INTERNATIONAL AUDIO LABORATORIES ERLANGEN

AUDIO
LABS

Tutorial
Automatisierte Methoden der Musikverarbeitung
47. Jahrestagung der Gesellschaft für Informatik

Further Topics in MIR

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FAU FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

Fraunhofer
IIS

Why is Music Processing Challenging?

Example: Chopin, Mazurka Op. 63 No. 3

Why is Music Processing Challenging?

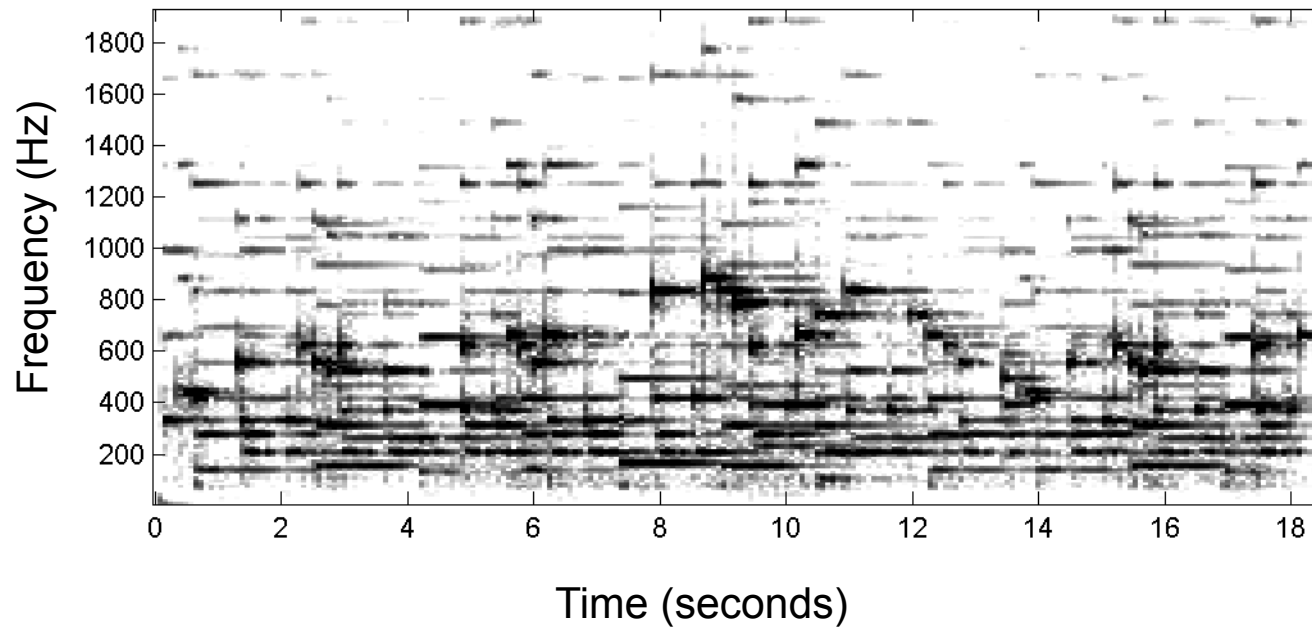**Example:** Chopin, Mazurka Op. 63 No. 3

- Waveform

Why is Music Processing Challenging?

Example: Chopin, Mazurka Op. 63 No. 3

- Waveform / Spectrogram

Why is Music Processing Challenging?

Example: Chopin, Mazurka Op. 63 No. 3

- Waveform / Spectrogram

- Performance
  - Tempo
  - Dynamics
  - Note deviations
  - Sustain pedal

Why is Music Processing Challenging?

Example: Chopin, Mazurka Op. 63 No. 3

- Waveform / Spectrogram

- Performance
  - Tempo
  - Dynamics
  - Note deviations
  - Sustain pedal

- Polyphony

Main Melody

Additional melody line

Accompaniment

Source Separation

- Decomposition of audio stream into different sound sources

- Central task in digital signal processing

- "Cocktail party effect"

Source Separation

- Decomposition of audio stream into different sound sources

- Central task in digital signal processing

- "Cocktail party effect"

- Several input signals

- Sources are assumed to be statistically independent

Source Separation (Music)

- Main melody, accompaniment, drum track

- Instrumental voices

- Individual note events

- Only mono or stereo

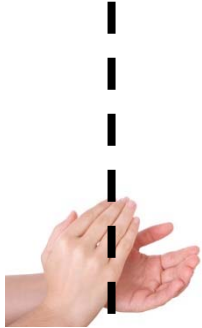- Sources are often highly dependent
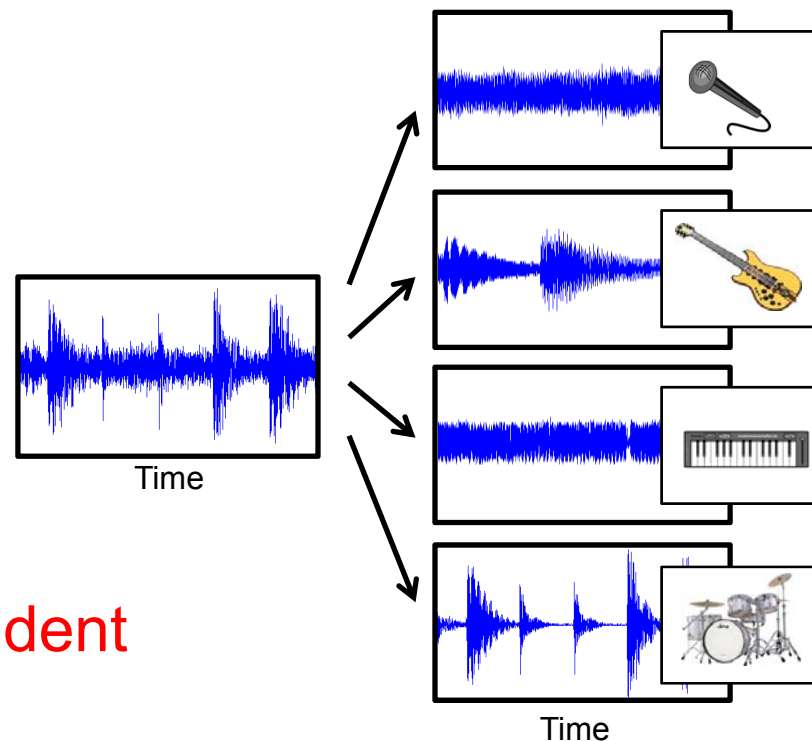
Time

Time

Harmonic-Percussive Decomposition

Mixture

Harmonic-Percussive Decomposition

Mixture

Clearly harmonic sounds

Clearly percussive sounds

Harmonic
component

Percussive
component

Harmonic-Percussive Decomposition

Mixture

Clearly harmonic sounds

Clearly percussive sounds

Harmonic
component

Residual
component

Percussive
component

Harmonic-Percussive Decomposition

Mixture:

