

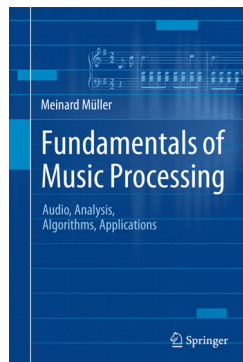
Lecture
Music Processing

Audio Decomposition

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

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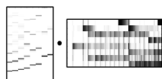
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Chapter 8: Audio Decomposition

- 8.1 Harmonic-Percussive Separation
- 8.2 Melody Extraction
- 8.3 NMF-Based Audio Decomposition
- 8.4 Further Notes



In the final Chapter 8 on audio decomposition, we present a challenging research direction that is closely related to source separation. Within this wide research area, we consider three subproblems: harmonic-percussive separation, main melody extraction, and score-informed audio decomposition. Within these scenarios, we discuss a number of key techniques including instantaneous frequency estimation, fundamental frequency (F0) estimation, spectrogram inversion, and nonnegative matrix factorization (NMF). Furthermore, we encounter a number of acoustic and musical properties of audio recordings that have been introduced and discussed in previous chapters, which rounds off the book.

Why is Music Processing Challenging?

Example: Chopin, Mazurka Op. 63 No. 3



Mazurka.
 F. CHOPIN. Op. 63, No. 3.

Allegretto.

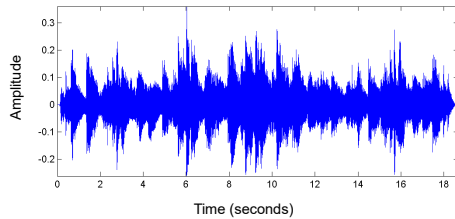
41.



Why is Music Processing Challenging?

Example: Chopin, Mazurka Op. 63 No. 3

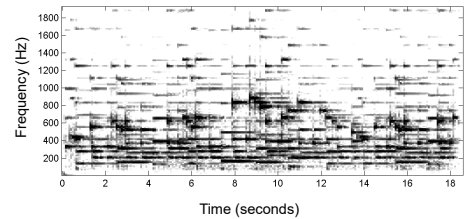
- Waveform



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

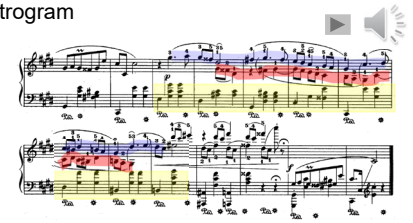
Why is Music Processing Challenging?

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”

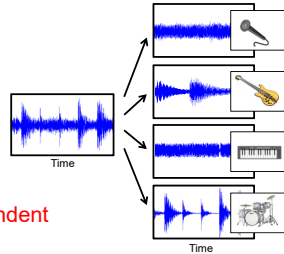


Source Separation

- 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)

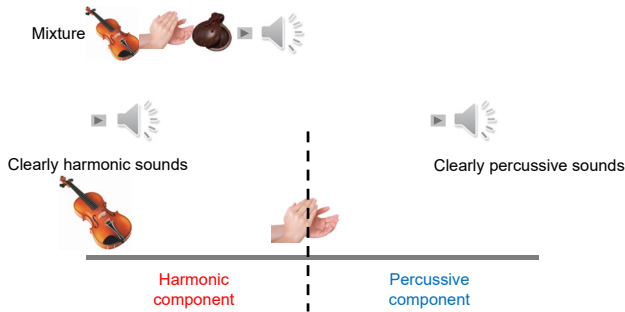
- Main melody, accompaniment, drum track
- Instrumental voices
- Individual note events
- Only mono or stereo
- Sources are often highly dependent



