

Development of a Fully Automated Dj-mixing Algorithm for Electronic Dance Music

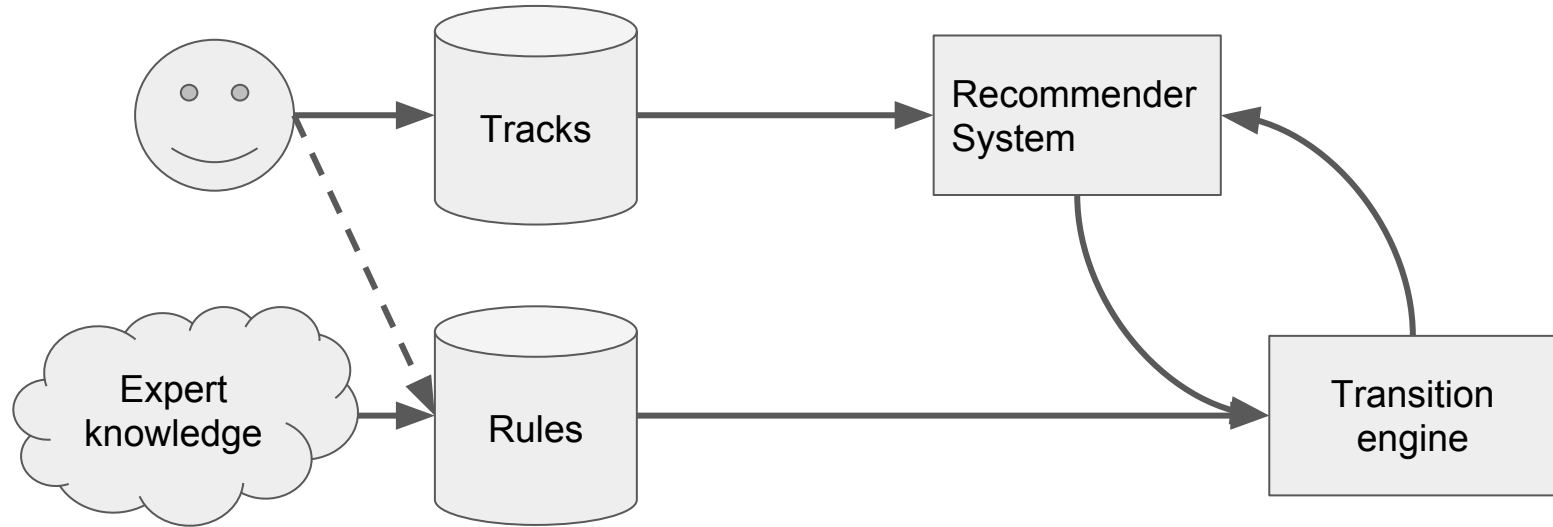
Mickaël Zehren, Marco Alunno, Paolo Bientinesi

December 12, 2018
Umeå Universitet

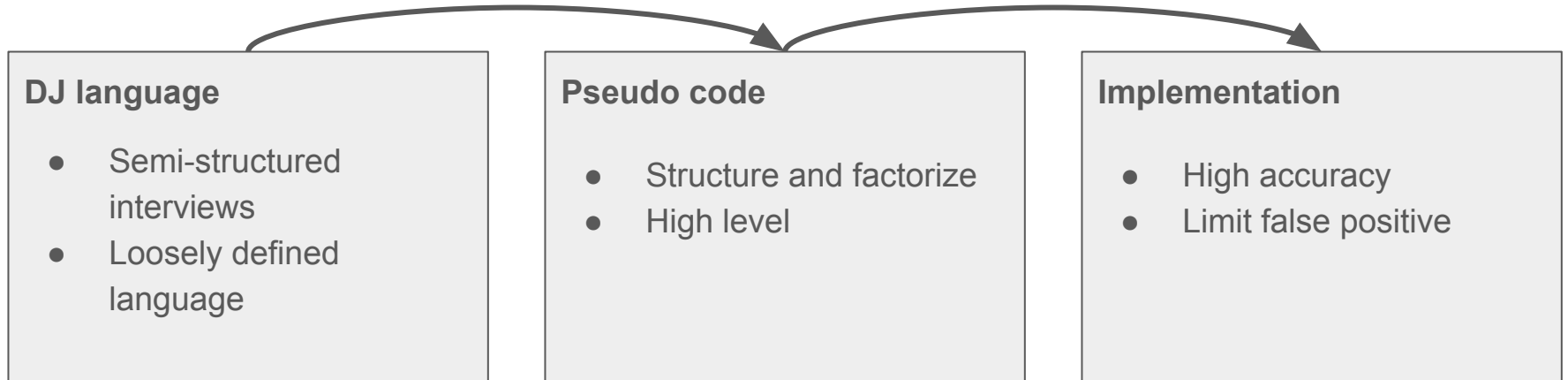


- **Input:** A collection of music tracks
 - Electronic dance music
 - Steady, repetitive, predictable, 4/4
- **Output:** A continuous stream of music – “Dj mix”
 - No interruptions
 - Pleasant, seamless transitions between tracks
 - Real-time processing
- **Why?**
 - Targets: Parties, clubs, shopping malls, radios, in-flight entertainment, fashion shows, . . .
 - Service sought by Spotify, iTunes, . . .
- **How?**
 - Signal Processing, Music Information Retrieval (MIR)
 - Rule-based approach
 - Recommender system + “Transition engine”
- **Challenges**
 - No ground-truth. “Matter of taste” vs. musical guiding principles
 - Parametric: different targets, different needs, different experiences
 - Computationally expensive