- Clearly harmonic sounds of singing voice and accompaniment

- Noise-like sounds
- Vibrato/glissando sounds

- Drum hits
- Fricatives & plosives in singing voice

Harmonic component

Residual component

Percussive component
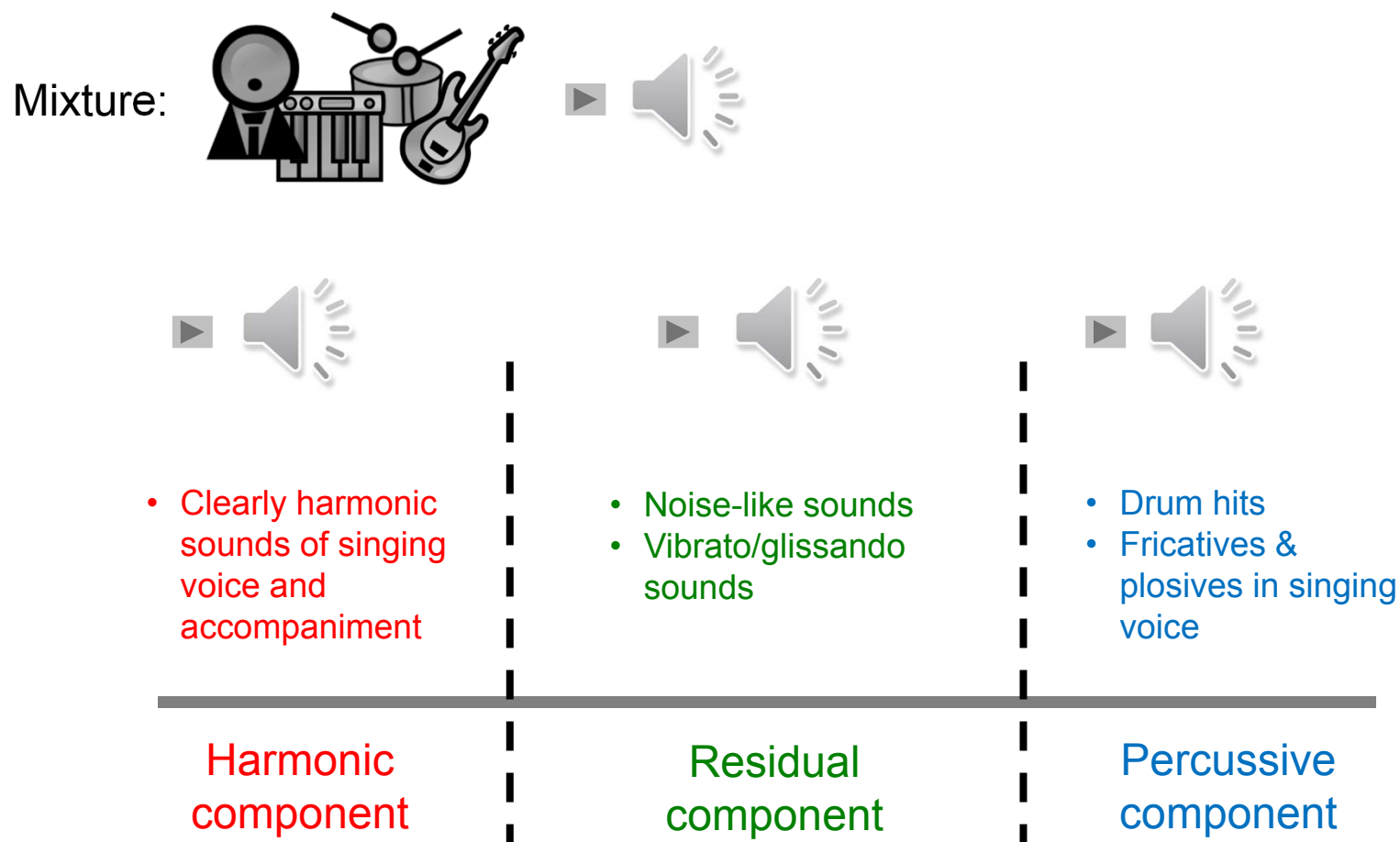
Literature: [Driedger/Müller/Disch, ISMIR 2014]

Demo: https://www.audiolabs-erlangen.de/resources/2014-ISMIR-ExtHPSep/

Singing Voice Extraction

Original Recording
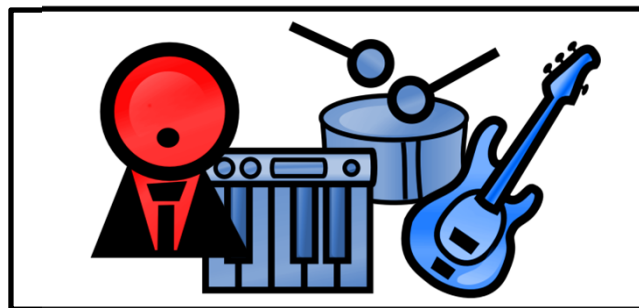
Singing voice
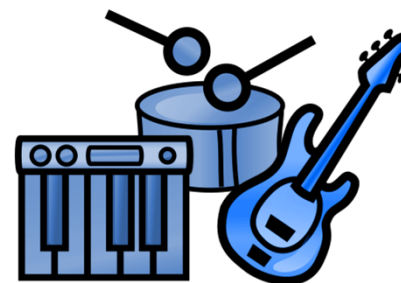
Accompaniment

Singing Voice Extraction

Original recording

HPR

F0 annotation

Harmonic component

MR

Percussive component

TR

Residual component

SL

Harmonic portion
singing voice

Harmonic portion
accompaniment

Fricatives
singing voice

Instrument onsets
accompaniment

Vibrato & formants
singing voice

Diffuse instruments sounds
accompaniment

Estimate
singing voice

Estimate
accompaniment
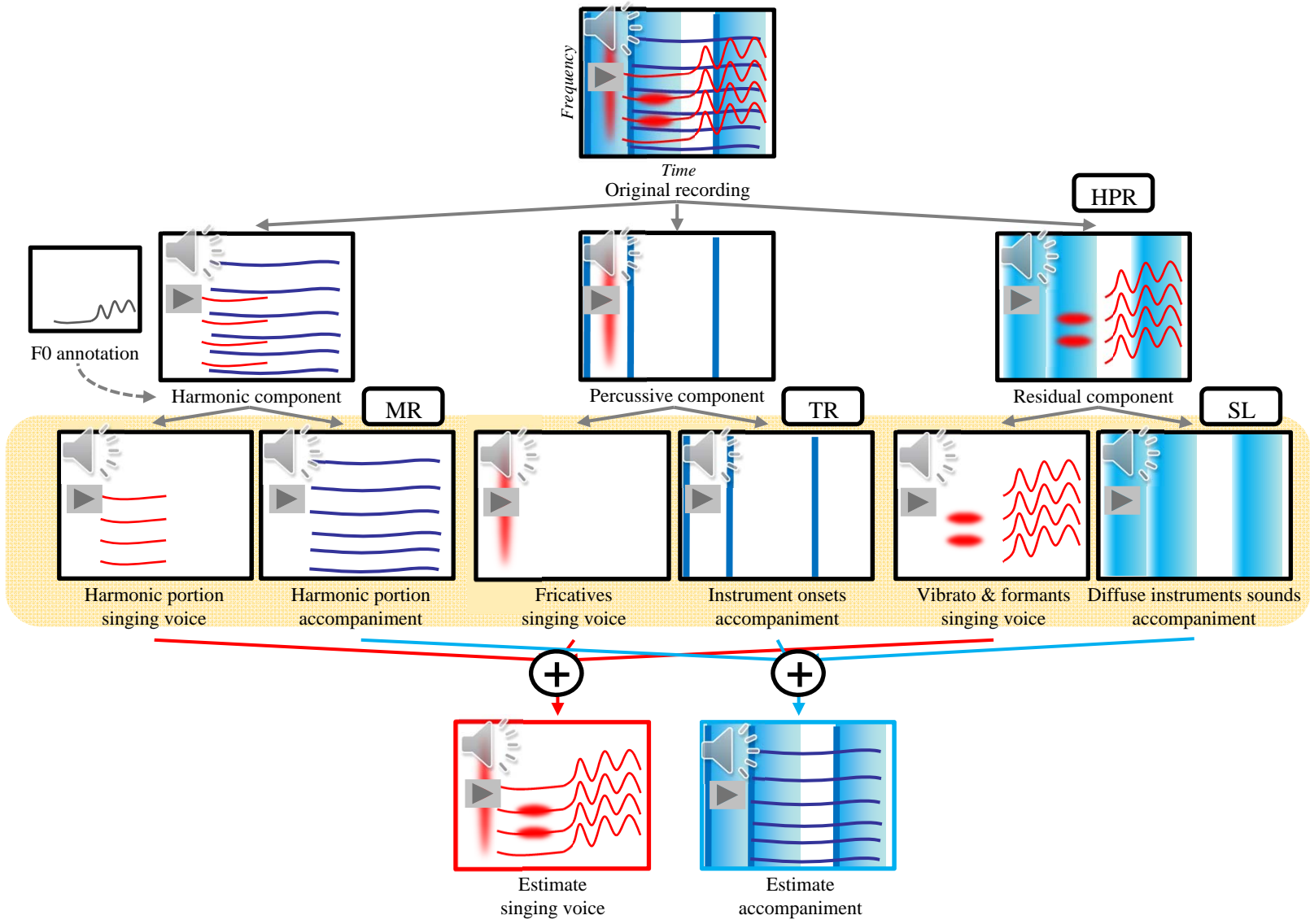
Score-Informed Source Separation

