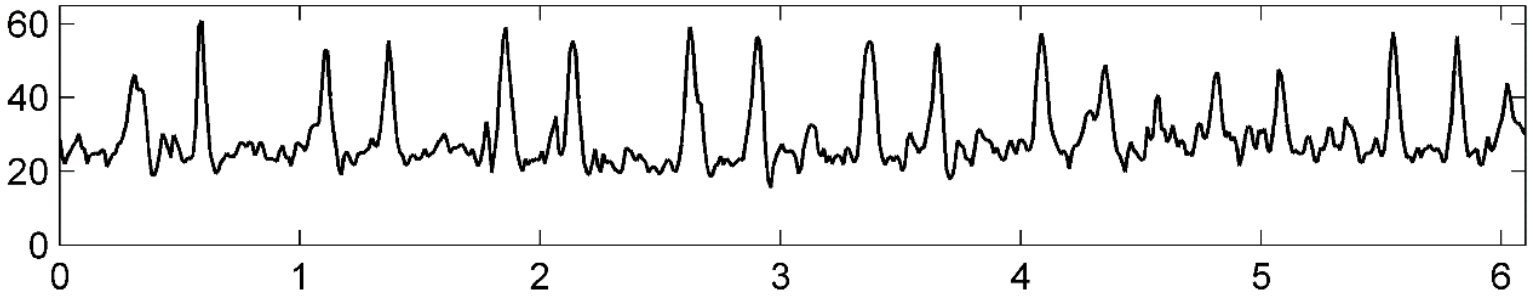
Novelty curve

Onset Detection (Spectral Flux)

Steps:

1. Spectrogram
2. Logarithmic compression
3. Differentiation & half wave rectification
4. Accumulation

Novelty function



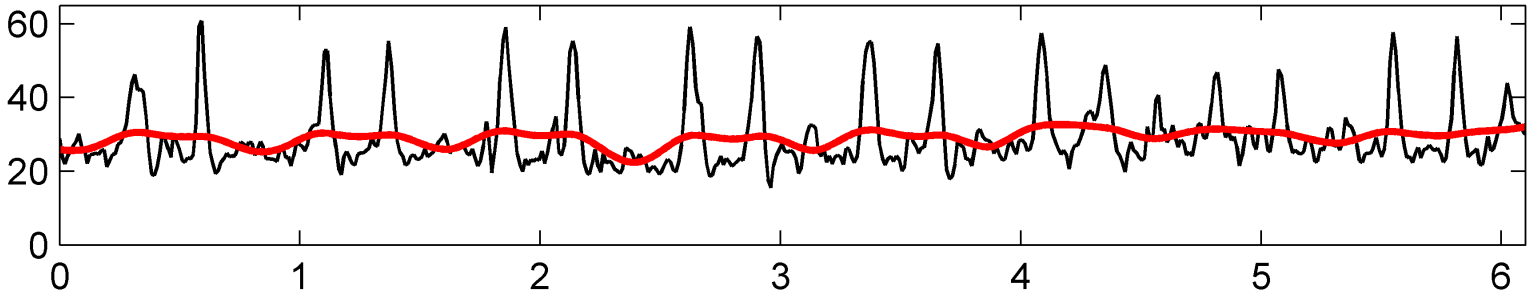
Onset Detection (Spectral Flux)

Steps:

1. Spectrogram
2. Logarithmic compression
3. Differentiation & half wave rectification
4. Accumulation
5. Normalization

Novelty function

Subtraction of local average

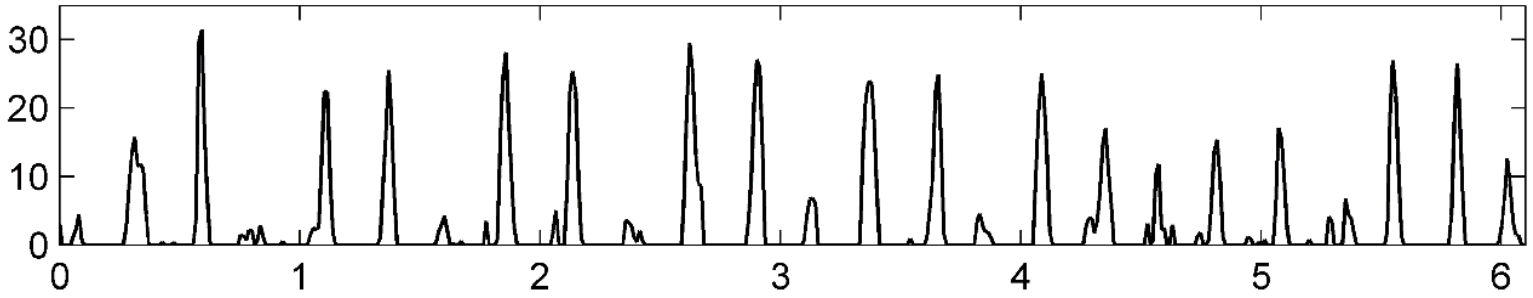


Onset Detection (Spectral Flux)

Steps:

1. Spectrogram
2. Logarithmic compression
3. Differentiation & half wave rectification
4. Accumulation
5. Normalization

Normalized novelty function



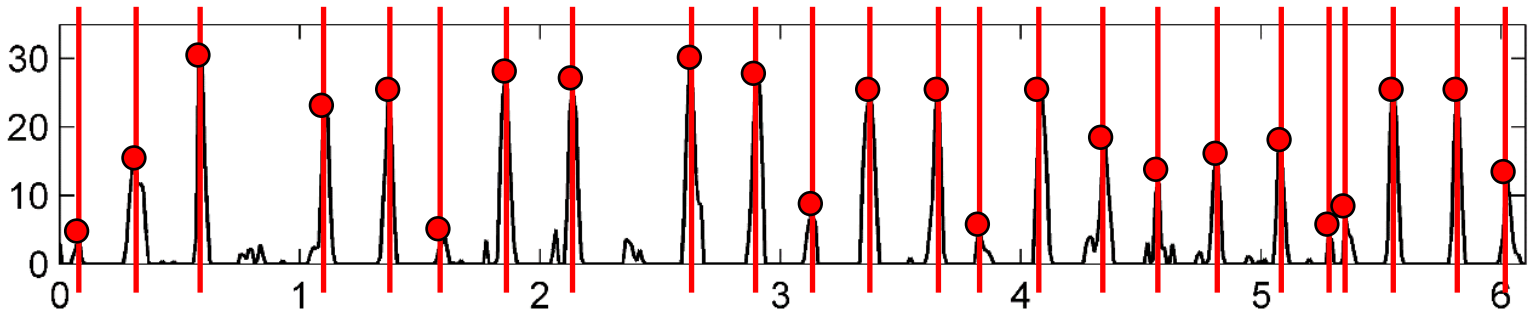
Onset Detection (Spectral Flux)

Steps:

1. Spectrogram
2. Logarithmic compression
3. Differentiation & half wave rectification
4. Accumulation
5. Normalization

Normalized novelty function

Peak positions indicate beat candidates



Onset Detection (Spectral Flux)

Deep Learning

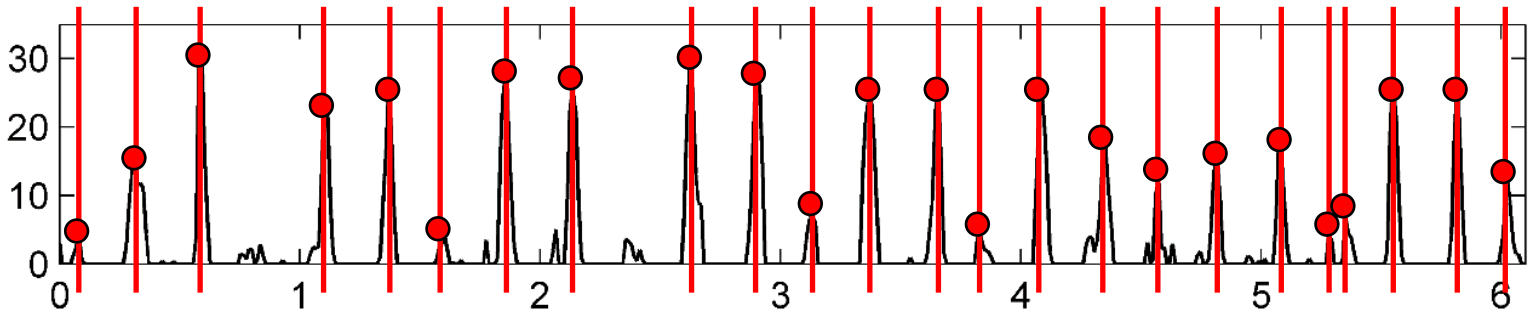
1. Input representation
2. Sigmoid activation
3. Convolution & rectified linear unit (ReLU)
4. Pooling
5. Convolution & ReLU