Our workflow

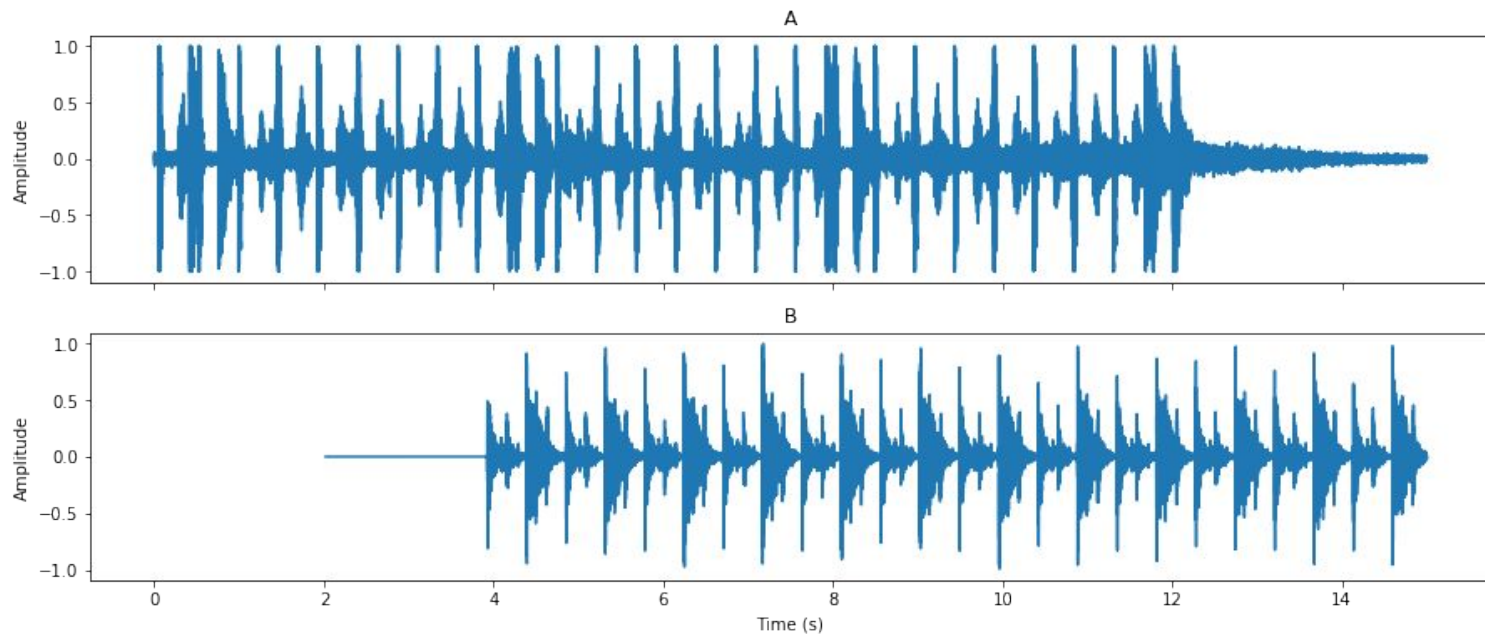


A rule based approach



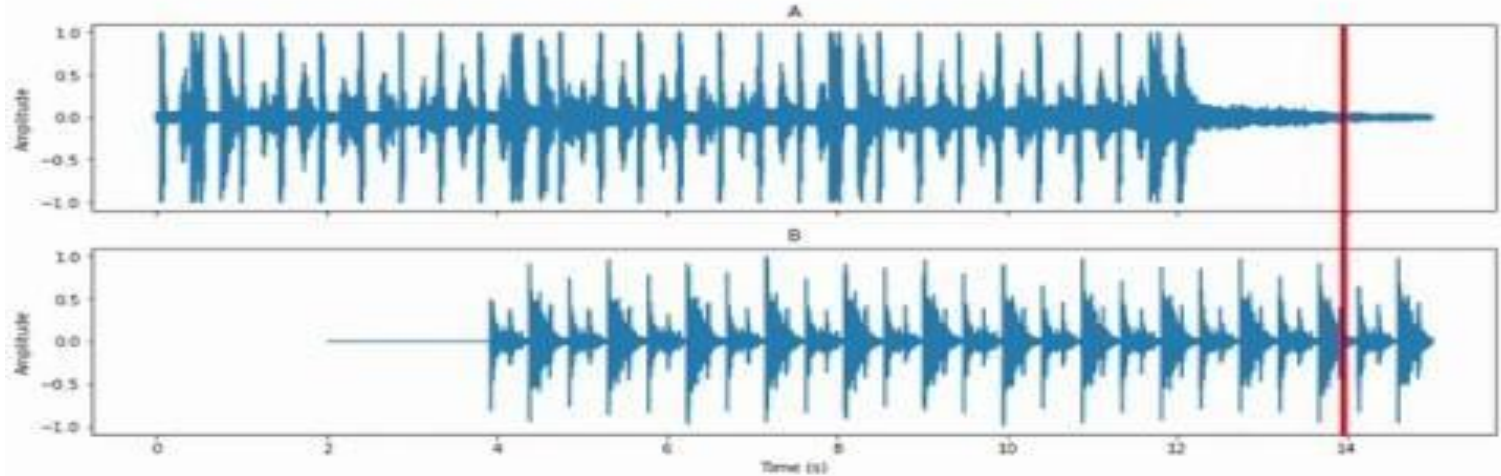
Example: naive overlap

Rules = {}

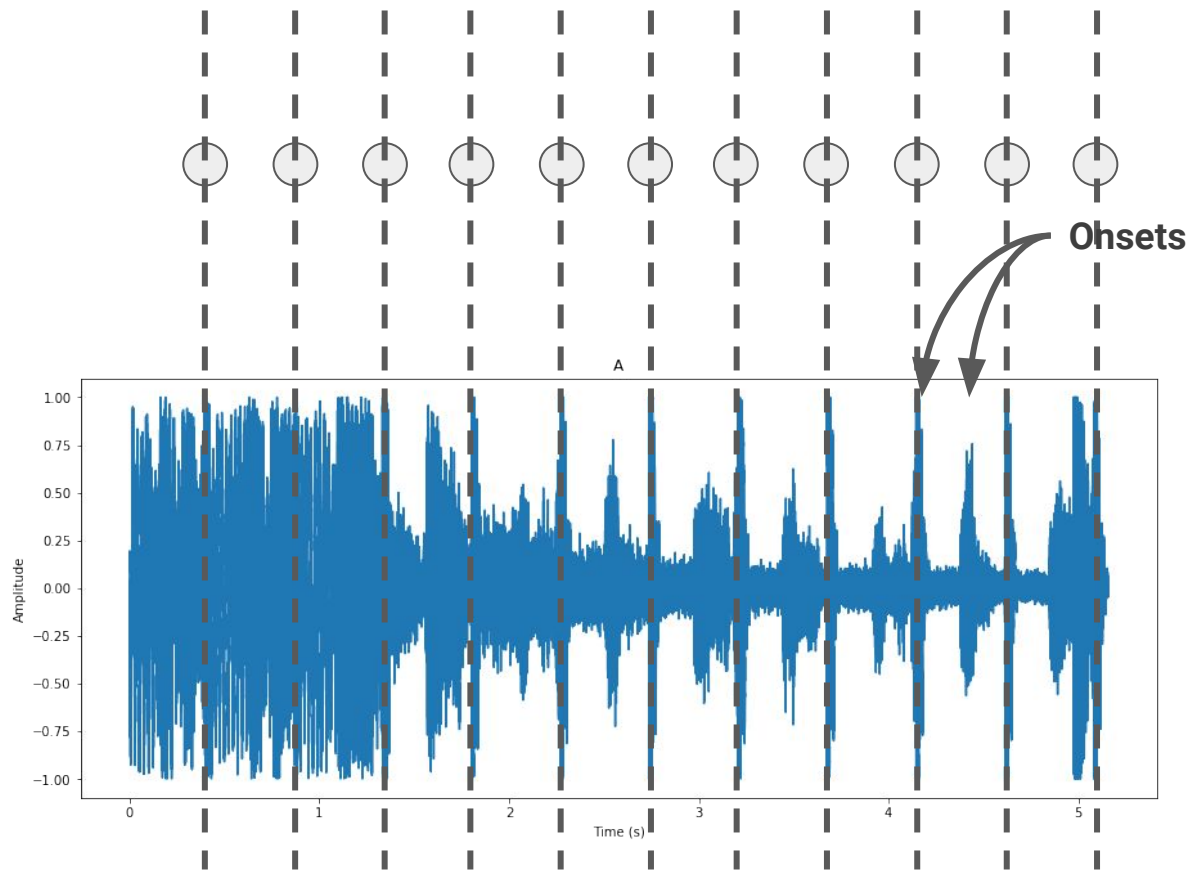
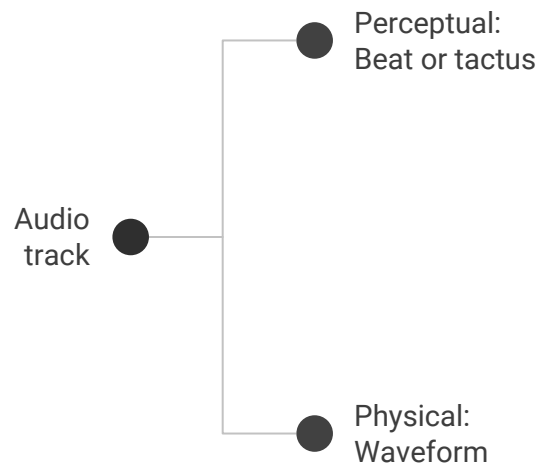


Example: click on the box to access the video

Rules = {}



Track's beat



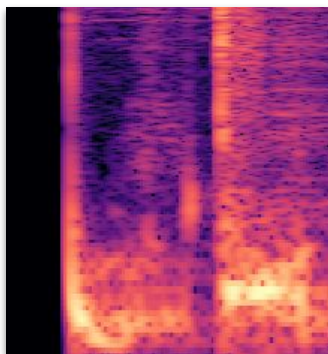
Beat detection

Böck et al., "madmom: A New Python Audio and Music Signal Processing Library", 2016.

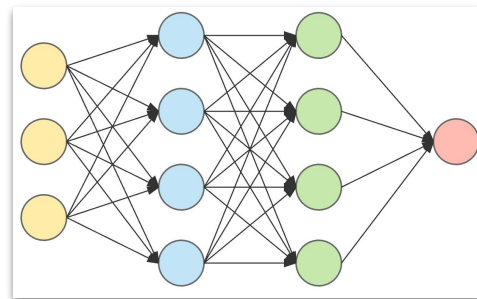
Böck et al., "Joint Beat and Downbeat Tracking with Recurrent Neural Networks", 2016.