Exploit musical score to support separation process
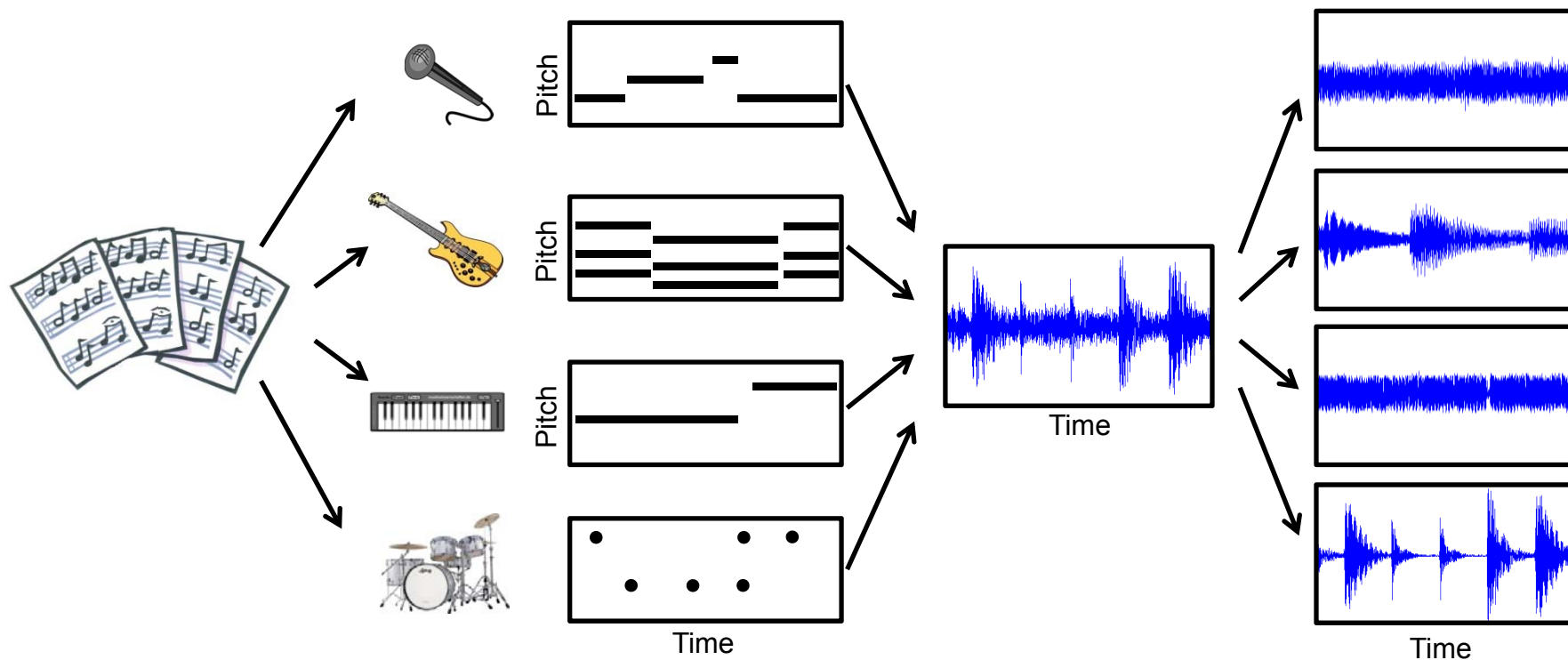
Parametric Model Approach

Rebuild spectrogram information
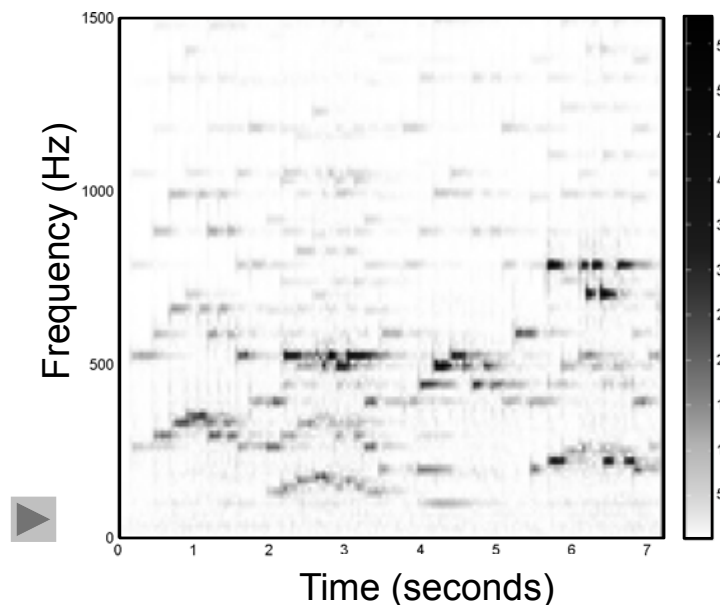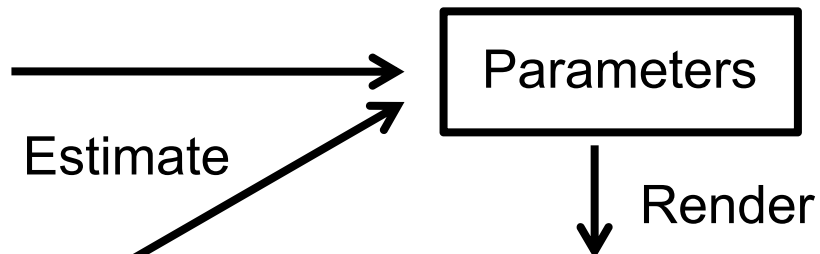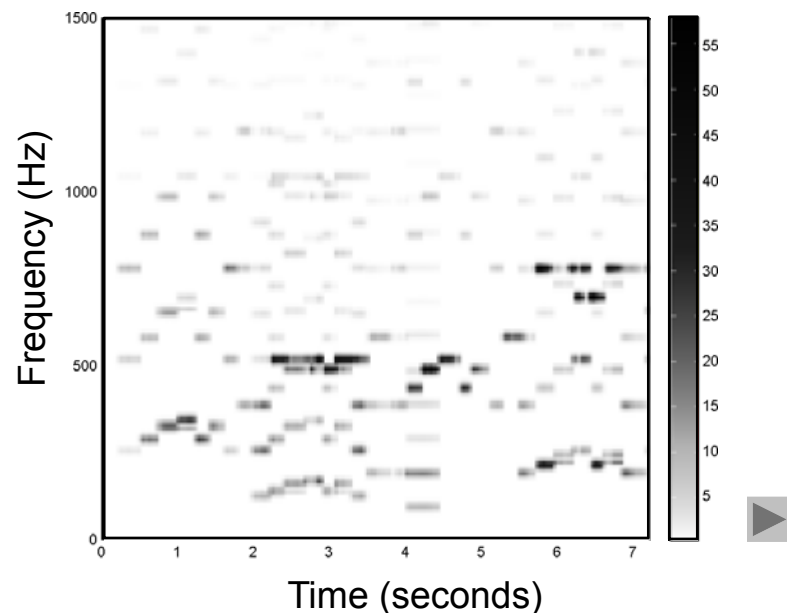
NMF (Nonnegative Matrix Factorization)

NMF (Nonnegative Matrix Factorization)