Steps:

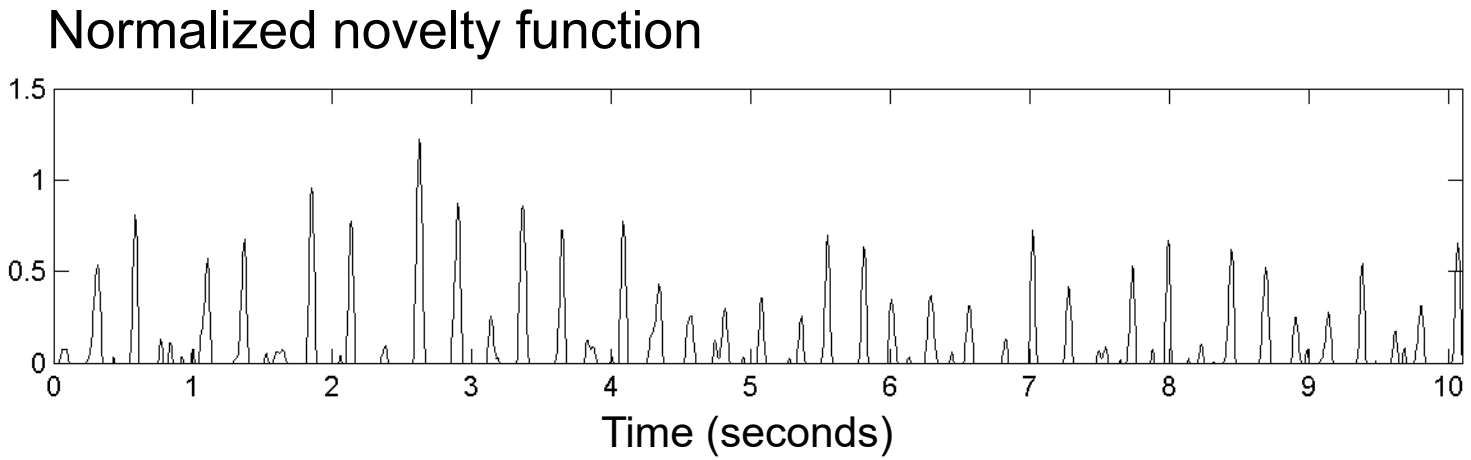
1. Spectrogram
2. Logarithmic compression
3. Differentiation & half wave rectification
4. Accumulation
5. Normalization

Normalized novelty function

Peak positions indicate beat candidates

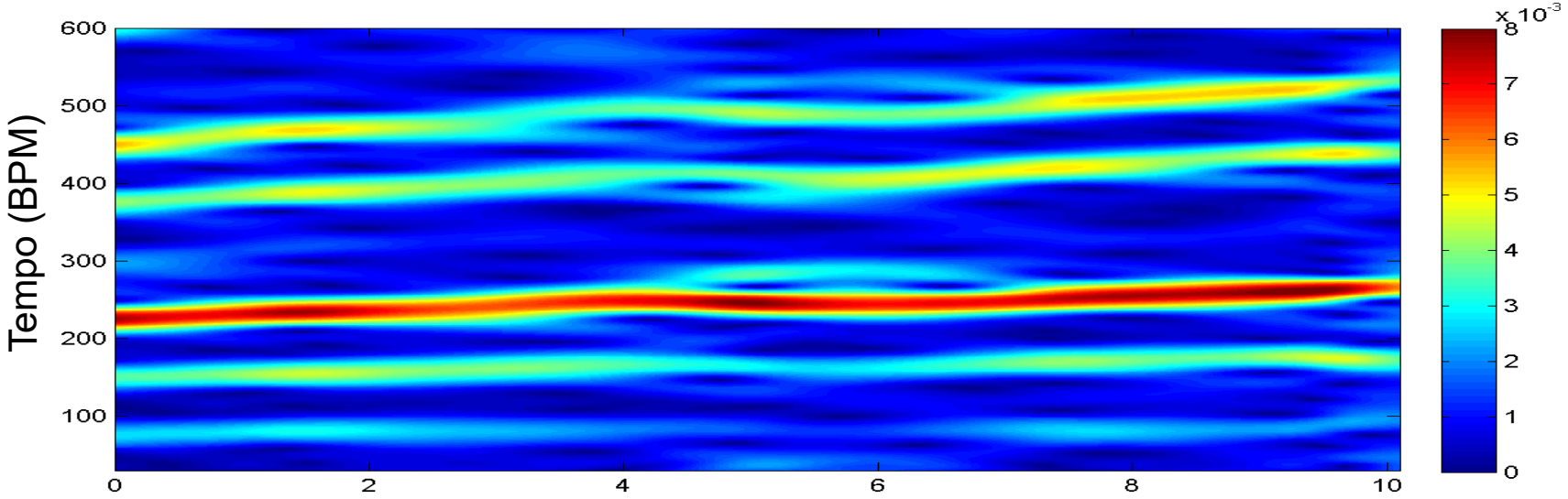


Local Pulse and Tempo Tracking

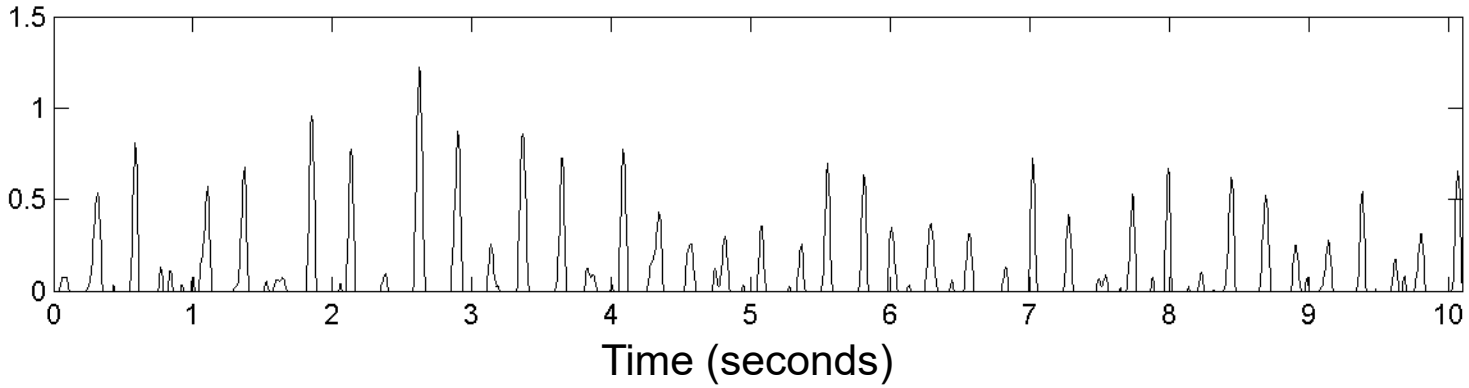


Local Pulse and Tempo Tracking

Fourier temogram (STFT of novelty function)