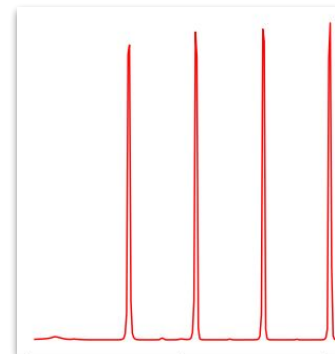
Signal



Short-time Fourier transform

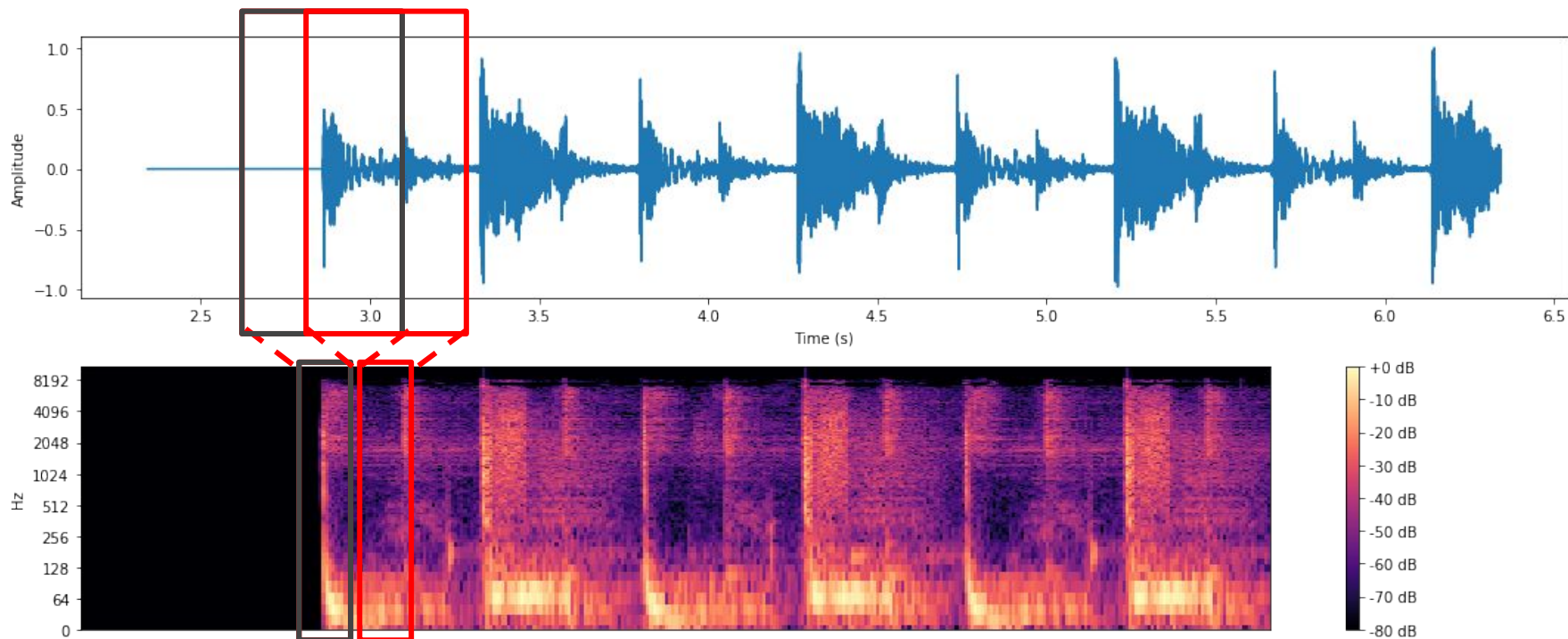


Recurrent neural network (LSTM)



Activation function

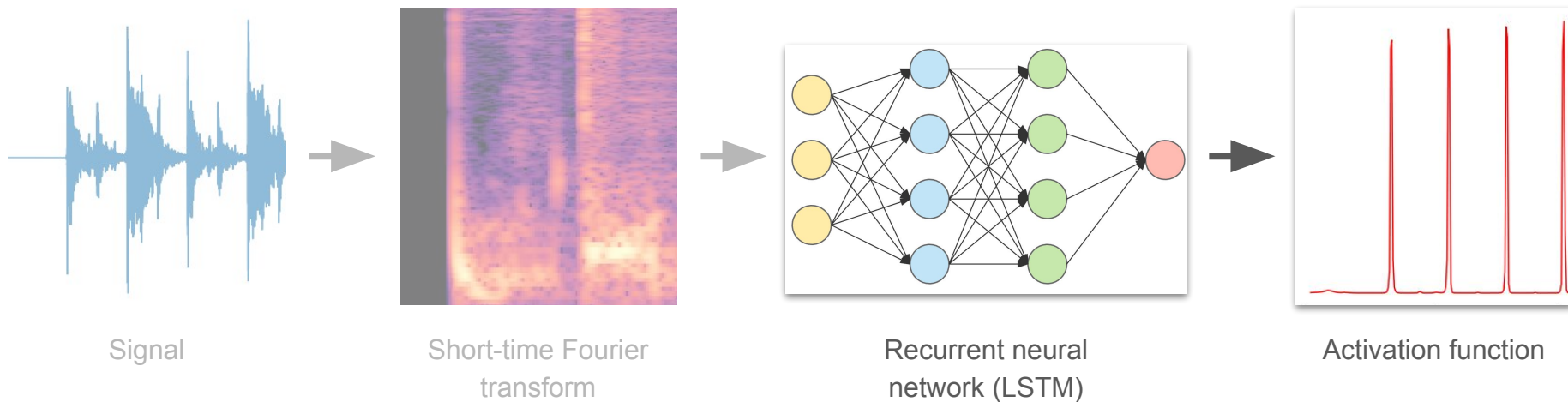
Beat detection: Short-time Fourier transform



Beat detection

Böck et al., "madmom: A New Python Audio and Music Signal Processing Library", 2016.

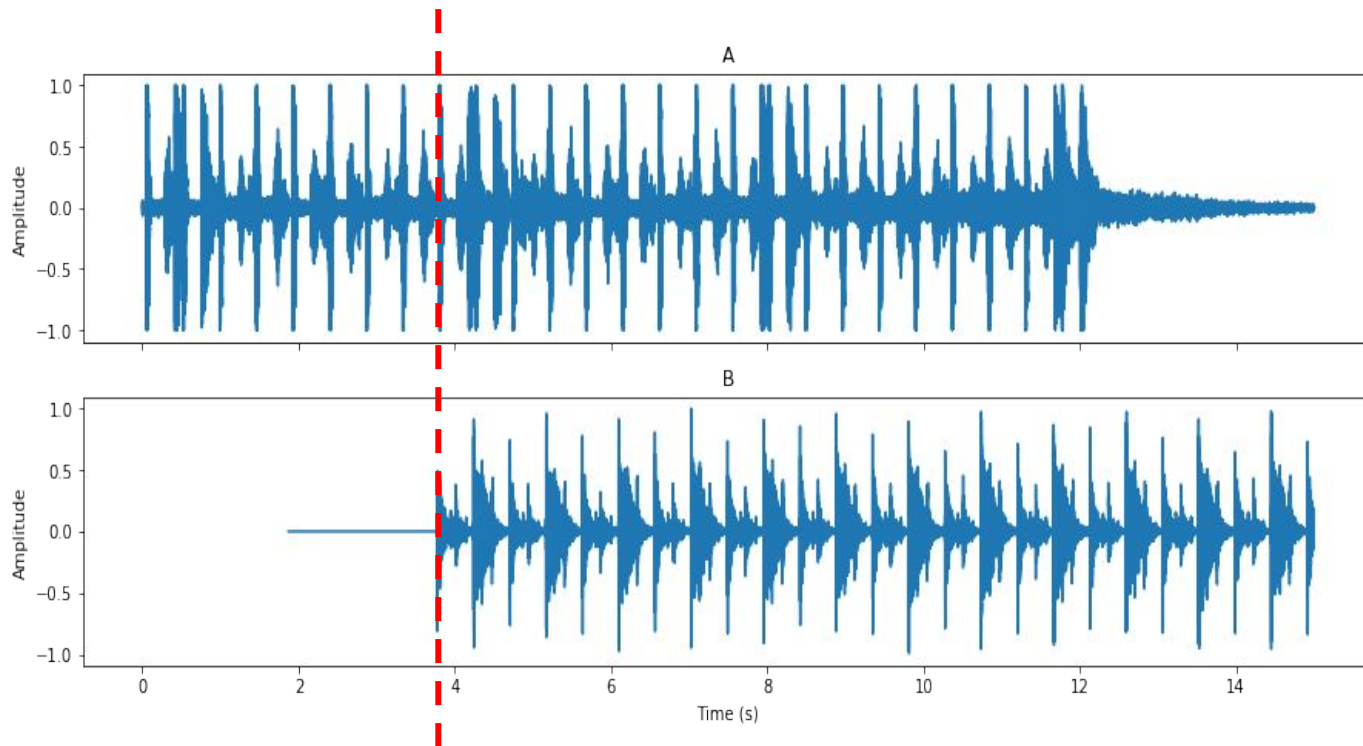
Böck et al., "Joint Beat and Downbeat Tracking with Recurrent Neural Networks", 2016.