Magnitude Spectrogram **Templates** **Activations**
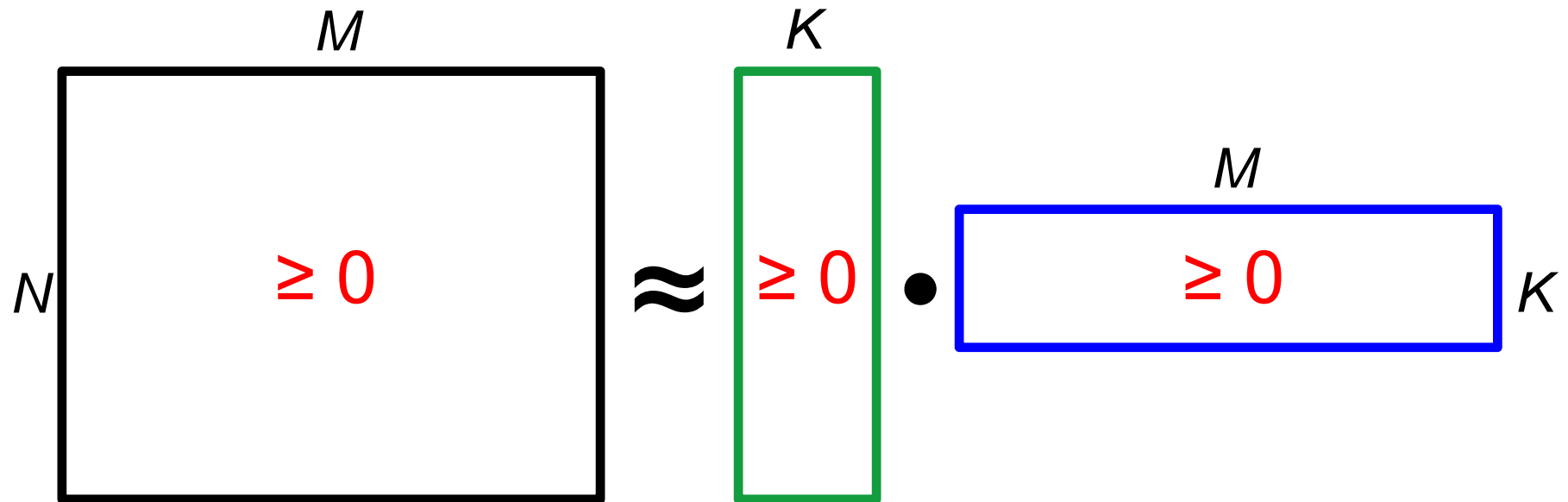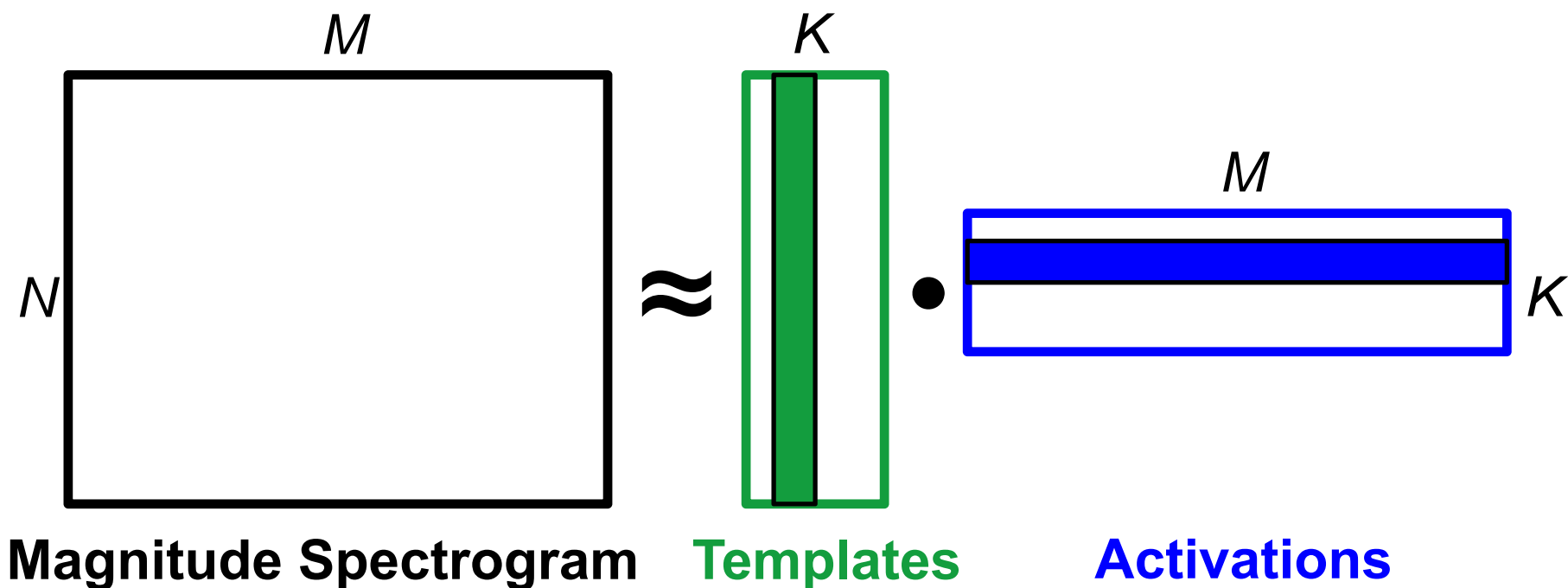
Templates: Pitch + Timbre   "How does it sound"

Activations: Onset time + Duration   "When does it sound"

NMF-Decomposition
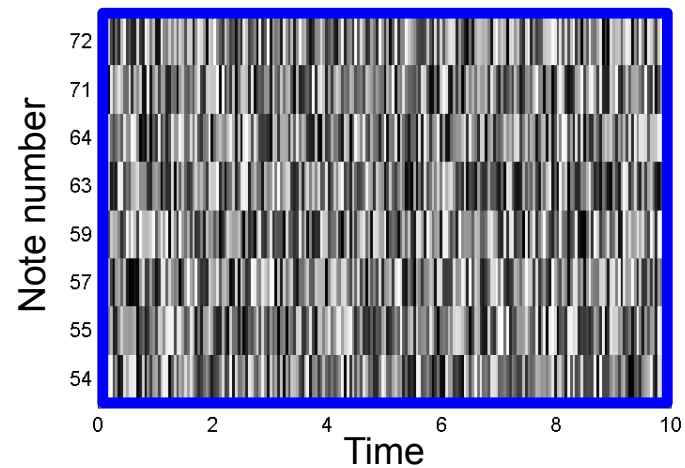
Initialized template

Initialized activations

Random initialization

NMF-Decomposition

Initialized template
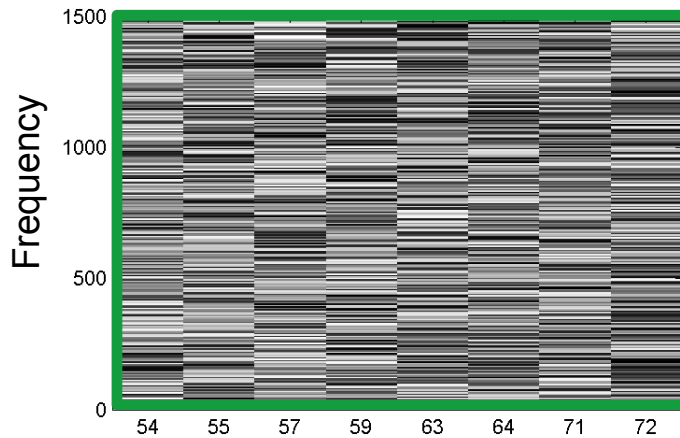
Initialized activations
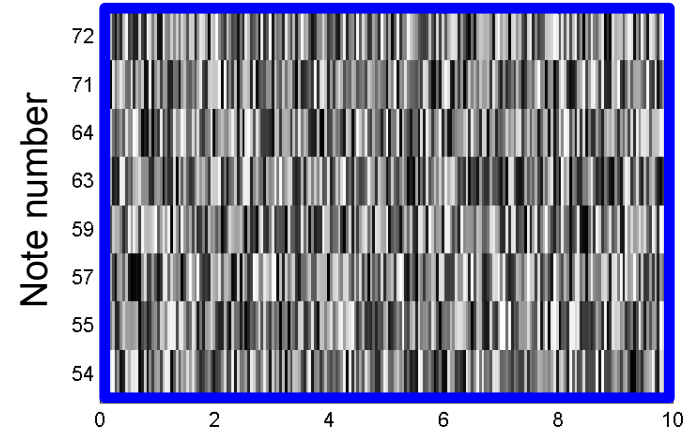
Learnt templates
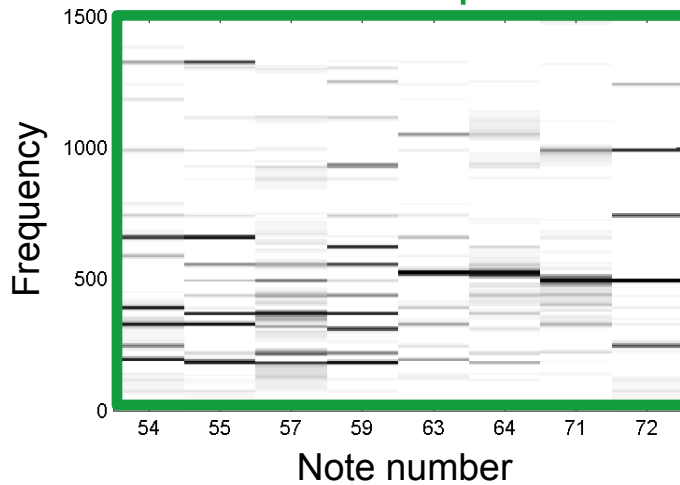
Learnt activations
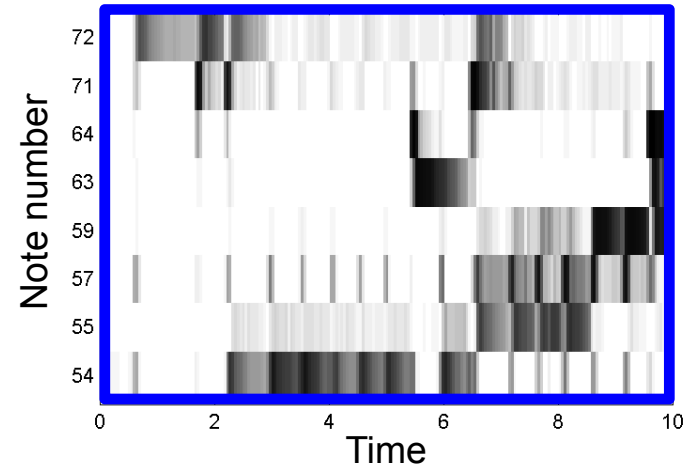
Random initialization → No semantic meaning