Normalized novelty function



Local Pulse and Tempo Tracking

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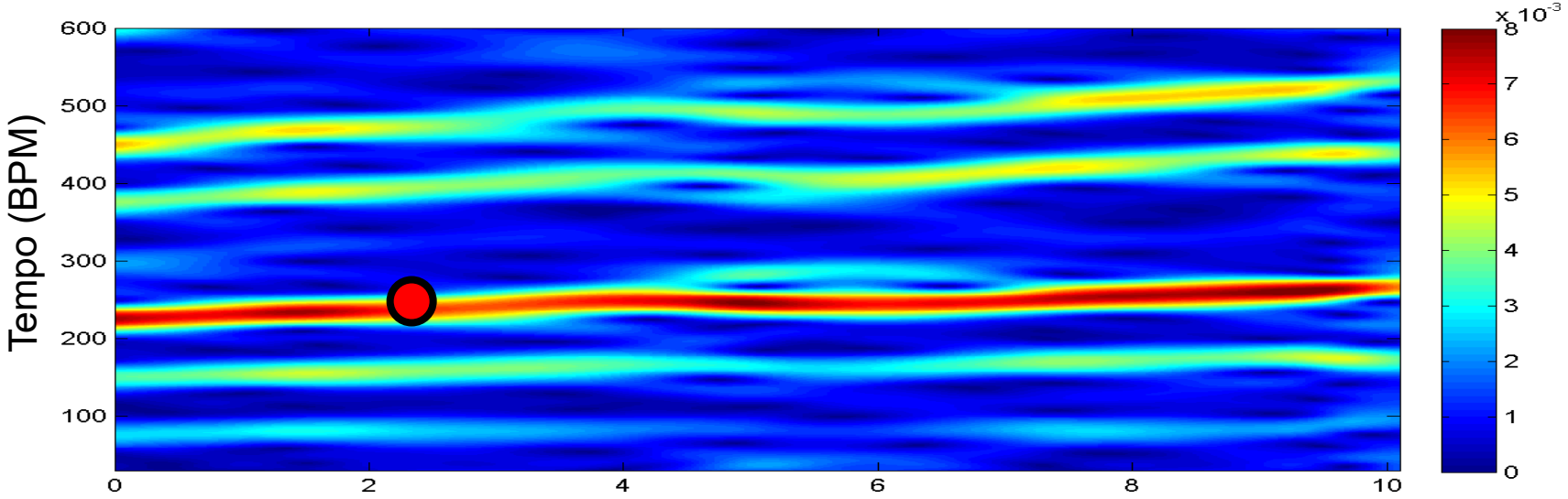
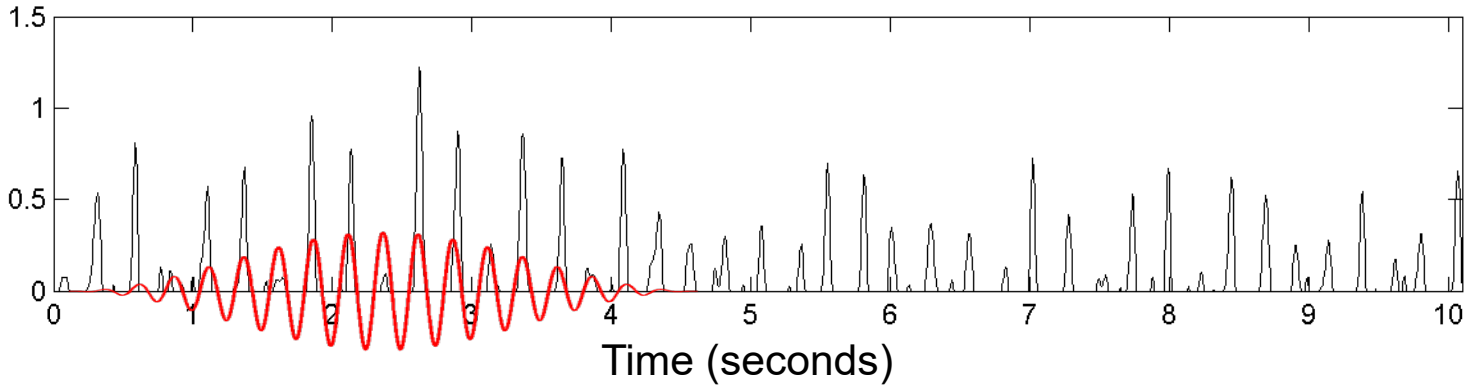


Optimizing local periodicity kernel



Local Pulse and Tempo Tracking

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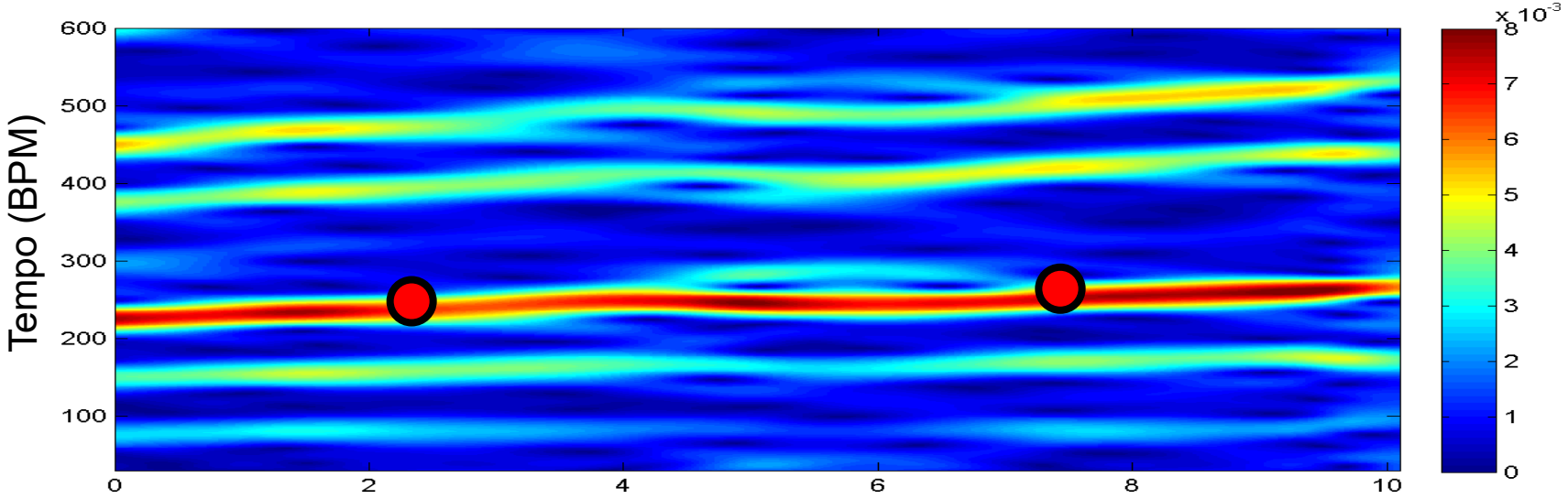
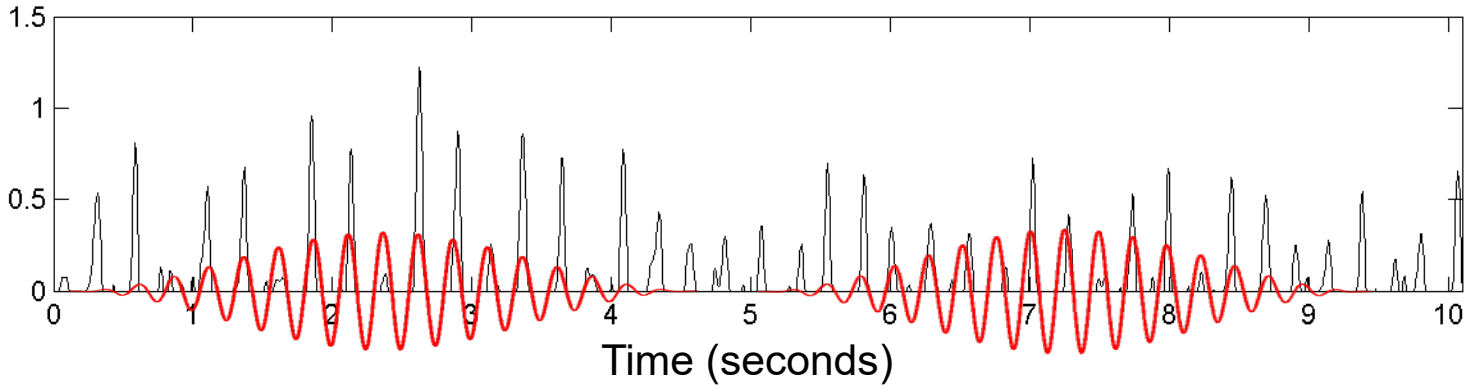
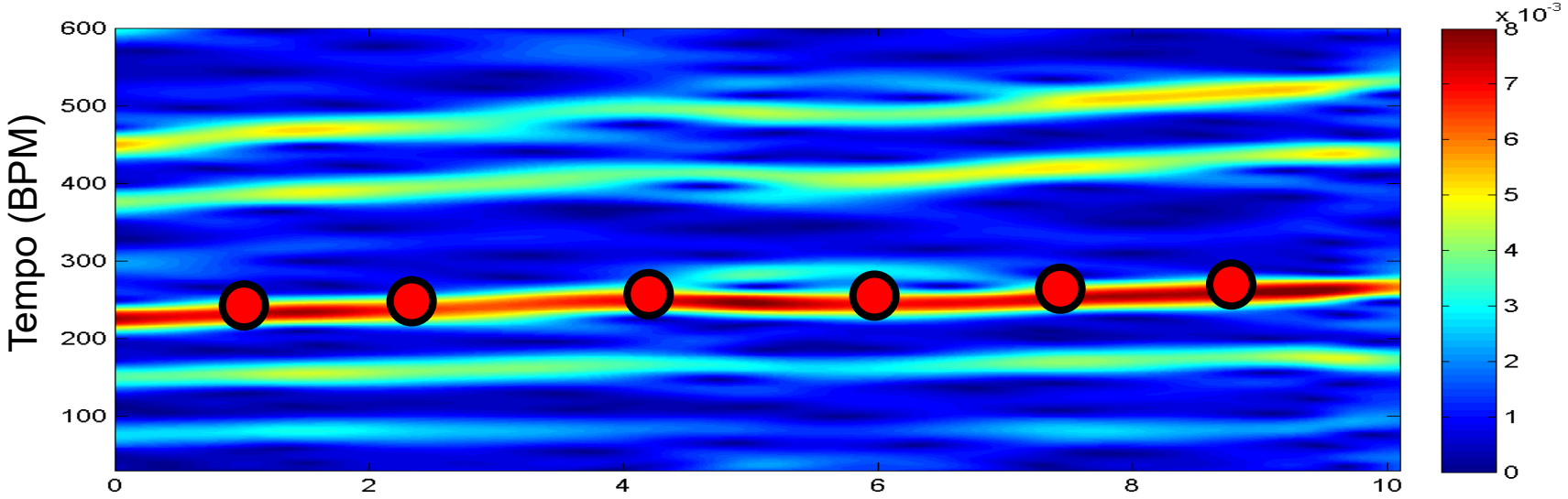