Example

Rules

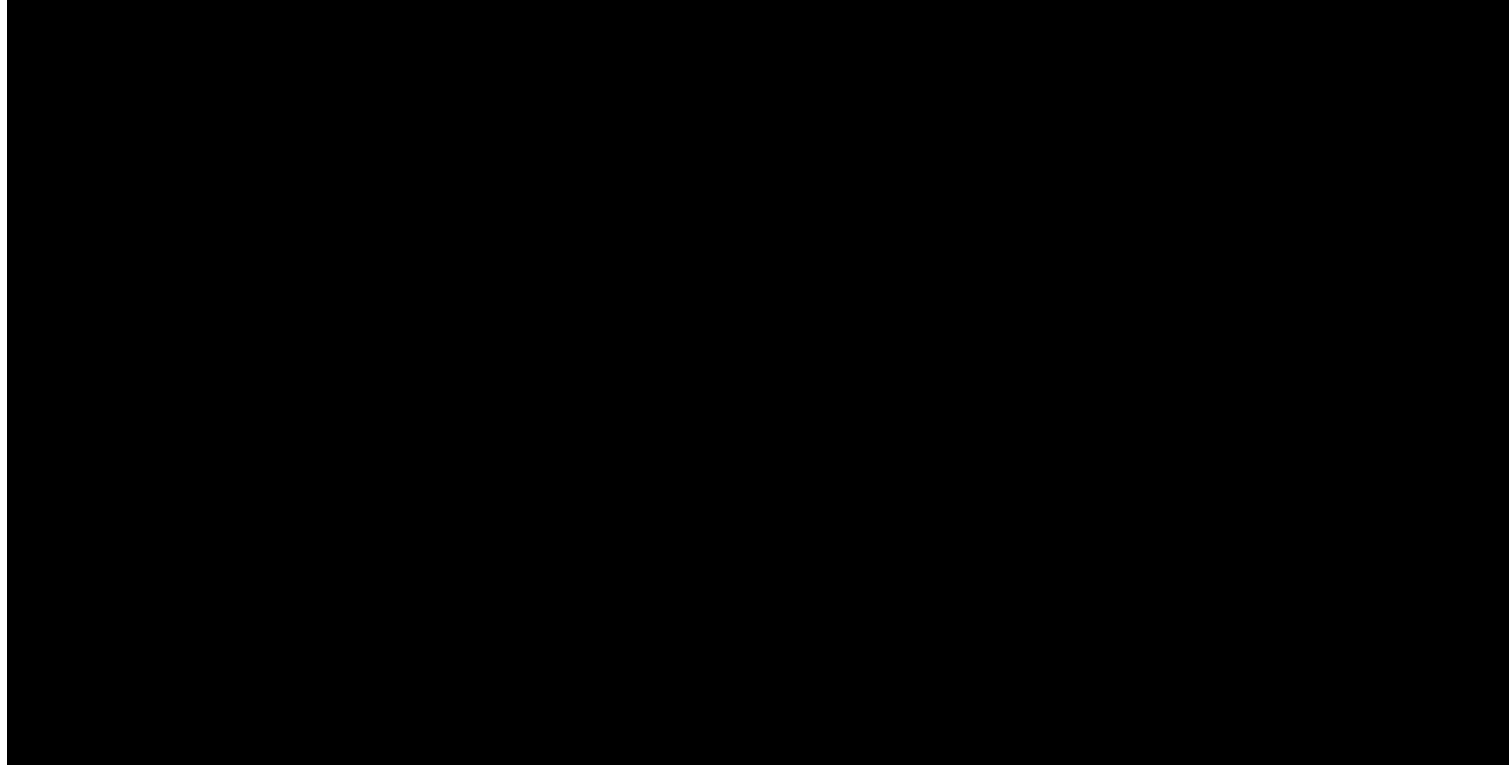
- First beat aligned



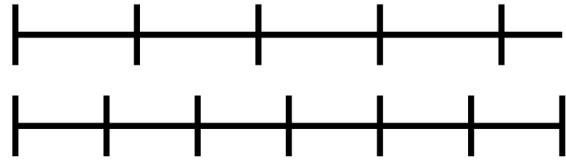
Example: click on the box to access the video