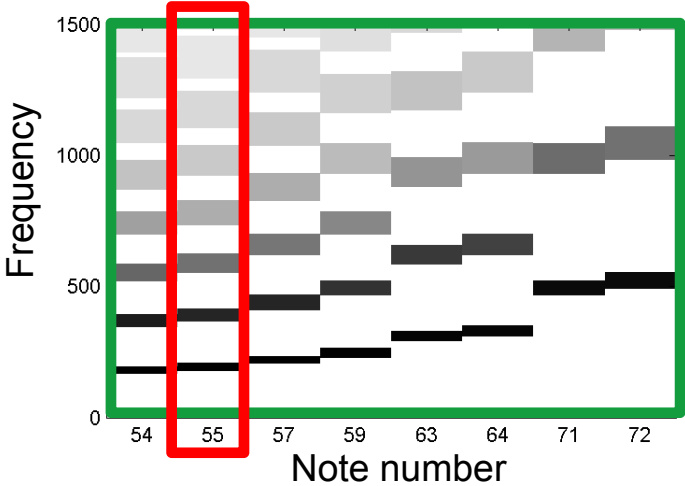# NMF-Decomposition

Initialized template
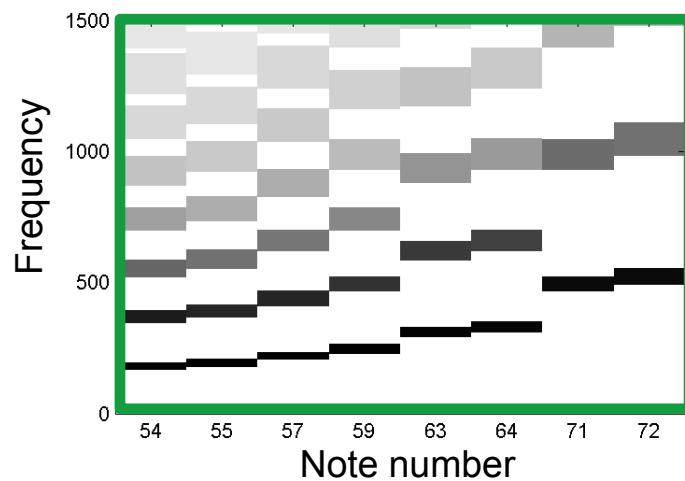
Initialized activations
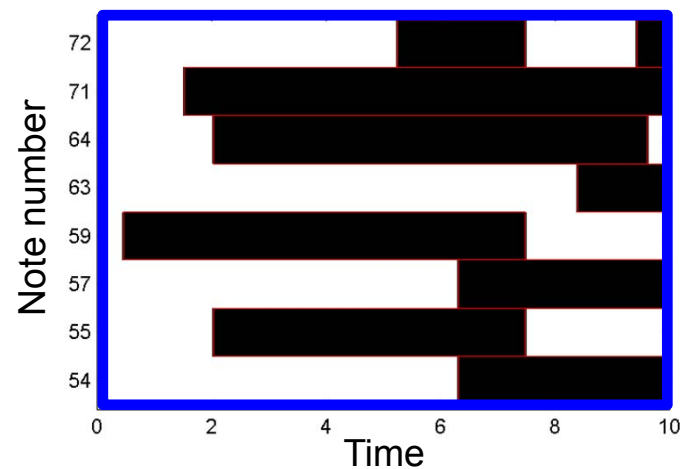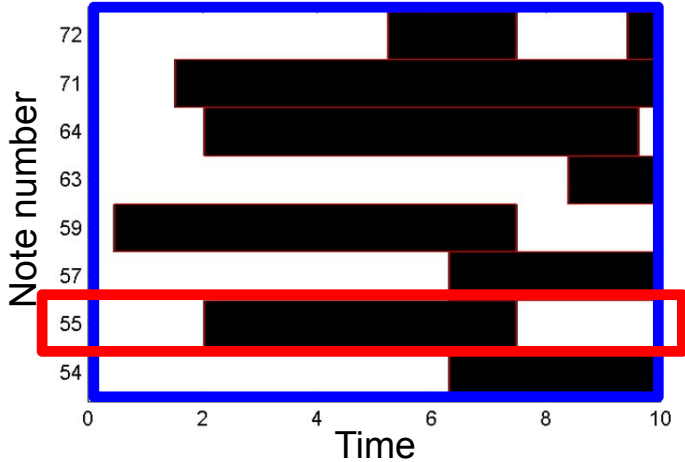
Constrained initialization

NMF-Decomposition

Initialized template
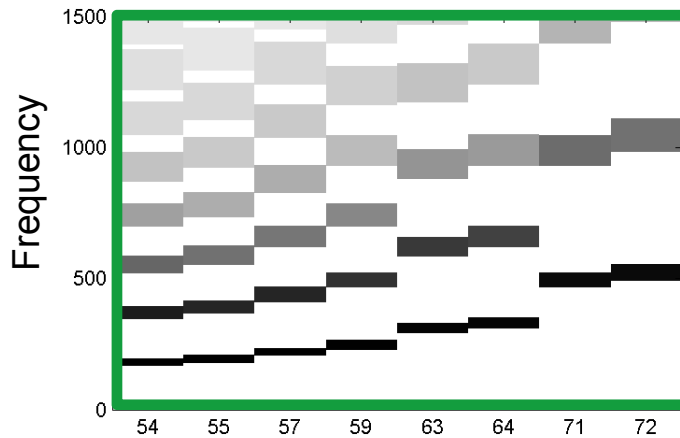
Template constraint for p=55
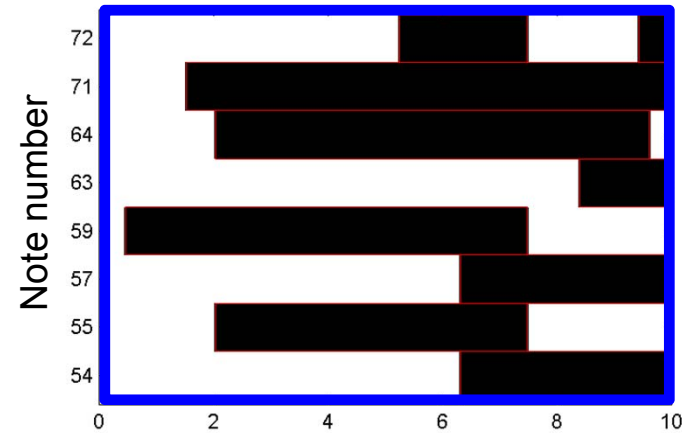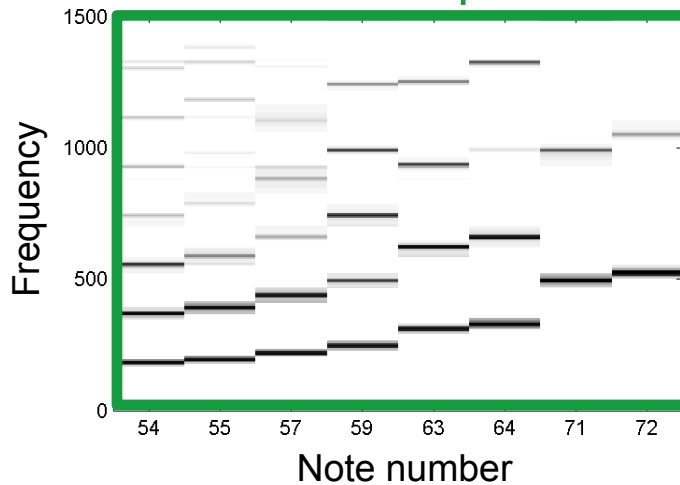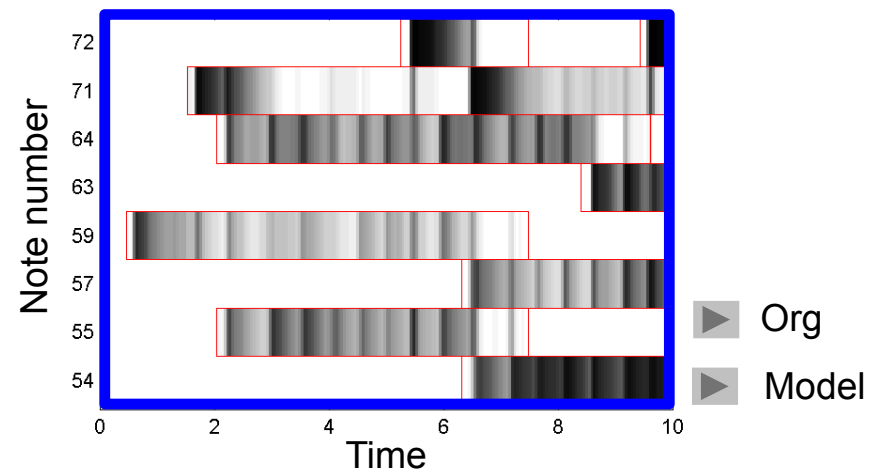
Initialized activations