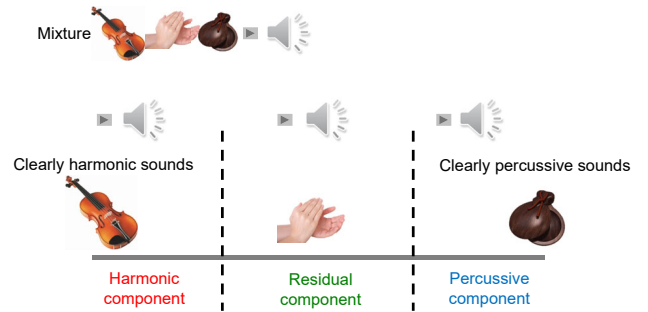
Harmonic-Percussive Decomposition



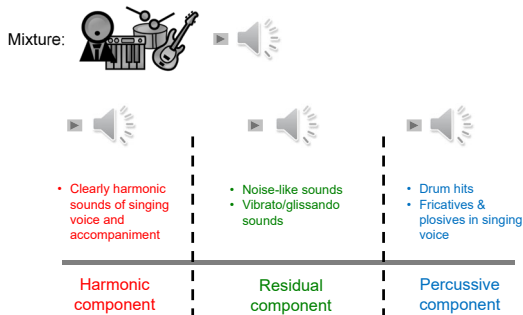
Harmonic-Percussive Decomposition



Harmonic-Percussive Decomposition

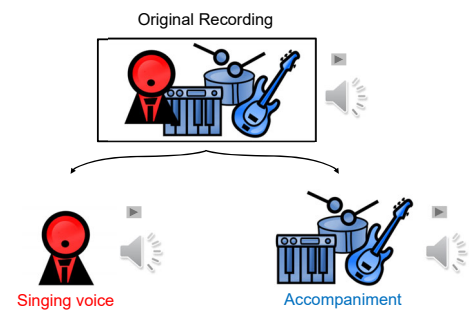


Harmonic-Percussive Decomposition

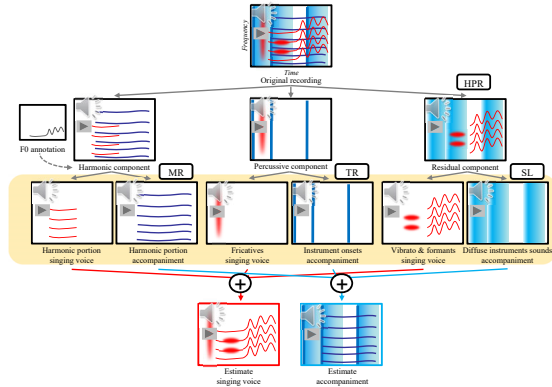


Literature: [Driedger/Müller/Disch, ISMIR 2014]
 Demo: <https://www.audiolabs-erlangen.de/resources/2014-ISMIR-ExtHPSep/>

Singing Voice Extraction

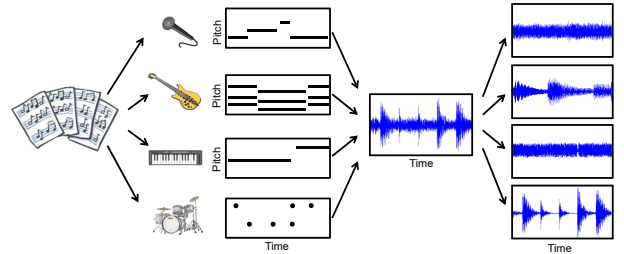


Singing Voice Extraction



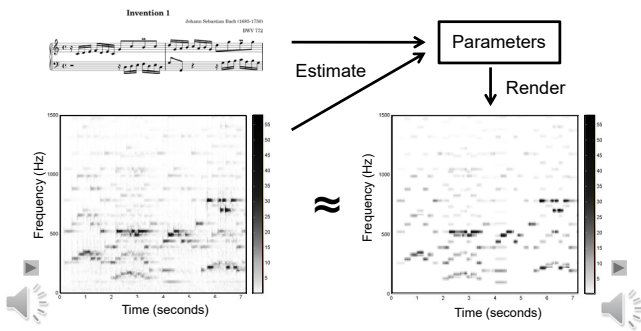
Score-Informed Source Separation

Exploit musical score to support separation process

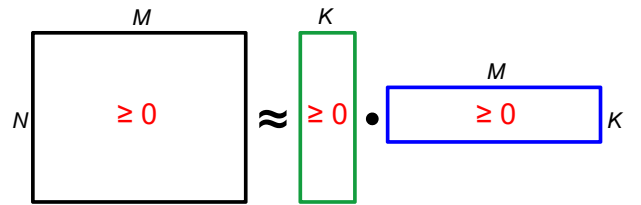


Parametric Model Approach

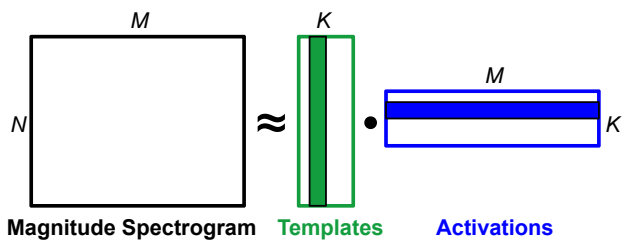
Rebuild spectrogram information



NMF (Nonnegative Matrix Factorization)



NMF (Nonnegative Matrix Factorization)



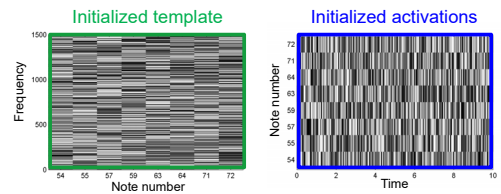
Templates: Pitch + Timbre

"How does it sound"