Rules

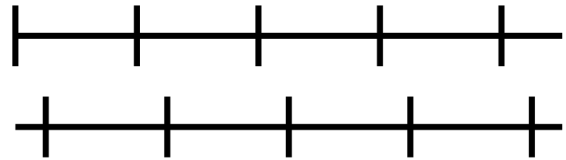
- First beat aligned



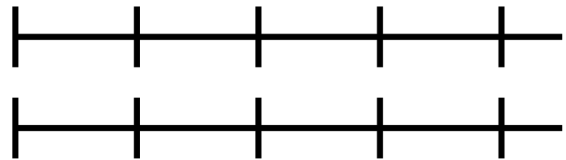
Beat alignment



Tempo mismatch

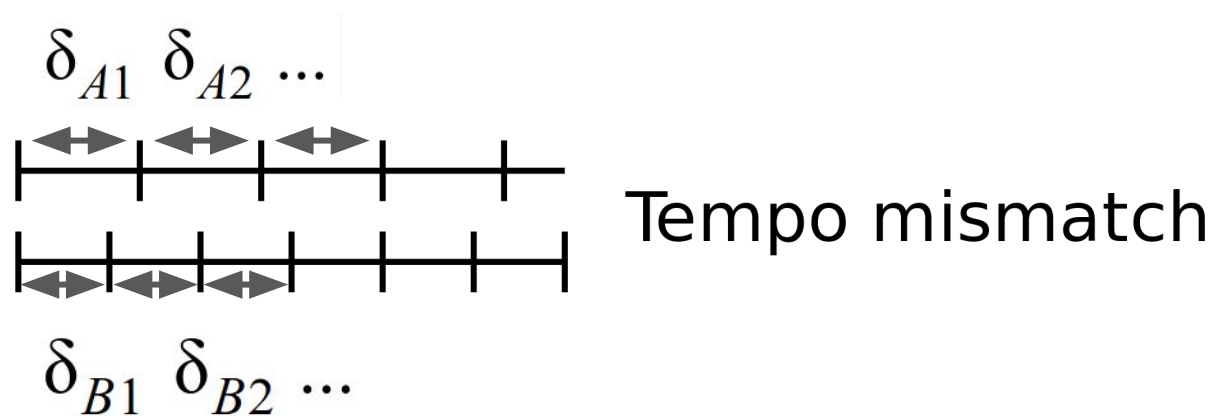


Phase mismatch



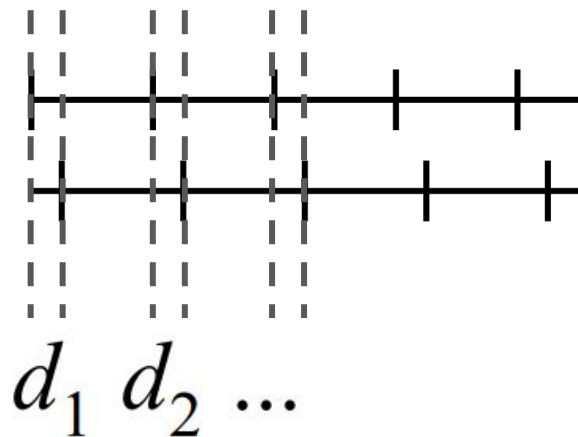
Beat-matched

Beat alignment



$$PlaybackRate_B = \frac{\overline{\Delta_B}}{\overline{\Delta_A}}$$

Beat alignment



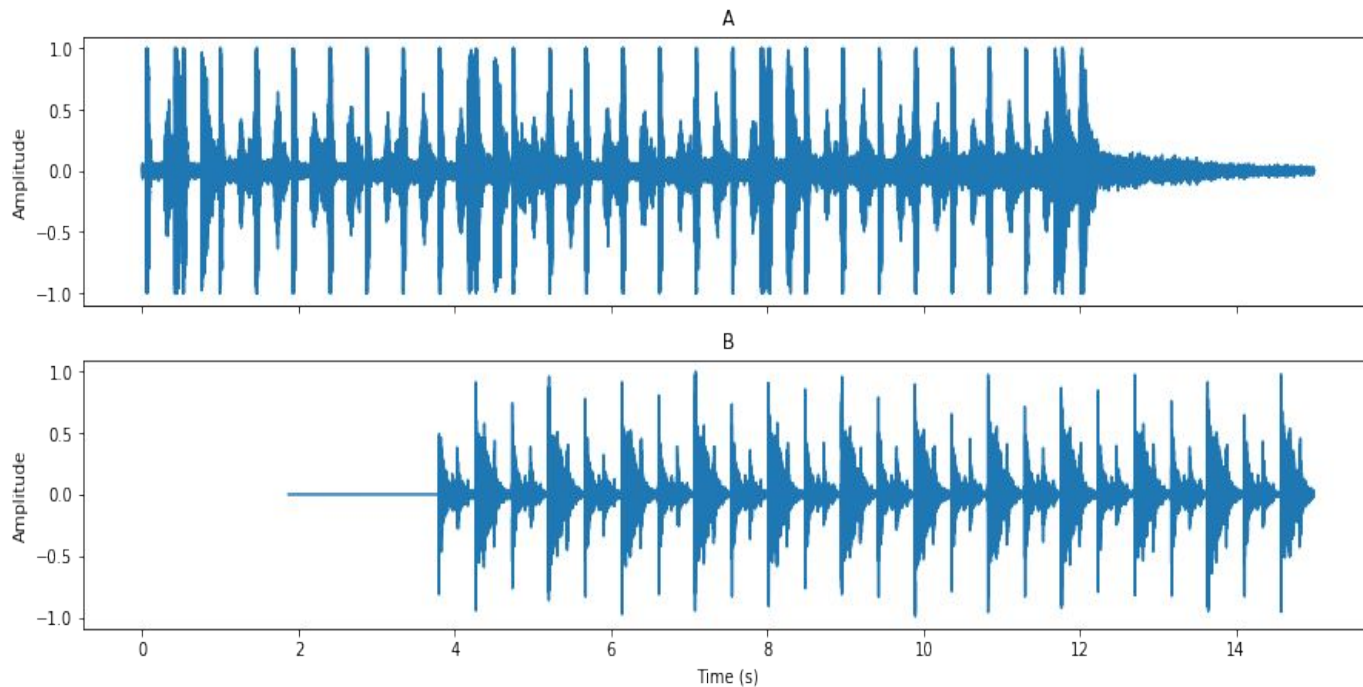
Phase mismatch

$$Phase_B = -\overline{D}$$

Example

Rules

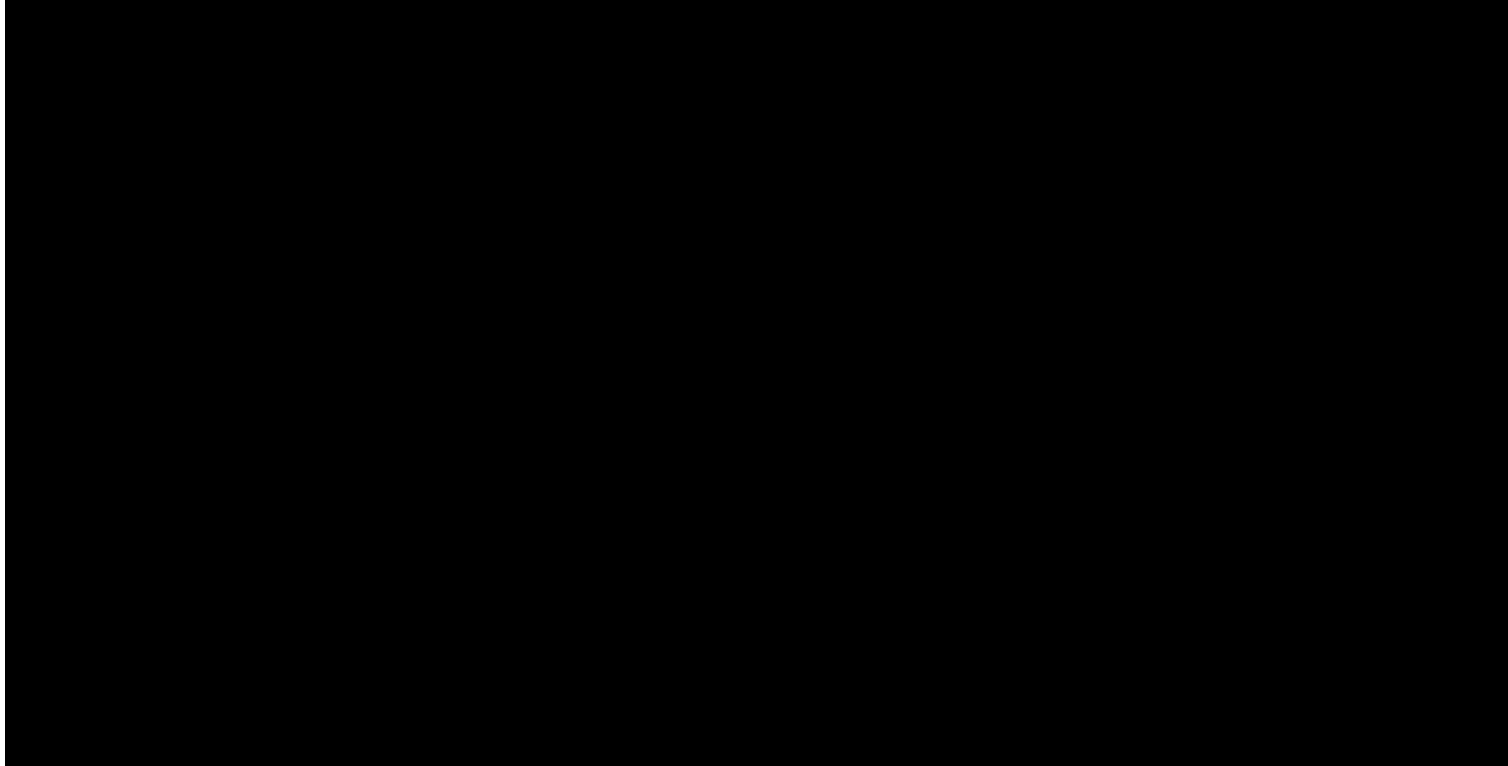
- Tempo matched
- Beat aligned