Activation constraints for p=55

Constrained initialization

NMF-Decomposition

Initialized template
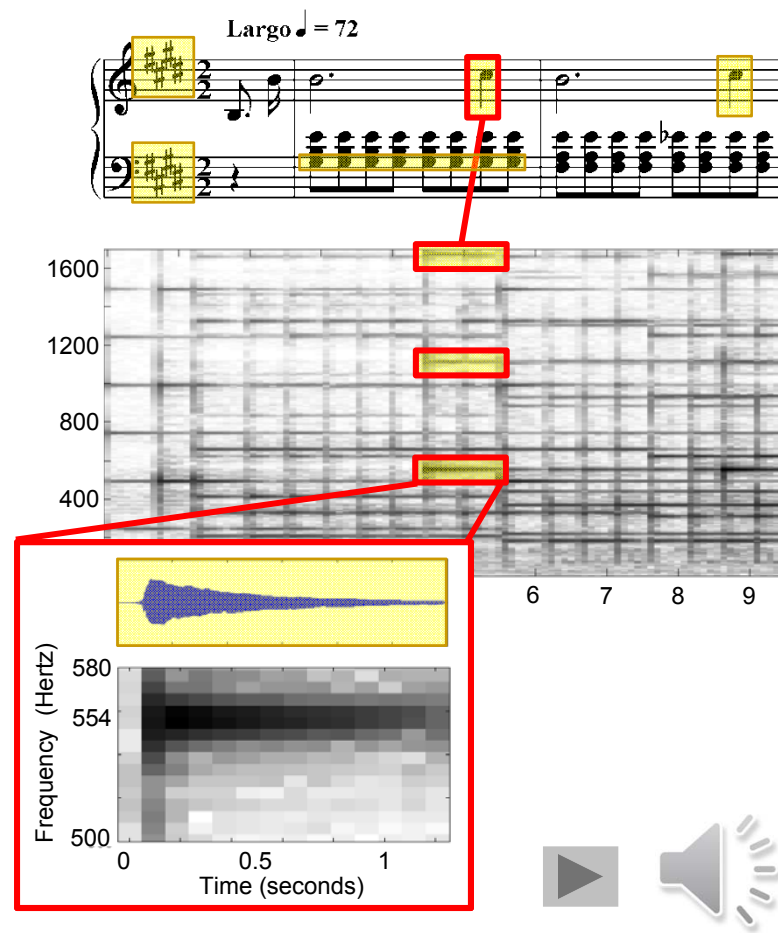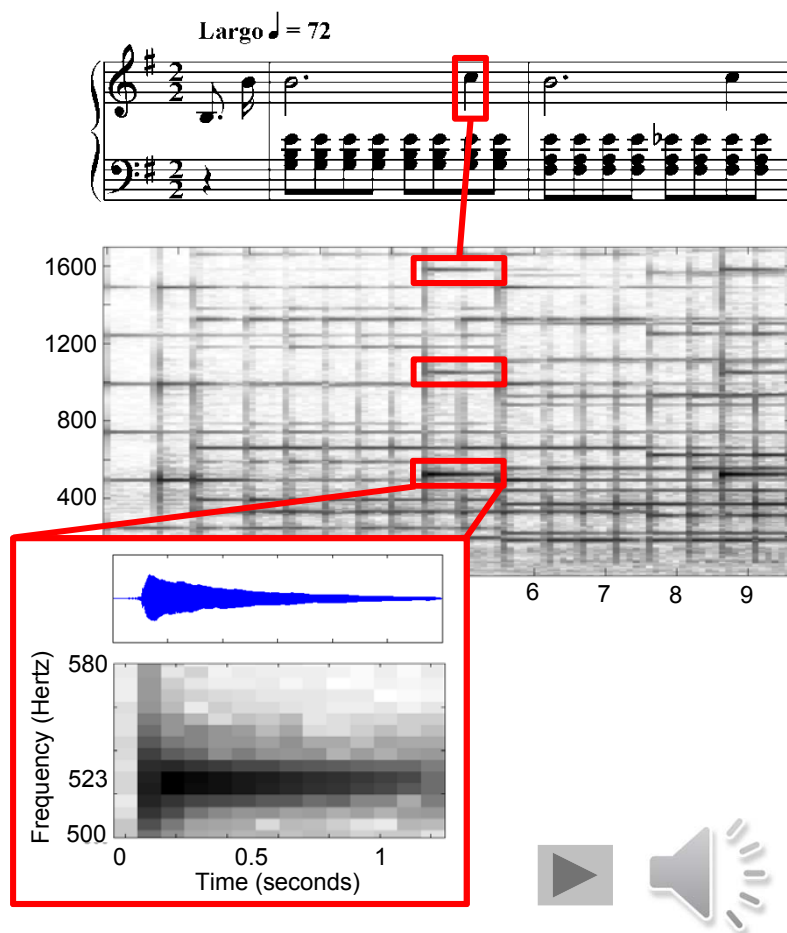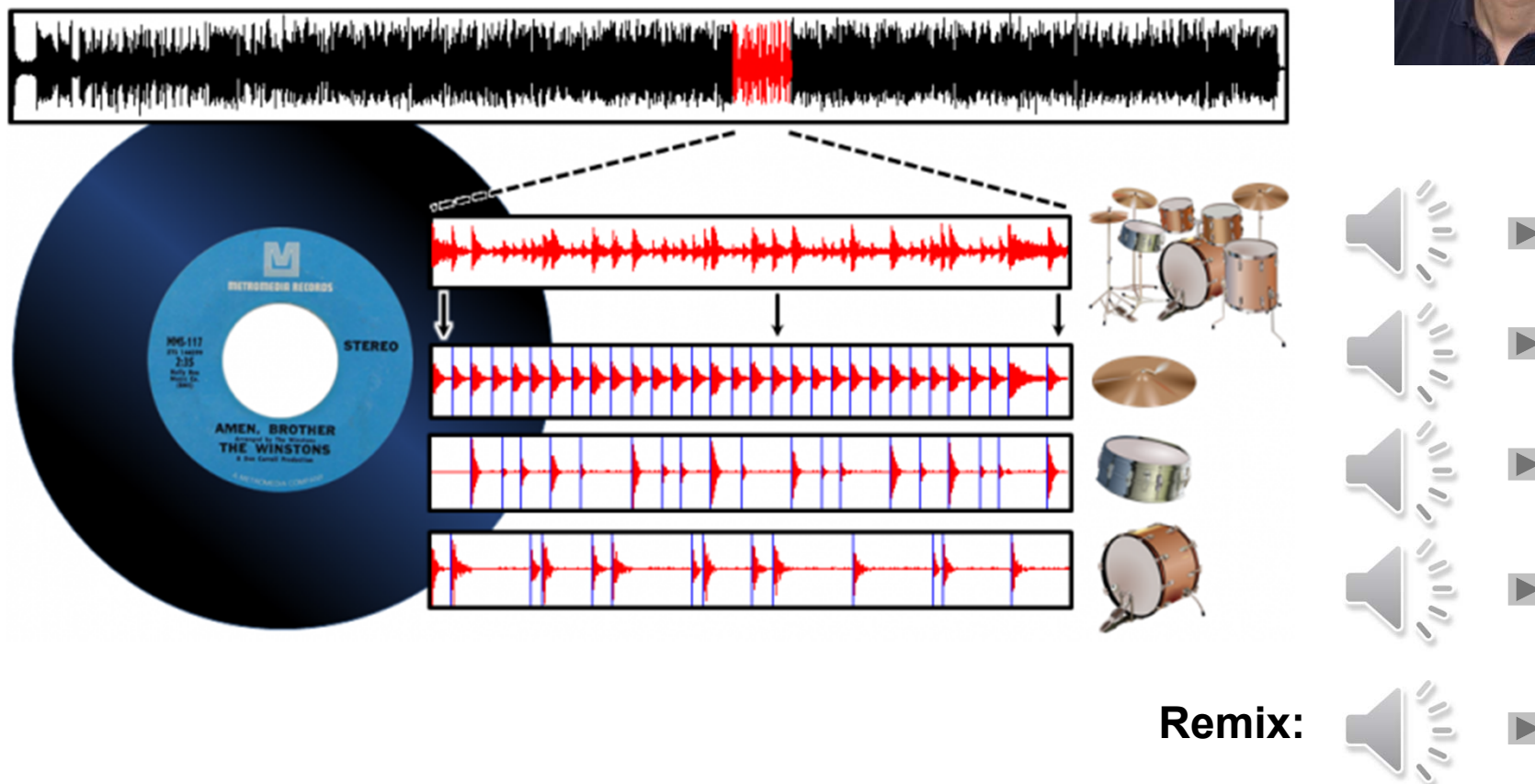
Learnt templates