Optimizing local periodicity kernel

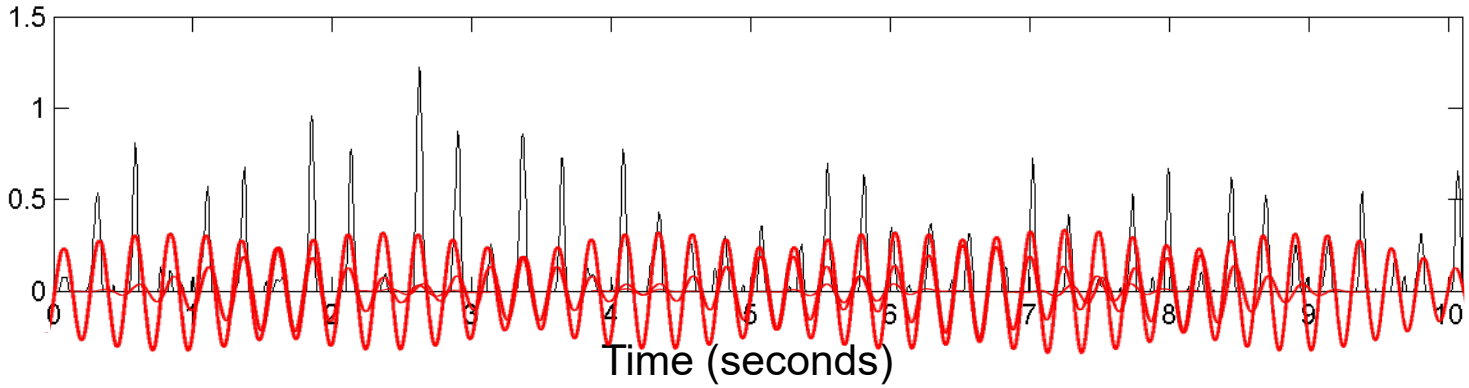


Local Pulse and Tempo Tracking

Fourier temogram (STFT of novelty function)

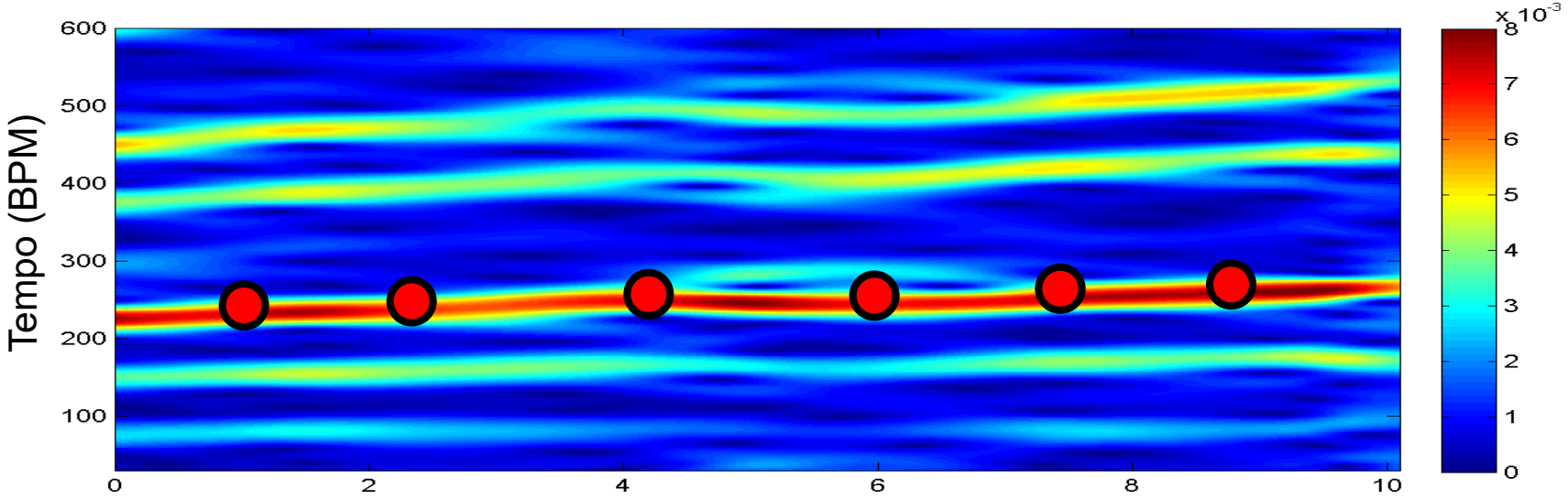


Optimizing local periodicity kernel

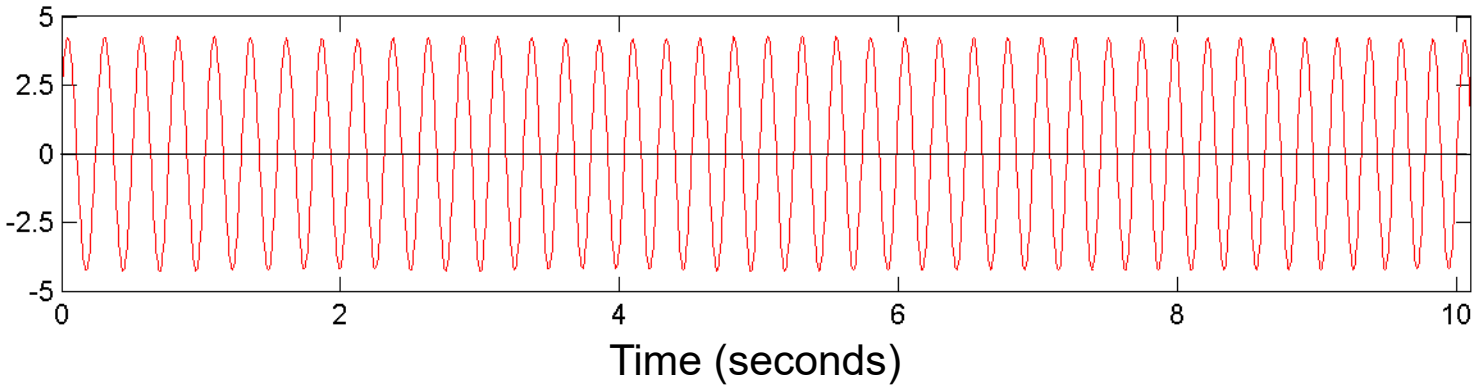


Local Pulse and Tempo Tracking

Fourier temogram (STFT of novelty function)