Example: click on the box to access the video

Rules

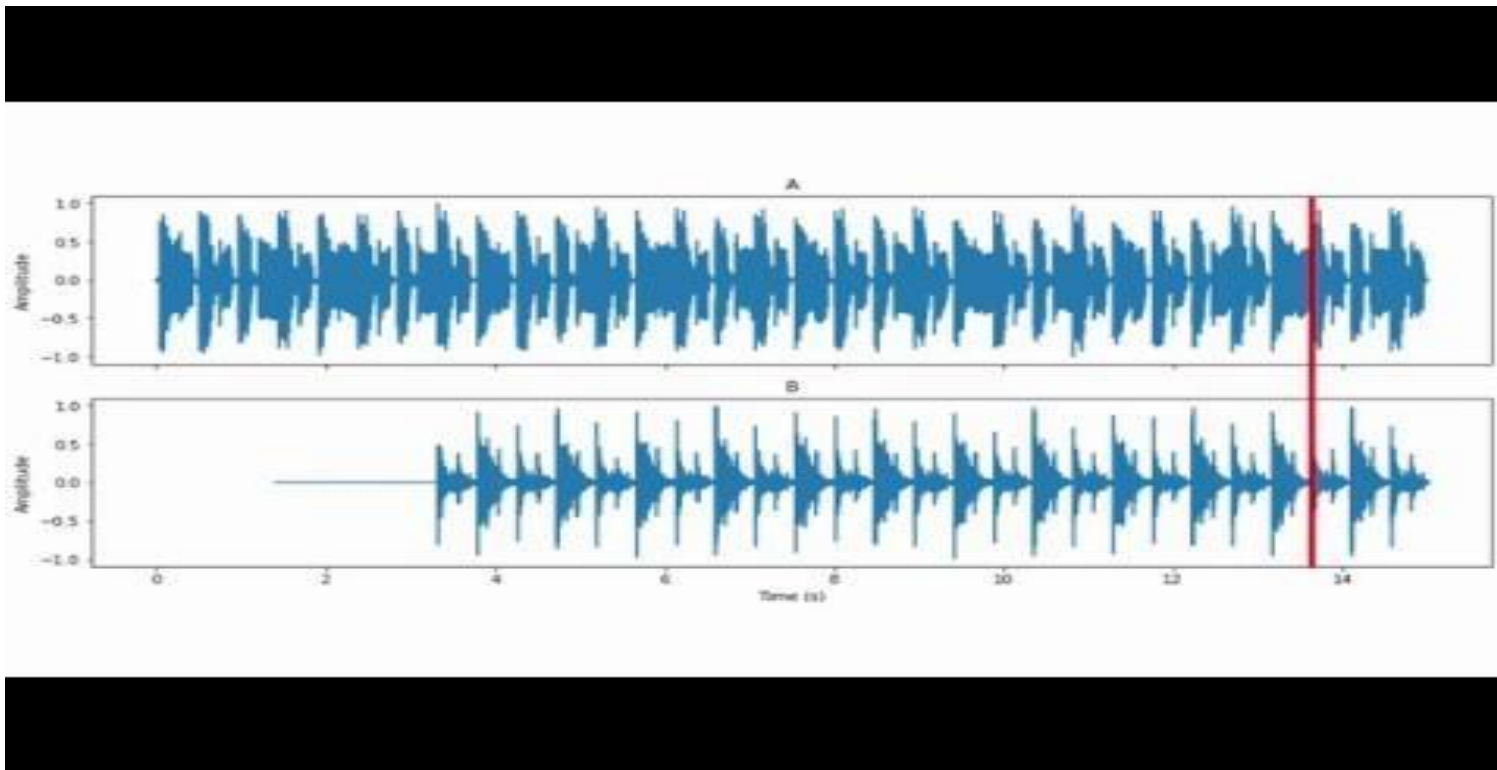
- Tempo matched
- Beat aligned



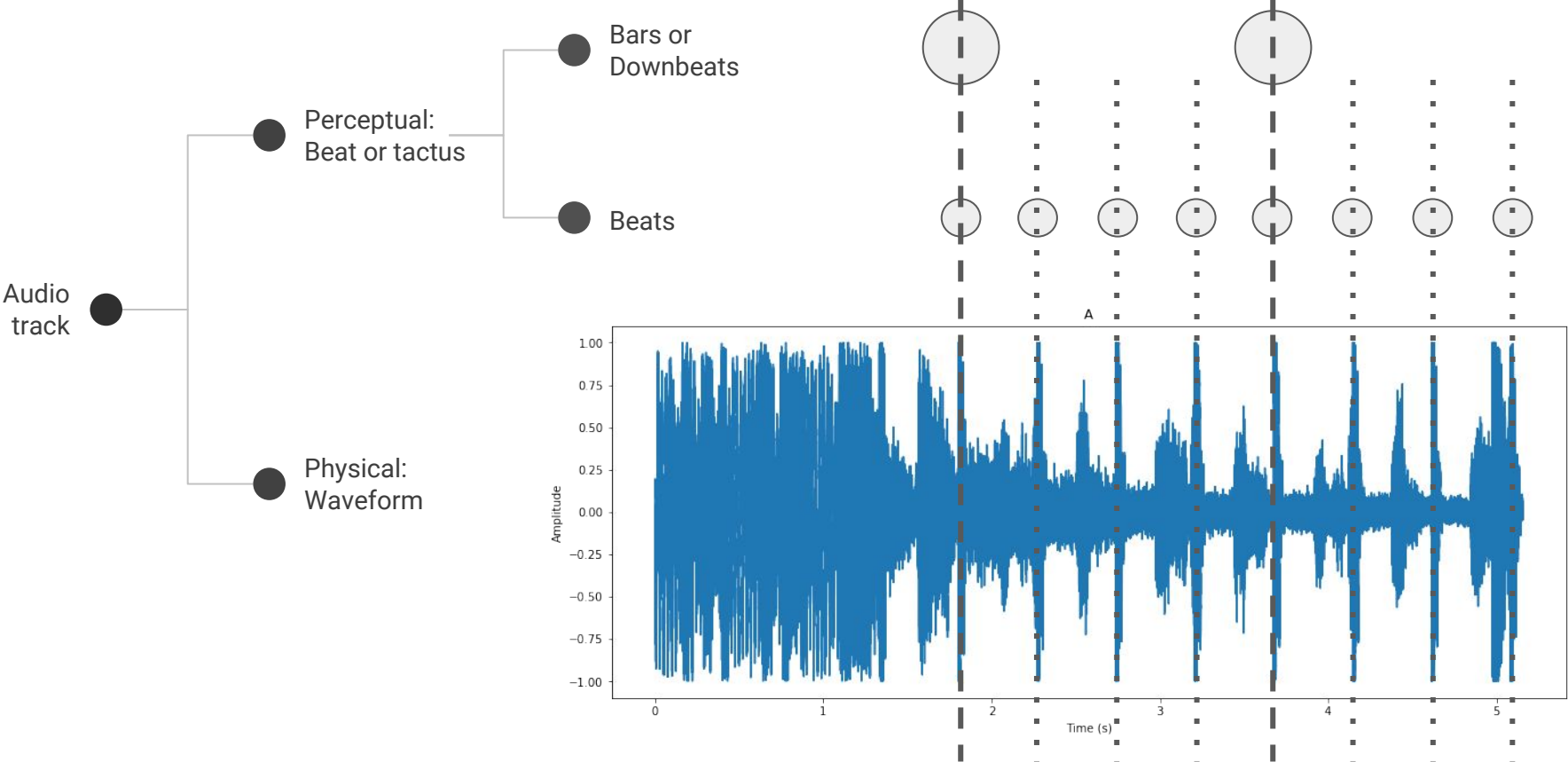
Example: click on the box to access the video

Rules

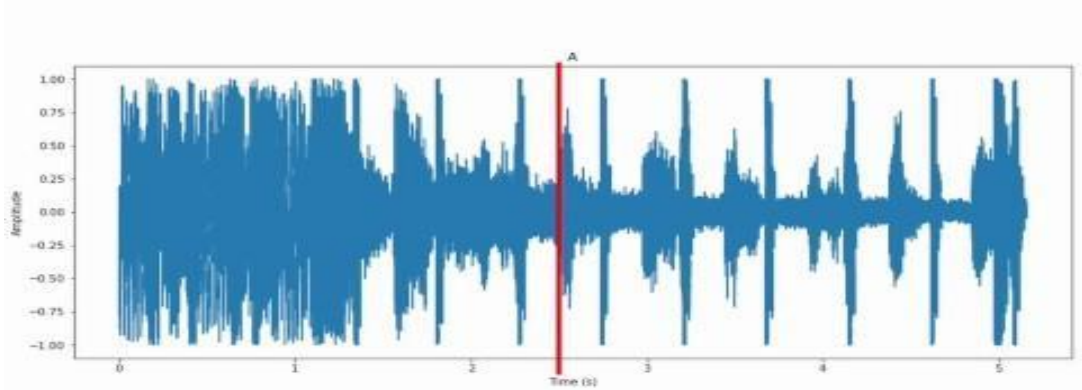
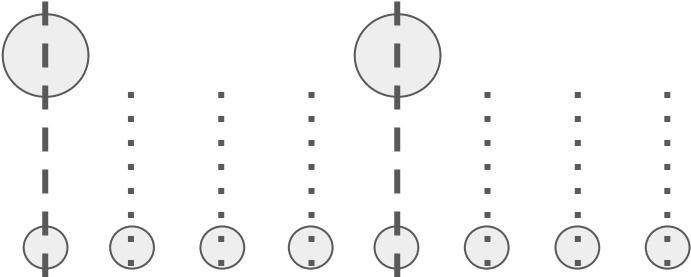
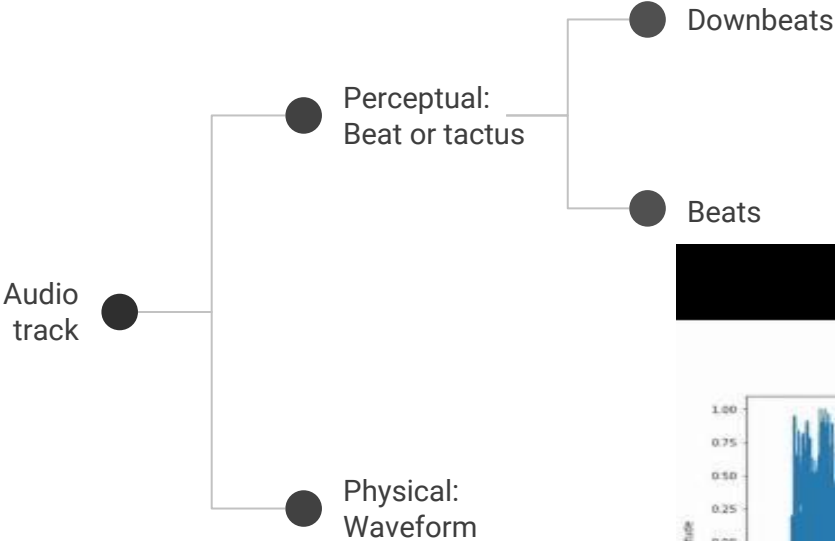
- Tempo matched
- Beat aligned



Downbeat



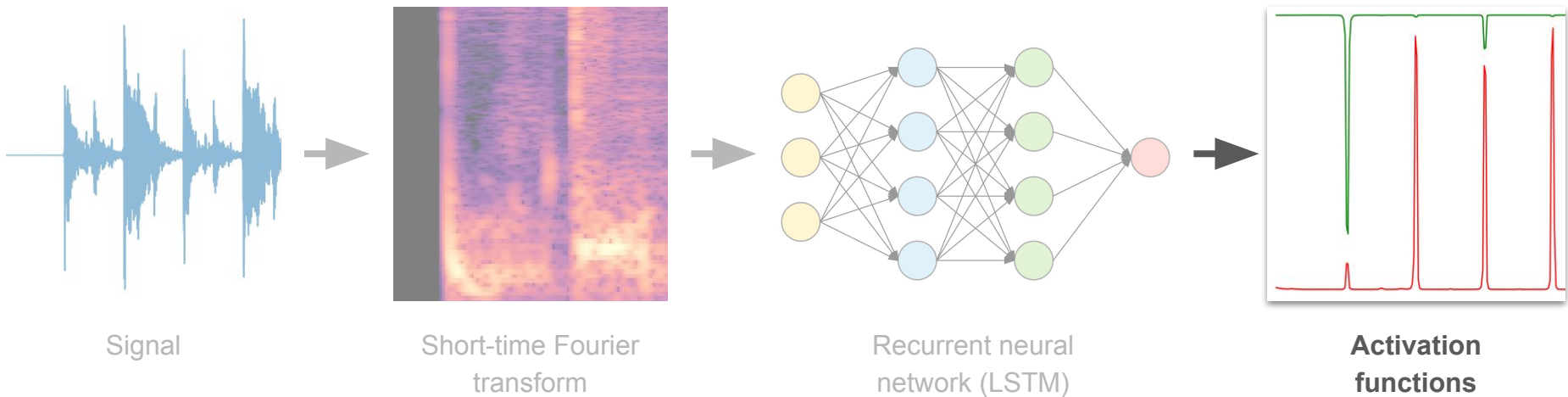
Downbeat



Downbeat detection

Böck et al., "madmom: A New Python Audio and Music Signal Processing Library", 2016.