Activations: Onset time + Duration

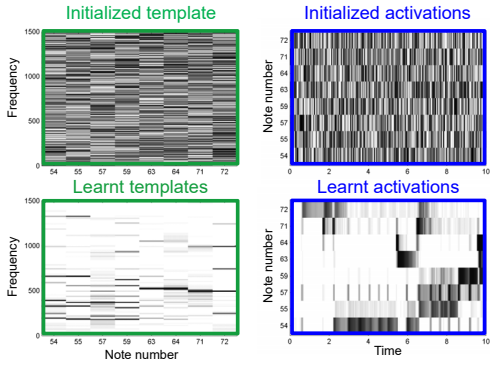
"When does it sound"

NMF-Decomposition



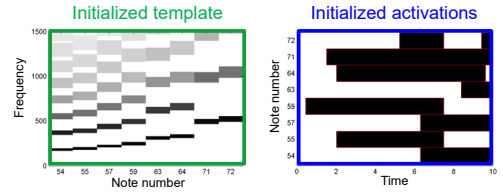
Random initialization

NMF-Decomposition



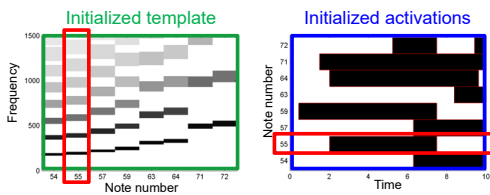
Random initialization → No semantic meaning

NMF-Decomposition



Constrained initialization

NMF-Decomposition

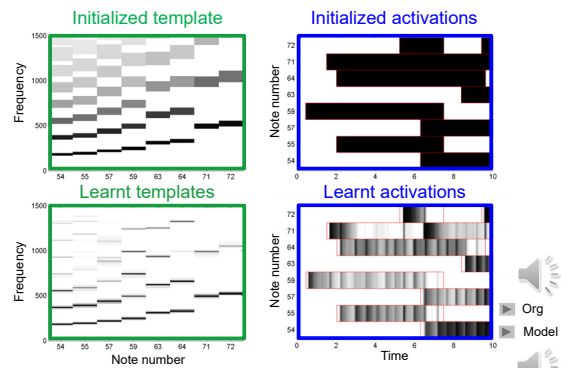


Template constraint for $p=55$

Activation constraints for $p=55$

Constrained initialization

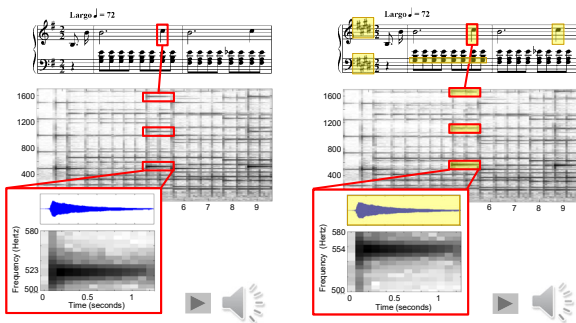
NMF-Decomposition



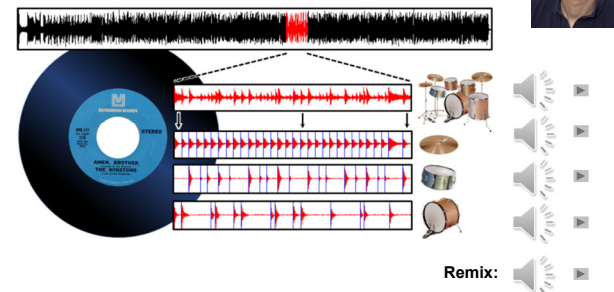
Constrained initialization → NMF as refinement

Score-Informed Audio Decomposition

Application: Audio editing



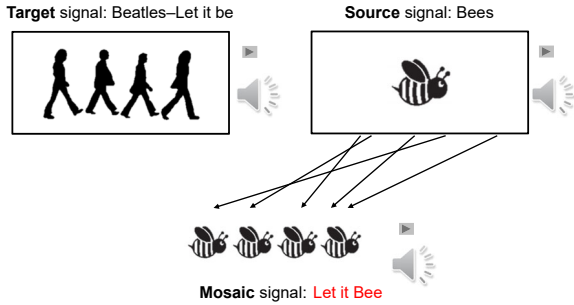
Informed Drum-Sound Decomposition



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

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

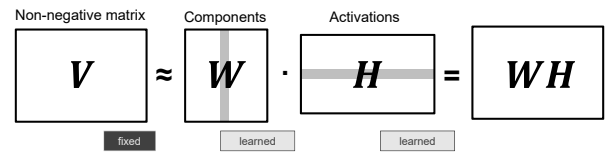
Audio Mosaicing



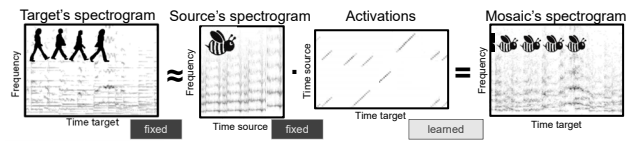
Literature: [Driedger/Müller, ISMIR 2015]
 Demo: <https://www.audiolabs-erlangen.de/resources/MIR/2015-ISMIR-LettBee>