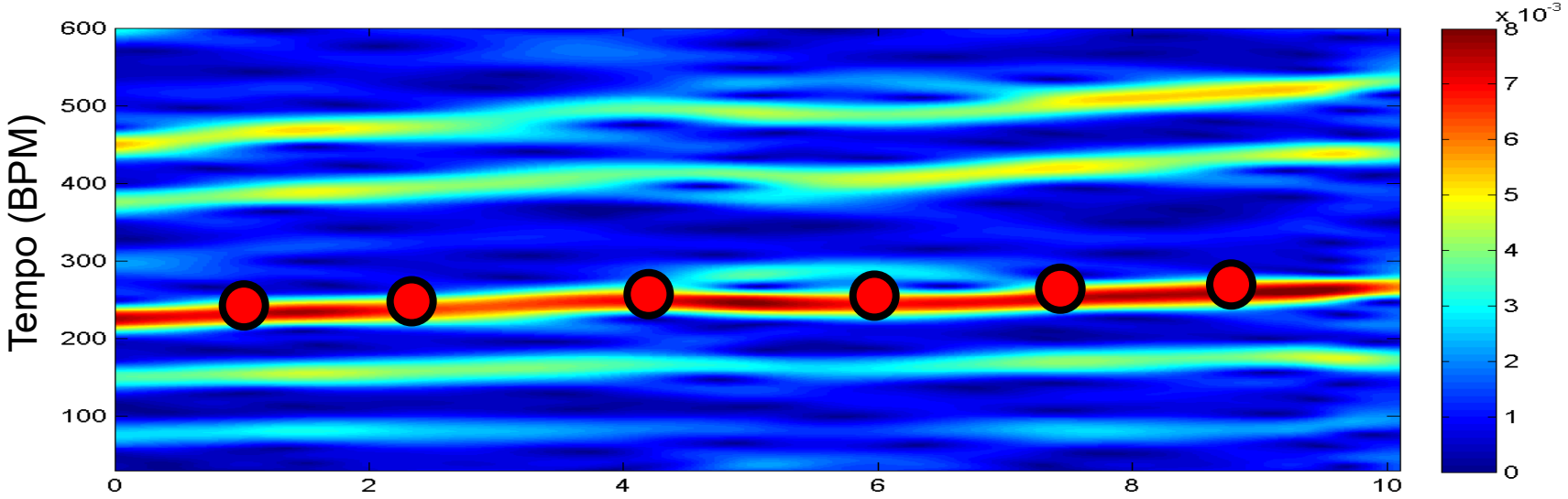


Accumulation of kernels

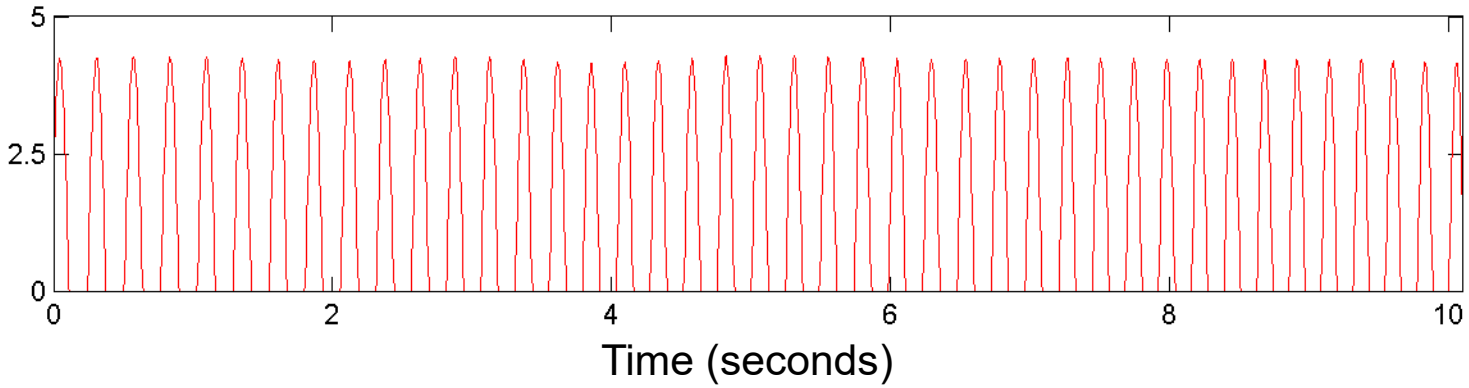


Local Pulse and Tempo Tracking

Fourier temogram (STFT of novelty function)

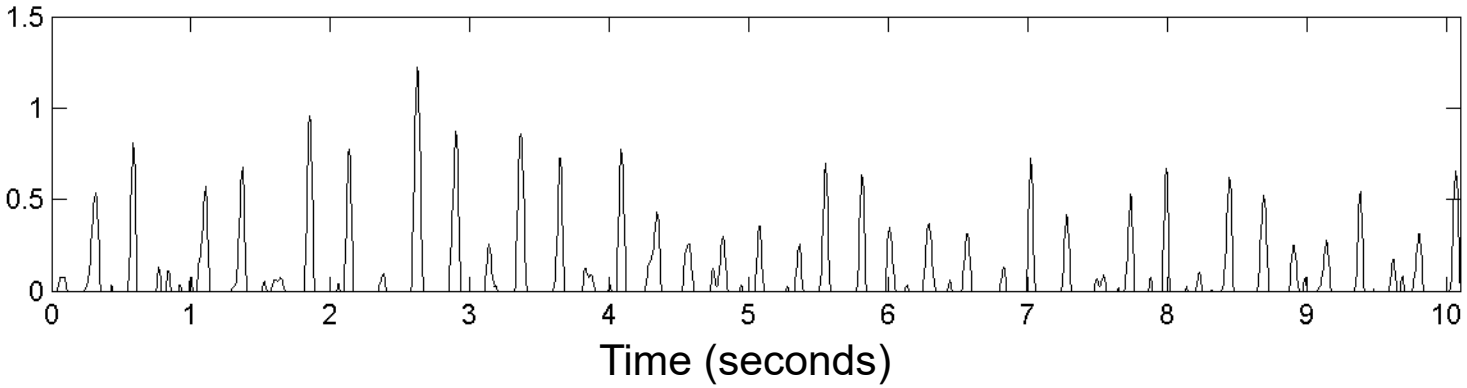


Halfwave rectification

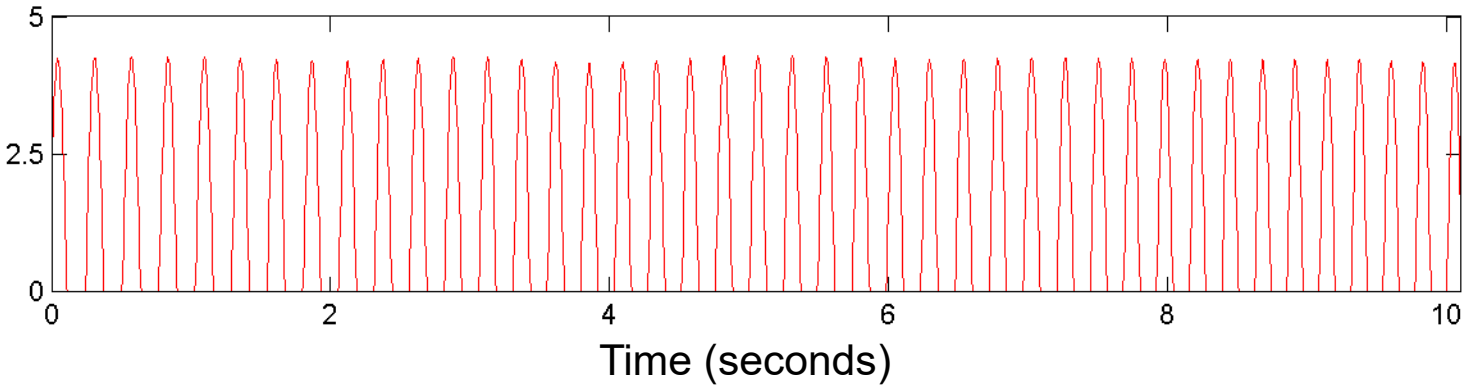


Local Pulse and Tempo Tracking

Novelty Curve



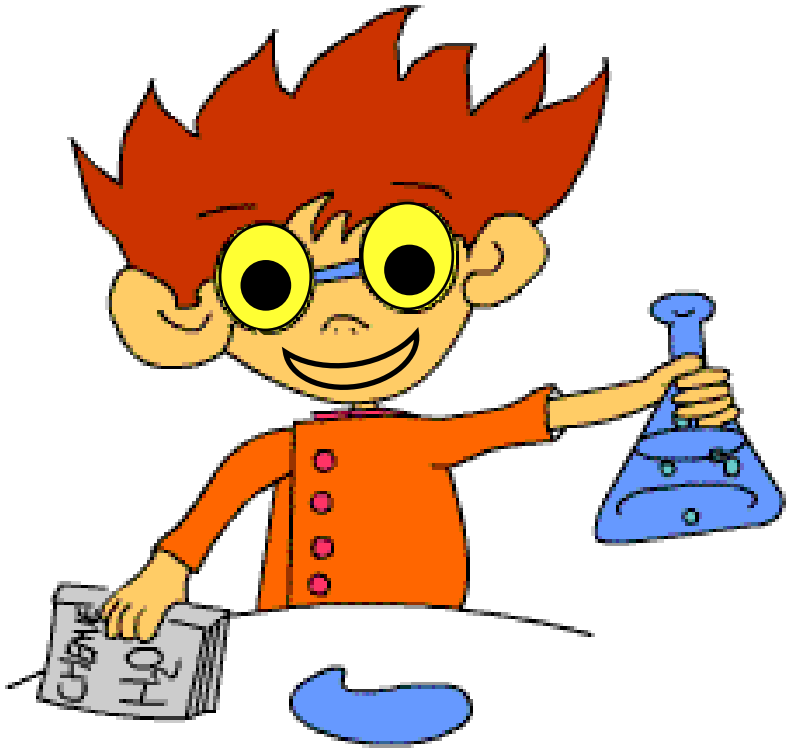
Predominant Local Pulse (PLP)