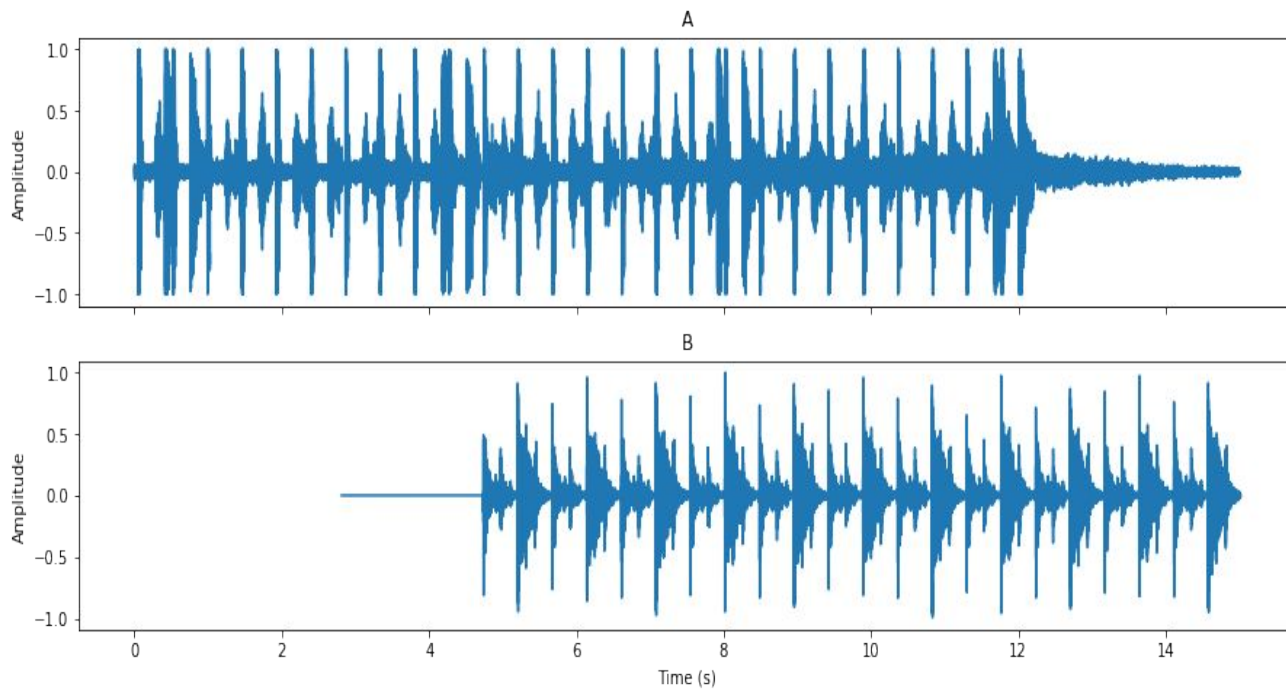
Böck et al., "Joint Beat and Downbeat Tracking with Recurrent Neural Networks", 2016.