NMF-Inspired Audio Mosaicing

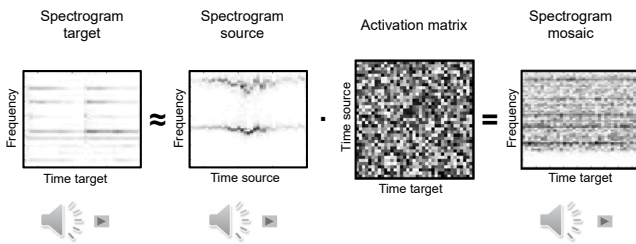
Non-negative matrix factorization (NMF)



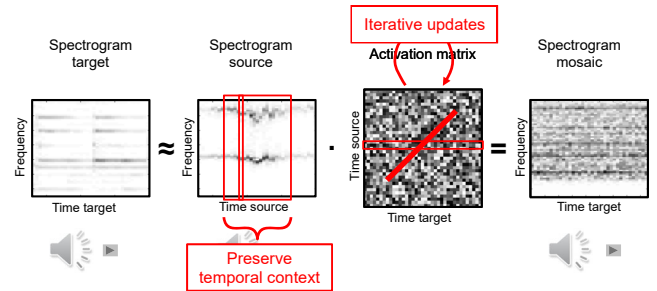
Proposed audio mosaicing approach



NMF-Inspired Audio Mosaicing

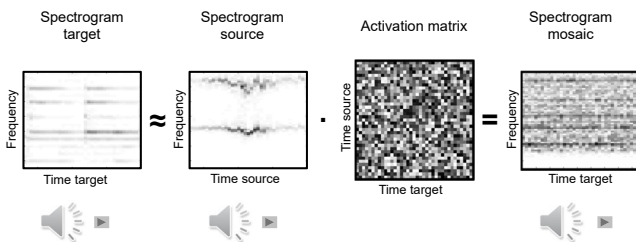


NMF-Inspired Audio Mosaicing

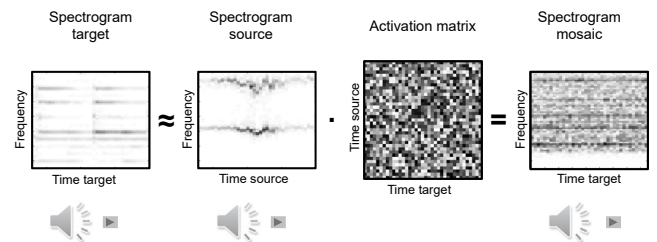


Core idea: support the development of sparse diagonal activation structures

NMF-Inspired Audio Mosaicing



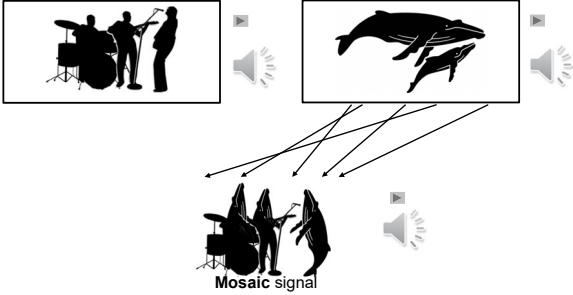
NMF-Inspired Audio Mosaicing



Audio Mosaicing

Target signal: Chic–Good times

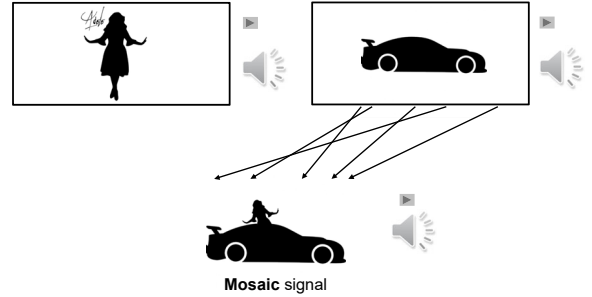
Source signal: Whales



Audio Mosaicing

Target signal: Adele–Rolling in the Deep

Source signal: Race car



Links

- SiSEC: Signal Separation Evaluation Campaign
<https://www.sisec17.audiolabs-erlangen.de/>
- MedleyDB: A Dataset of Multitrack Audio
<http://steinhardt.nyu.edu/marl/research/medleydb>
- LibROSA (Python)
<https://librosa.github.io/librosa/>