Tempo and Beat Tracking

Basic task: “Tapping the foot when listening to music”

- Computational approach
- Implementation
- Data & annotations
- Evaluation measures
- Experiments …



Tempo and Beat Tracking

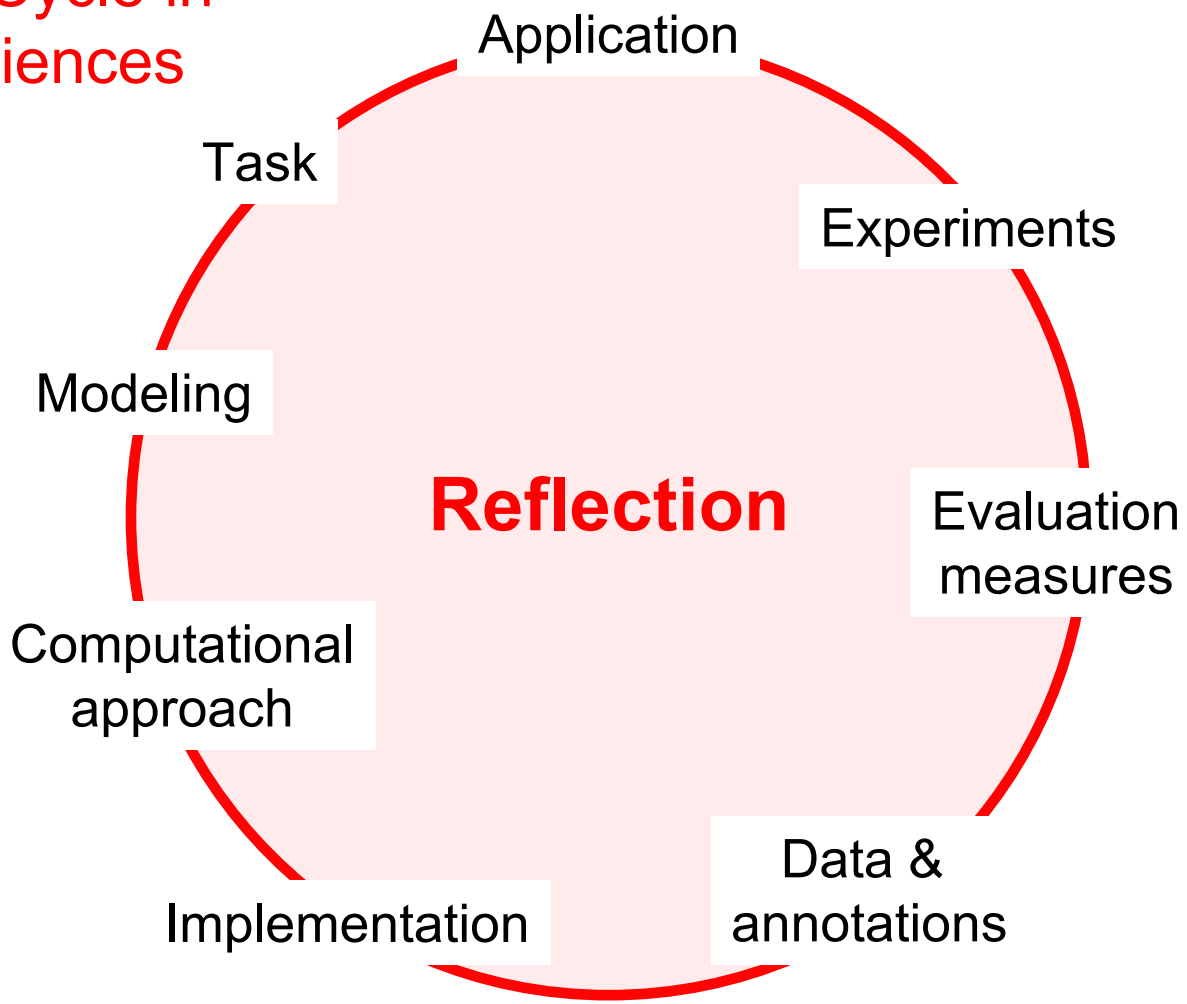
Basic task: “Tapping the foot when listening to music”

- Computational approach
- Implementation
- Data & annotations
- Evaluation measures
- Experiments …

Nothing seems to work!

What is a “Contribution”? What are “Insights”?

Research Cycle in Applied Sciences



The Blessing and Curse of Applied Sciences

- You can make contributions in many ways
  - Novel application or task
  - Novel computational approach
  - Efficient implementation
  - Novel dataset and annotations
  - Novel evaluation measures
  - Interesting experiments
  - …
- A problem is hardly ever "solved" – so you can always contribute something

Accept

- You never "solve" a problem completely
- You always miss some aspects
- Your modelling always goes along with simplifications
- Your work is always vulnerable and disputable

Reject

The Blessing and Curse of Interdisciplinarity

- You can make contributions coming from various disciplines
  - Information retrieval
  - Signal processing
  - Musicology
  - Library sciences
  - Human computer interaction
  - Machine learning
  - …
- You can contribute with novel collaborative work

Accept

- There are many different perspectives on your work
  - Technical perspective
  - Music perspective
  - Data perspective
  - …
- You will never do justice to all disciplines
- Your work is always vulnerable and disputable

Reject

The Blessing and Curse of ISMIR

- Support of young researchers
- Balance in topics and approaches
- High acceptance rate (40-50%)
- Open exchange of ideas
- Cooperative environment

Accept

- Authors and reviewers may have little experience
- Inconsistent reviews
- Paper quality is very mixed
- Get a publication out
- Competitive environment

Reject

Why PhD?

- Why do I want to do a PhD?
- Why do I want to do a PhD in MIR?
- Why do I want to do a PhD at a specific institute or group?

Why PhD?

- **Personal motivation**

Why MIR?

- Why do I want to do a doctorate?
  - Research
  - Curiosity
  - Recognition
  - Social status / title
  - Career
- What career am I striving for?
  - Academia
  - Industry
  - Management
- Do I have an intrinsic motivation?

Fascination

Why PhD?

- Personal motivation
- **Scientific aspects**

Why MIR?

- Which research direction am I interested in?
  - Field
  - Theory
  - Methods
  - Application
- Which concrete research questions fascinate me?
- What do I want to learn?

Multi- and interdisciplinarity

Why PhD?

- Personal motivation
- Scientific aspects
- **Additional qualifications**

ISMIR & TISMIR

Why MIR?

- Which qualifications do I want to gain during my doctorate?
- Do I like scientific writing and giving public presentations?
- Do I like teaching and supervising students?
- How about management tasks?
  - Research management
  - Project management
  - Event management

  Committee work

Why PhD?

- Personal motivation
- Scientific aspects
- Additional qualifications
- **Integration and communication**

Support of next generation

Why MIR?

- Do my interests fit the research environment ?
- Do I have the same wavelength as my potential collaborators and supervisors?
- Do I feel that my needs are understood?
- What can I give back?
- What is my gut feeling about the research environment?

Why PhD?

- Personal motivation
- Scientific aspects
- Additional qualifications
- Integration and communication
- **Organizational aspects**

Integrity & inclusiveness

Why MIR?

- How well am I organized?
  - Realistic schedule
  - Time management
  - Networking
- What are the criteria for admission to doctoral studies?
  - University
  - Faculty
  - Institute
- Do I know the scientific rules of good research practice?

Why PhD?

- Personal motivation
- Scientific aspects
- Additional qualifications
- Integration and communication
- Organizational aspects
- **Risk taking and alternatives**

Why MIR?