Initialized activations

Learnt activations

Constrained initialization → NMF as refinement

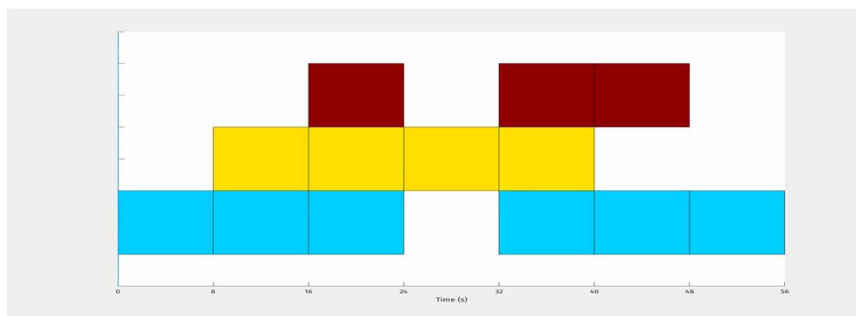# Score-Informed Audio Decomposition

Application: Audio editing
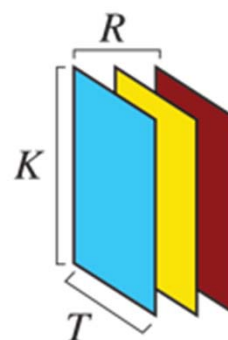
Informed Drum-Sound Decomposition

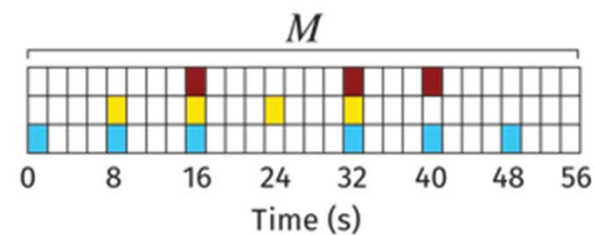Literature: [Dittmar/Müller, IEEE/ACM-TASLP 2016]

Demo: https://www.audiolabs-erlangen.de/resources/MIR/2016-IEEE-TASLP-DrumSeparation

Loop Decomposition of EDM

Decomposition   Patterns   Activations

Literature: [López-Serrano/Dittmar/Müller, ISMIR 2016]

Demo: https://www.audiolabs-erlangen.de/resources/MIR/2016-ISMIR-EMLoop

Audio Mosaicing

Target signal: Beatles–Let it be   **Source** signal: Bees

Mosaic signal: Let it Bee
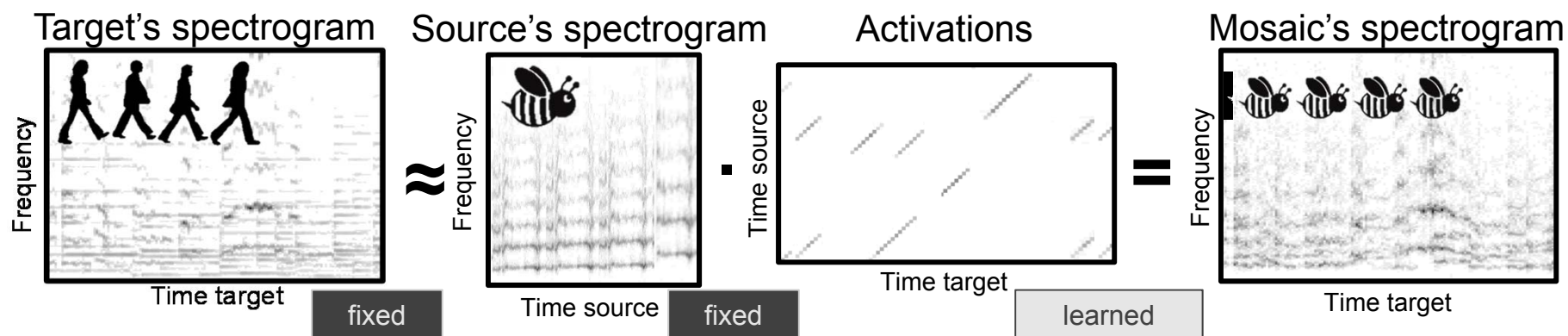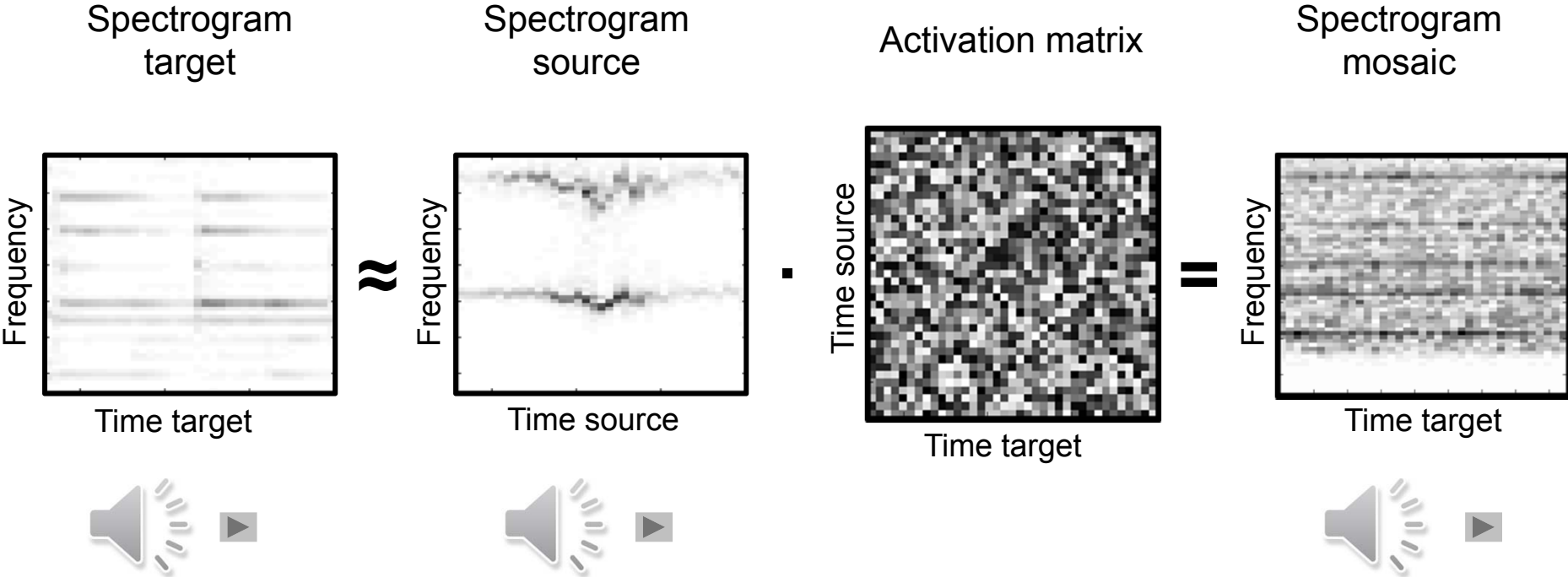
Literature: [Driedger/Müller, ISMIR 2015]

Demo: https://www.audiolabs-erlangen.de/resources/MIR/2015-ISMIR-LetItBee

NMF-Inspired Audio Mosaicing

Non-negative matrix factorization (NMF)