- How big is my need for security?
- What are financial risks?
  - Financial support
  - Funding type
  - Legal regulations
- What is a reasonable time perspective for me?
- Do I have a “Plan B” in the case the doctorate does not work out?

Technology

What are a Doctorate's General Goals?

- Advance knowledge in a specific research area
- Make novel contributions and provide insights
- Acquire skills for becoming an independent researcher, problem solver, and leader

Support of MIR community

- **Recognize** problems as such and develop solutions
- **Write** up the essence of your ideas in an understandable form
- **Disseminate** your results in the form of publications and code
- **Communicate** and **defend** your results to a critical audience
- **Collaborate** with and **guide** other people in their scientific work

Scientific Writing

Why is this important?

- Communicates ideas
- Extracts essence of work
- Forces precision and clarity
- Helps reflect on ideas
- Creates a long-term record
- Peer review strengthens ideas
- Provides bases for PhD thesis

- Proceedings ISMIR (since 2000)
  - Fixed yearly deadline
  - Six pages
  - Single-round peer review
  - No revision
  - Presentation at ISMIR conference
- Journal TISMIR (since 2018)
  - Any time
  - Roughly 12 pages
  - Multiple-round peer review
  - Revision possible
  - Presentation at ISMIR conference
  - Various article types:
    - Research
    - Overview
    - Dataset
    - Education

Reviewing

Why Should You Become a Reviewer?

- Get to know “the other side”
- Reflect on your own work and publications
- Read interesting articles
- Learn about new research trends
- Become part and give something back to the community

Tutorials

ISMIR

- Since ISMIR 2002
  - 2002: 3 tutorials
  - 2003-2014: 4 tutorials
  - From 2015: 5 – 8 tutorials
- Divers topics:
  - Symbolic music and audio processing
  - Specific MIR tasks
  - Interfaces & users
  - Introduction to specific music genre
- Presenters:
  - Established researchers
  - PhD students

Website: **https://www.ismir.net/resources/tutorials/**

Resources

ISMIR

Website: **https://ismir.net/**

- Conferences
- Transactions of ISMIR
- Women in MIR
- Resources
- About the Society
- Membership
- Community Statistics
- Contact

Resources

ISMIR

Website: https://ismir.net/

- Conferences
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- Women in MIR
- **Resources**
- About the Society
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- Contact

- Ethics
- Datasets
- Educational Materials
- Related Conferences and Journals
- Reproducible Research
- Research Centers
- Software Tools
- Tutorials

Why is MIR and ISMIR special?

ISMIR

- Fascination for music & technology …
- Independent, young & vibrant community
- Support for next generation of scientists
- Focus on research & education
- Encouragement of interdisciplinarity & diversity
- Support of open access & reproducibility

ISMIR

Review Decision Process

- Scientific Program Chairs
  - Organize review process
  - Make final decisions (accept vs. reject)
  - Compile scientific program
- Meta Reviewers
  - Help selecting reviewers
  - Review papers
  - Lead discussion phase
  - Provide summary with preliminary decision
- Reviewers
  - Review papers
  - Participate in discussion phase

Reviewing

What Should a Review Achieve?

- Help scientific program chairs making a fair and transparent decision
- Help meta reviewers making a balanced recommendation
- Work out strengths and weaknesses of paper
- Give authors feedback on their work
- Help authors improve their work
- Support and shape the ISMIR community

Reviewing

What are Possible Evaluation Criteria?

- Appropriateness of topic
  - Does the paper fit into the scope of ISMIR?
- Scientific and technical soundness
  - Is the notation and math correct?
- Reproducibility
  - Can the results can be understood and reproduced?
- Readability & paper organization
  - Are the essential points worked out clearly? Is there a take-home message?
- Stimulation potential
  - May the paper trigger exciting discussions?
- Novelty and relevance
  - Does the paper make some original and substantial “contributions”?
  - Does the paper provide “insights”?

Reviewing

- Show respect

- Show that you care and appreciate the article
  - Authors have worked hard
- Stay positive and assume good faith
- Be clear and direct, but also encouraging
- Criticize the work, but not the authors

Reviewing

- Show respect
- Be detailed and specific

- Short reviews are hardly useful (and may even be harmful)

> “ … I like the paper, and I think it should be accepted ...”

> “ … This paper offers no technical novelty and should be rejected ...”

- Your review should help
  - Authors
  - Meta reviewers
  - Program chairs / editors
- Justify the score in detail
- However, do not get lost in details (fixing typos, re-writing, …)

Reviewing

- Show respect
- Be detailed and specific
- Make your perspective explicit

- You may mention your background in the review
- Explain which perspective you take

> “ … My background is in music sciences, and I look at the paper from a musicological perspective …”

> “ … In the following, I want to comment on the paper from a technical perspective ...”

Reviewing

- Show respect
- Be detailed and specific
- Make your perspective explicit
- Be honest

- Never write something you are not sure of
- Better admit when you are lost and focus on the aspects you know well

> “ … Since I am not familiar with … I do not comment on the technical contributions ... However, from an application perspective, I can say that … ”

- Note: We are all learners in almost all areas

Reviewing

- Show respect
- Be detailed and specific
- Make your perspective explicit
- Be honest
- Take a clear position

- Use the whole spectrum of evaluation scores
- If you find a paper outstanding, give it the highest score
- If you think the paper is really bad, give it the lowest score
- Always give convincing support for your recommendation

Reviewing

- Show respect
- Be detailed and specific
- Make your perspective explicit
- Be honest
- Take a clear position
- Actively participate

- Read guidelines and examples
- Participate in discussion phase
- If you are unsure, ask for help
  - Supervisor
  - Meta reviewers
  - Program chairs / editors
- Better cancel in time than be sloppy

  Dealing with poor reviews is an editor's worst job
- Be reliable and responsive

  Chasing after reviewers is an editor's second worst job

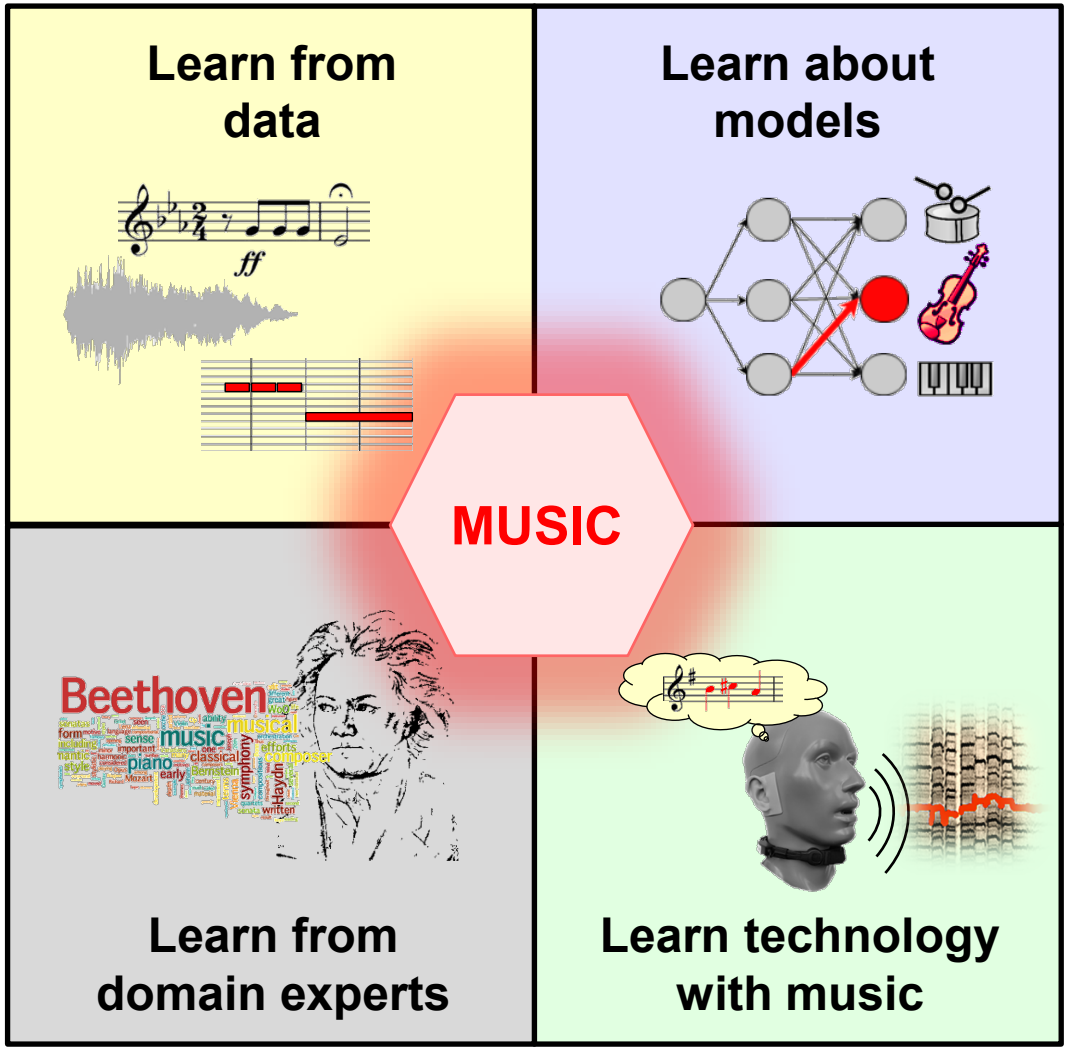
Reviewing

Why should you become a reviewer?

- Get to know “the other side”
- Reflect on your own work and publications
- Read interesting articles
- Learn about new research trends
- Become part and give something back to the community

Learning with MIR

Technology Meets Education



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

Resources

Get involved …

- Contact us for questions: board@ismir.net
- Become an ISMIR member: https://ismir.net/membership/
- Join ISMIR group (email list): community@ismir.net
- Join WiMIR group: https://groups.google.com/g/wimir
- Join WiMIR mentoring program: wimir-mentoring@ismir.net
- Become a volunteer for (virtual) ISMIR conferences
- Apply for registration fee waiver
- …

Resources (Why PhD?)

- Meinard Müller: Information for Doctoral Candidates
  https://www.audiolabs-erlangen.de/fau/professor/mueller/teaching/phd

- QualitätsZirkel Promotion (QZP): Doing your doctorate.
  https://www.qz-promotion.de/home/handbuecher/die-promotion-gut-starten/

- Zeit Campus: Ratgeber Promotion, 2023
  https://issuu.com/zeitmagazine/docs/campus_ratgeber_heft_pdf

- DFG: Guidelines for Safeguarding Good Research Practice
  https://www.dfg.de/download/pdf/foerderung/rechtliche_rahmenbedingungen/gute_wissenschaftliche_praxis/kodex_gwp_en.pdf/

Resources (Reviewing)

- Meinard Müller, Perfecto Herrera, Luis Gustavo Martins, Fabien Gouyon: Guidelines for Reviewers. ISMIR 2012
  https://ismir2012.ismir.net/authors/submission/2012_ISMIR_GuidelinesReview.pdf
- ISMIR Reviewer guidelines (ISMIR website)
  https://ismir.net/reviewer-guidelines/
- Tom Collins: ISMIR Review Examples. 2015 (updated 2019)
  https://tomcollinsresearch.net/pdf/ismirReviewExamples.pdf
- Blair Kaneshiro, Jordan B. L. Smith: Insights on the ISMIR Reviewing Experience. ISMIR 2021 Blog
  https://ismir2021.ismir.net/blog/insights/
  https://ismir2021.ismir.net/blog/insights2/
- Blair Kaneshiro, Zhiyao Duan, Juhan Nam, Preeti Rao, Peter van Kranenburg, Jordan B.L. Smith: Preparing a Successful ISMIR Submission. ISMIR 2021 Blog
  https://ismir2021.ismir.net/blog/preparing/
- ISMIR 2022 Review Form
  https://ismir2022.ismir.net/reviewform

References (Meinard Müller @ Education)

- Meinard Müller, Simon Dixon, Anja Volk, Bob L. T. Sturm, Preeti Rao, and Mark Gotham: Introducing the TISMIR Education Track: What, Why, How? Transaction of the International Society for Music Information Retrieval (TISMIR), 7(1): 85–98, 2024.
  https://transactions.ismir.net/articles/10.5334/tismir.199

- Meinard Müller and Ching-Yu Chiu: A Basic Tutorial on Novelty and Activation Functions for Music Signal Processing. Transaction of the International Society for Music Information Retrieval (TISMIR), 7(1): 179–194, 2024.
  https://transactions.ismir.net/articles/10.5334/tismir.202

- 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

- Meinard Müller: Fundamentals of Music Processing – Using Python and Jupyter Notebooks. 2nd Edition, Springer, 2021.
  https://www.springer.com/gp/book/9783030698072

Resources (Educational Software)

- librosa
  https://librosa.org/

- libfmp
  https://github.com/meinardmueller/libfmp

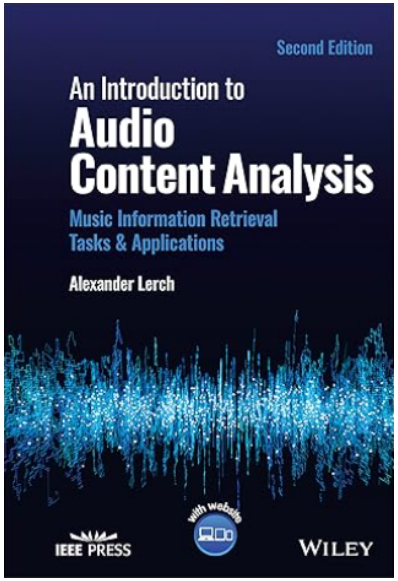
- PCP notebooks
  https://www.audiolabs-erlangen.de/PCP

- mirdata
  https://mirdata.readthedocs.io/

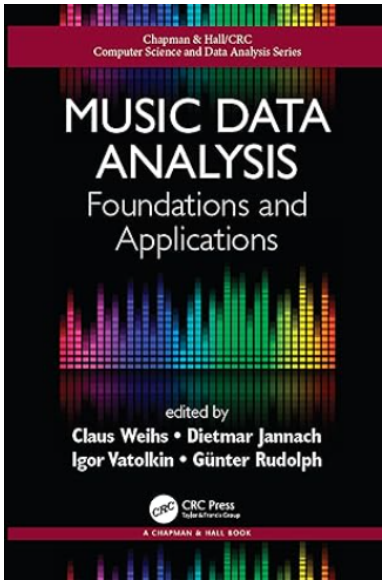
- Essentia Python tutorial
  https://essentia.upf.edu/essentia_python_tutorial.html

- ISMIR Tutorials
  https://www.ismir.net/resources/tutorials/

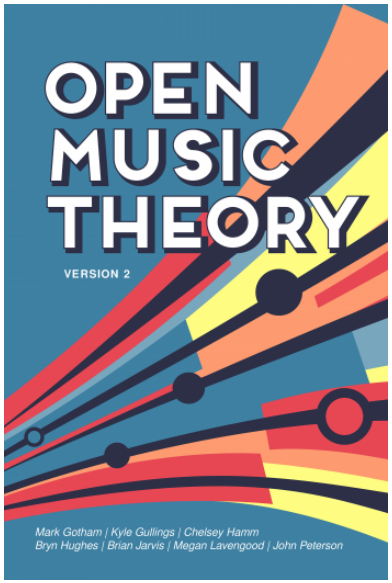
Resources (MIR Textbooks)



Alexander Lerch
An Introduction to Audio Content Analysis
Wiley
1st edition, 2012
2nd edition, 2022



Claus Weihs, Dietmar Jannach, Igor Vatolkin, Guenter Rudolph
Music Data Analysis
CRC Press, 2016



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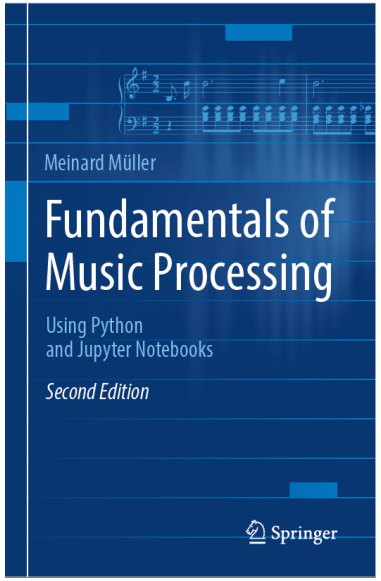
Open online book



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Springer
1st edition, 2015
2nd edition, 2021

25TH INTERNATIONAL SOCIETY FOR MUSIC INFORMATION RETRIEVAL CONFERENCE (ISMIR 2024)
NOVEMBER 10 - 14, 2024
SAN FRANCISCO, CALIFORNIA, USA

ISMIR 2024 Tutorial: Exploring 25 Years of MIR

Conclusions

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