Non-negative matrix   Components   Activations

$$V \approx W \cdot H = WH$$

fixed   learned   learned
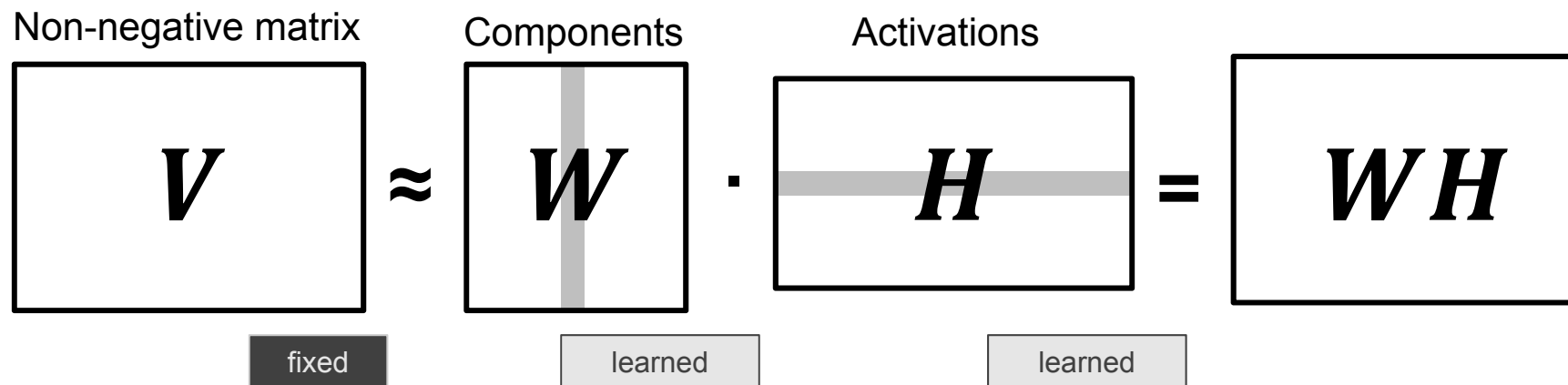
Proposed audio mosaicing approach

Target's spectrogram   Source's spectrogram   Activations   Mosaic's spectrogram

Frequency / Time target — fixed

Frequency / Time source — fixed

Time source / Time target — learned

Frequency / Time target

NMF-Inspired Audio Mosaicing

Spectrogram target $\approx$ Spectrogram source $\cdot$ Activation matrix $=$ Spectrogram mosaic

NMF-Inspired Audio Mosaicing

Core idea: support the development of sparse diagonal activation structures

NMF-Inspired Audio Mosaicing

Spectrogram target ≈ Spectrogram source · Activation matrix = Spectrogram mosaic

NMF-Inspired Audio Mosaicing

Audio Mosaicing

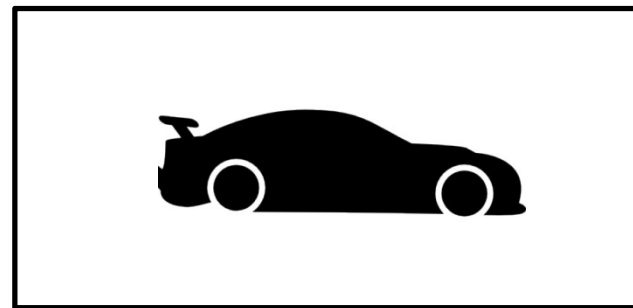**Target** signal: Chic–Good times

Source signal: Whales
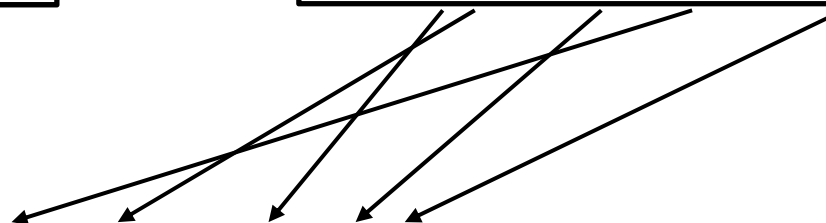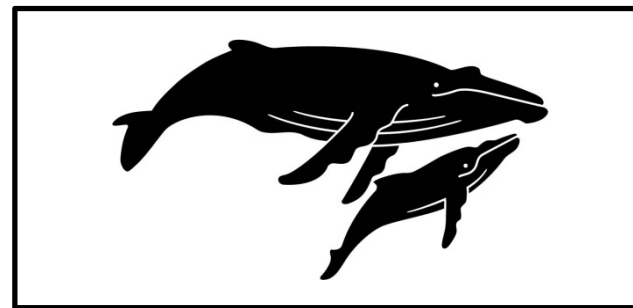
Mosaic signal

Audio Mosaicing

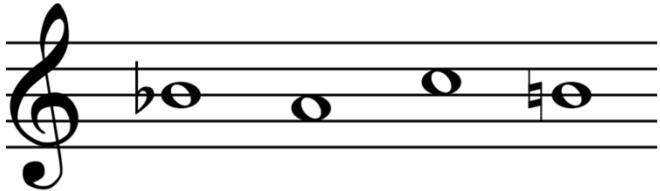**Target** signal: Adele–Rolling in the Deep   **Source** signal: Race car
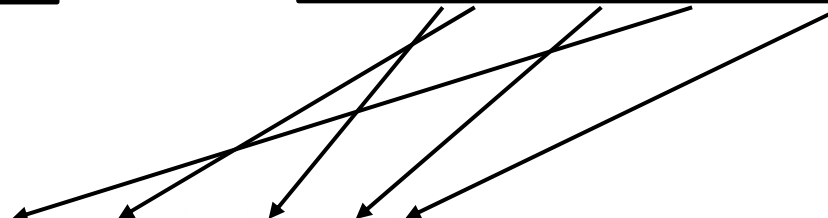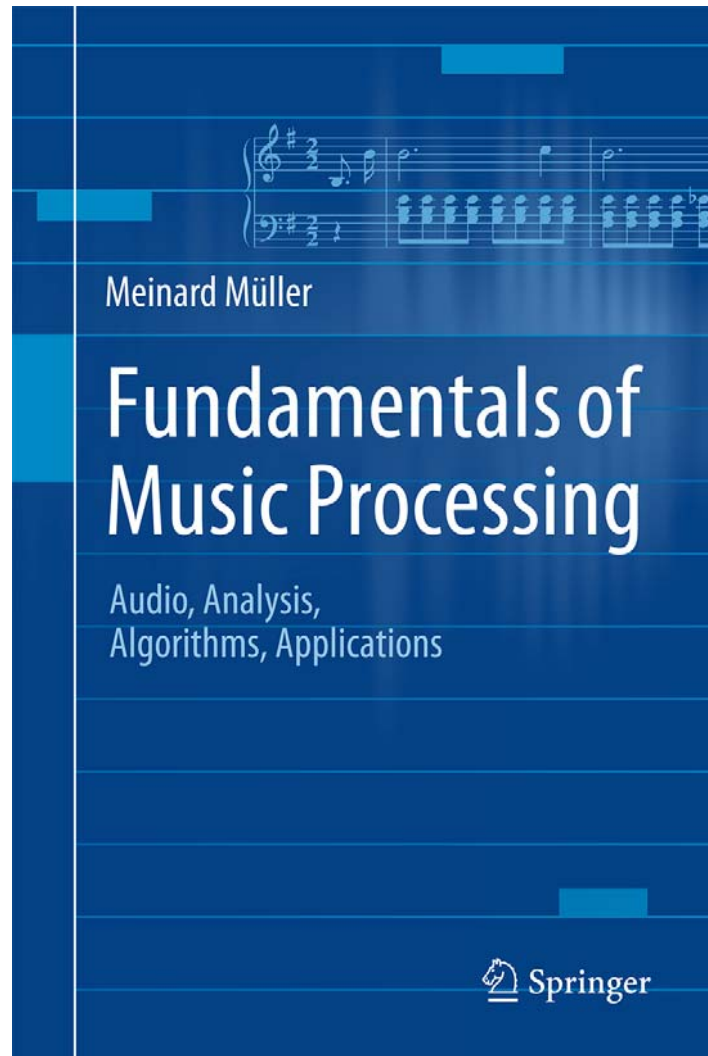

Mosaic signal

Motivic Similarity

Motivic Similarity

Summary

- Music information retrieval

- Audio decomposition techniques

- Machine learning

- Music applications & musicology

- Multimedia scenarios

- Web-based interfaces

- Teaching

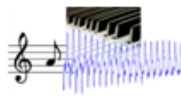- Academic training of students
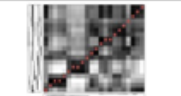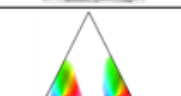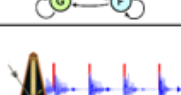
- Fundamental research

Book: Fundamentals of Music Processing

Meinard Müller
Fundamentals of Music Processing
Audio, Analysis, Algorithms, Applications
483 p., 249 illus., hardcover
ISBN: 978-3-319-21944-8
Springer, 2015

Accompanying website:
www.music-processing.de

Book: Fundamentals of Music Processing

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

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