Example

Rules

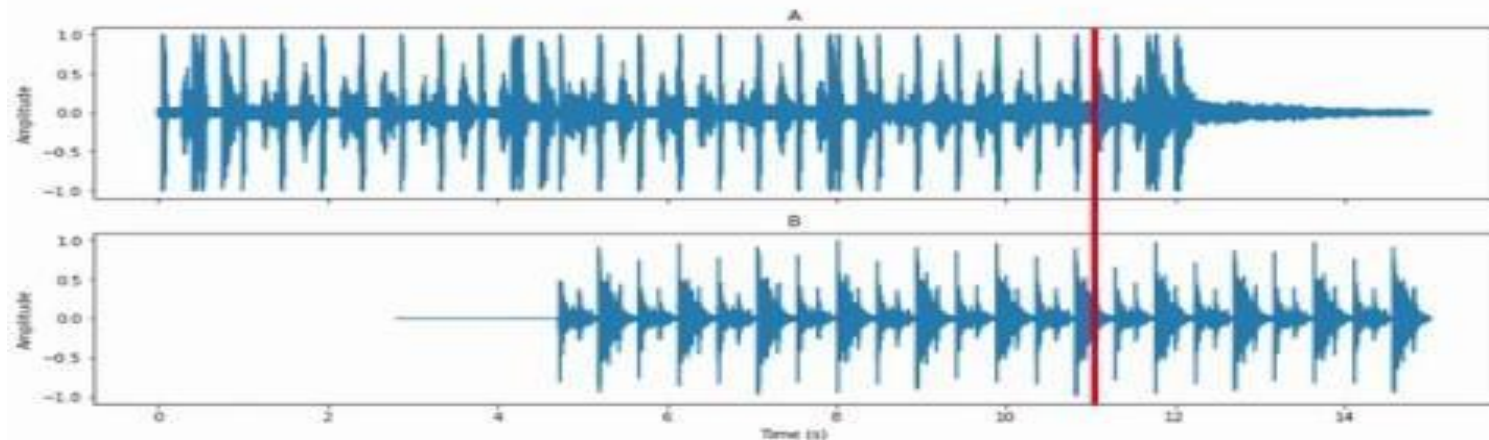
- Tempo matched
- Downbeat aligned



Example: click on the box to access the video

Rules

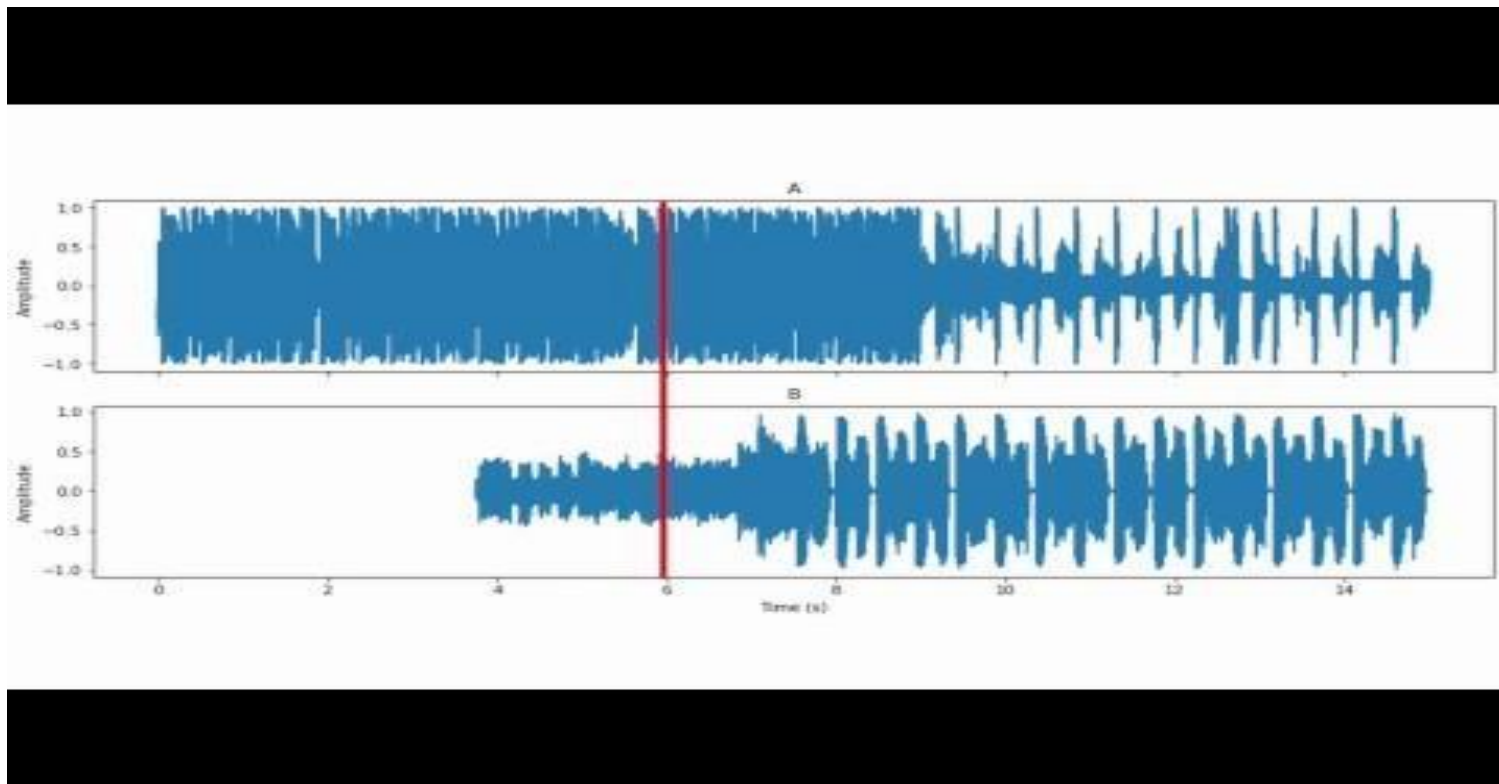
- Tempo matched
- Downbeat aligned



Example: click on the box to access the video

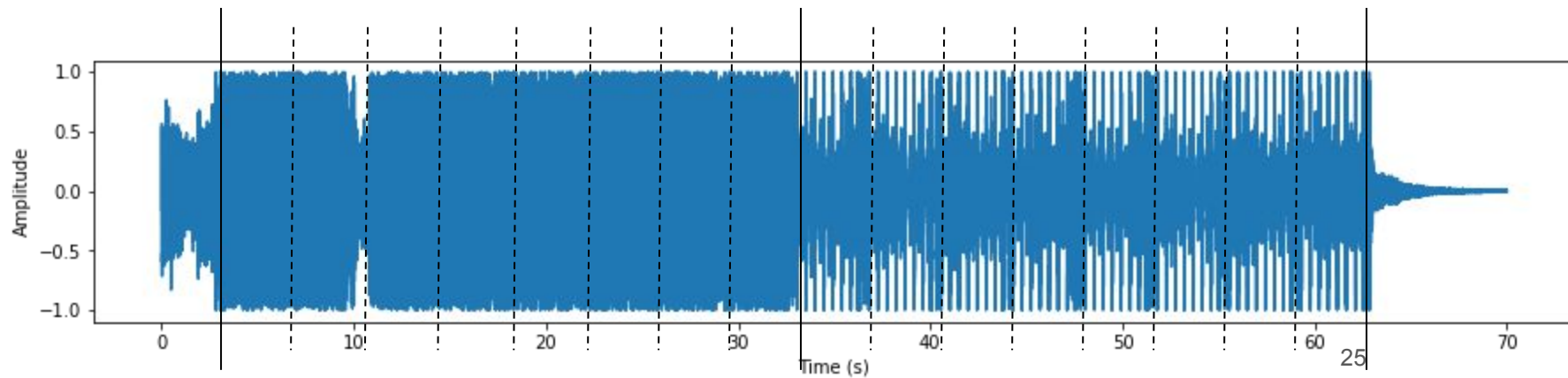
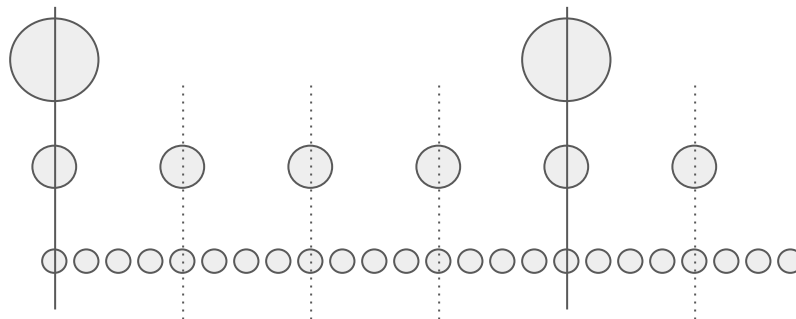
Rules

- Tempo matched
- Downbeat aligned

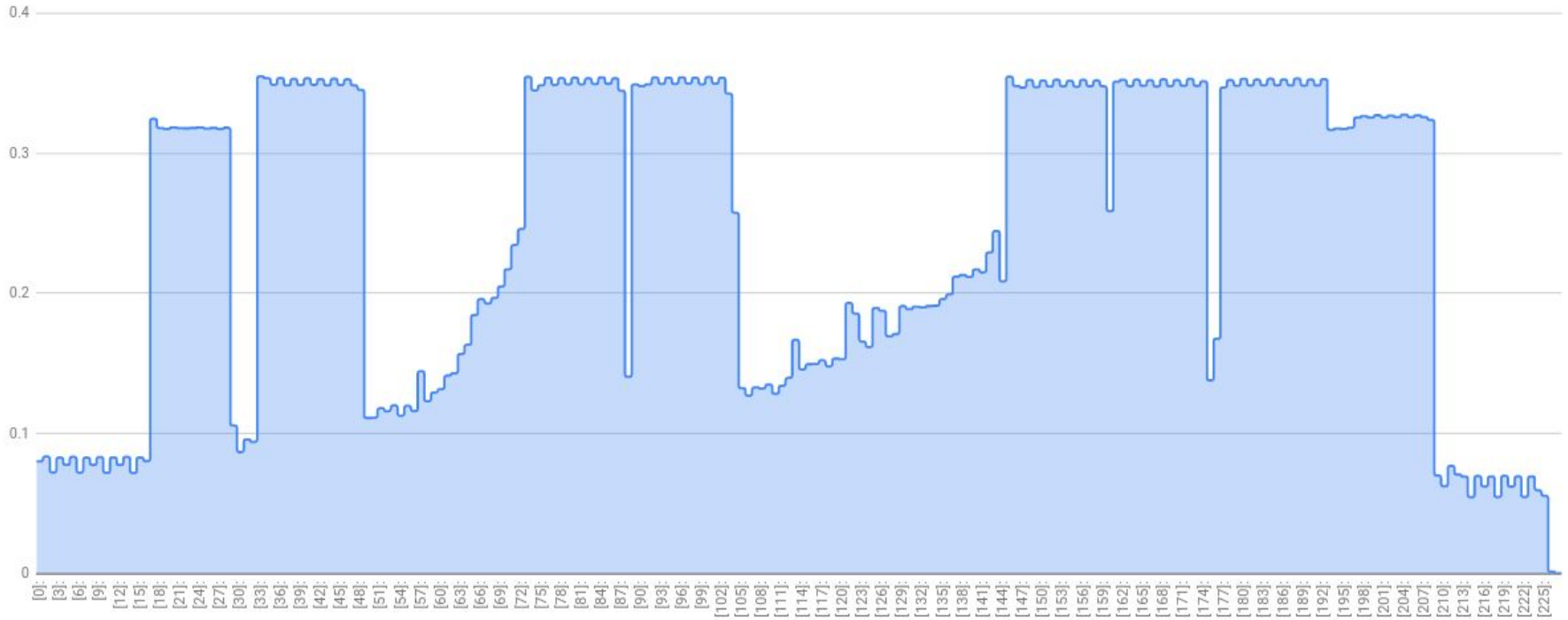


Structure

- Segments
- Downbeats
- Beats

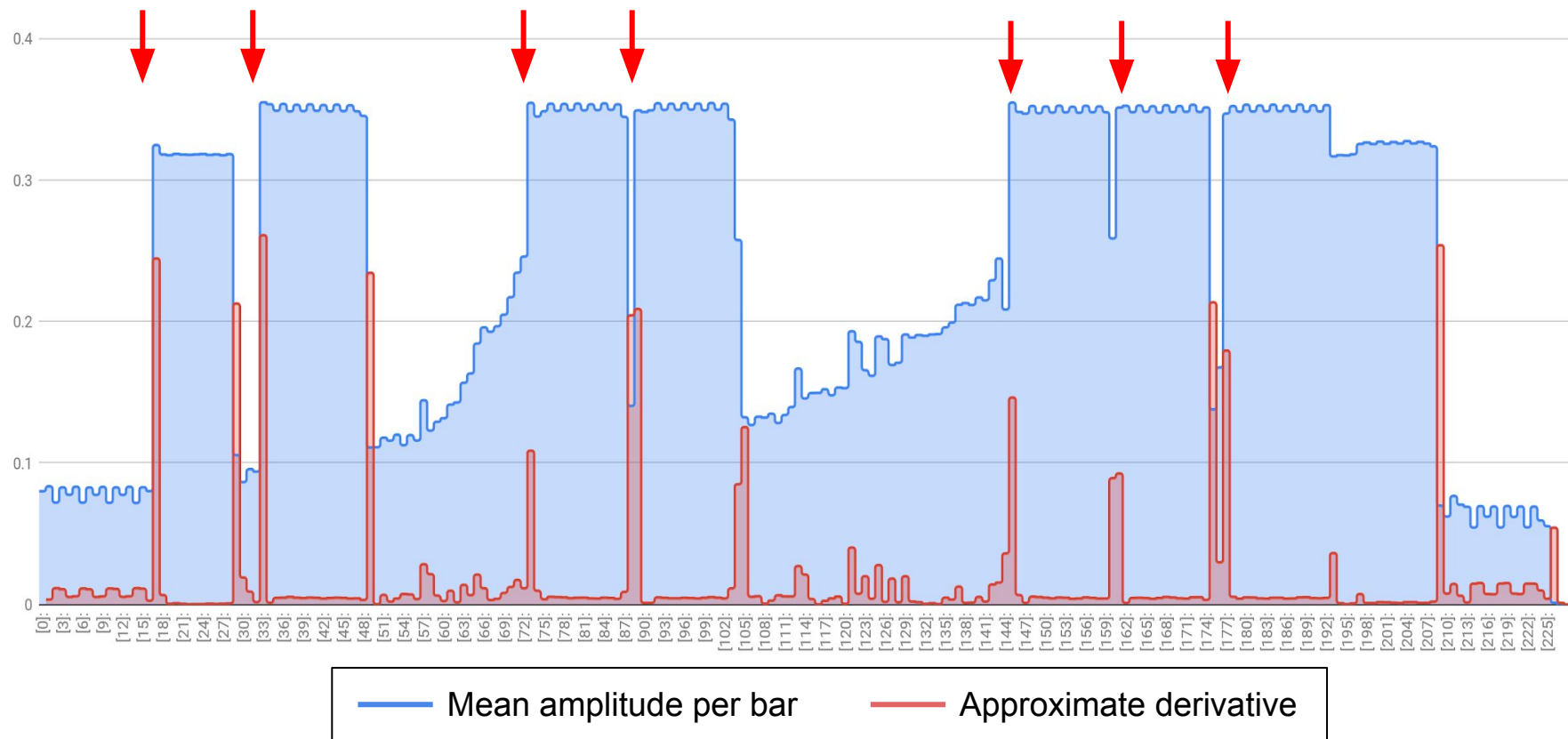


Structure analysis



— Mean amplitude per bar

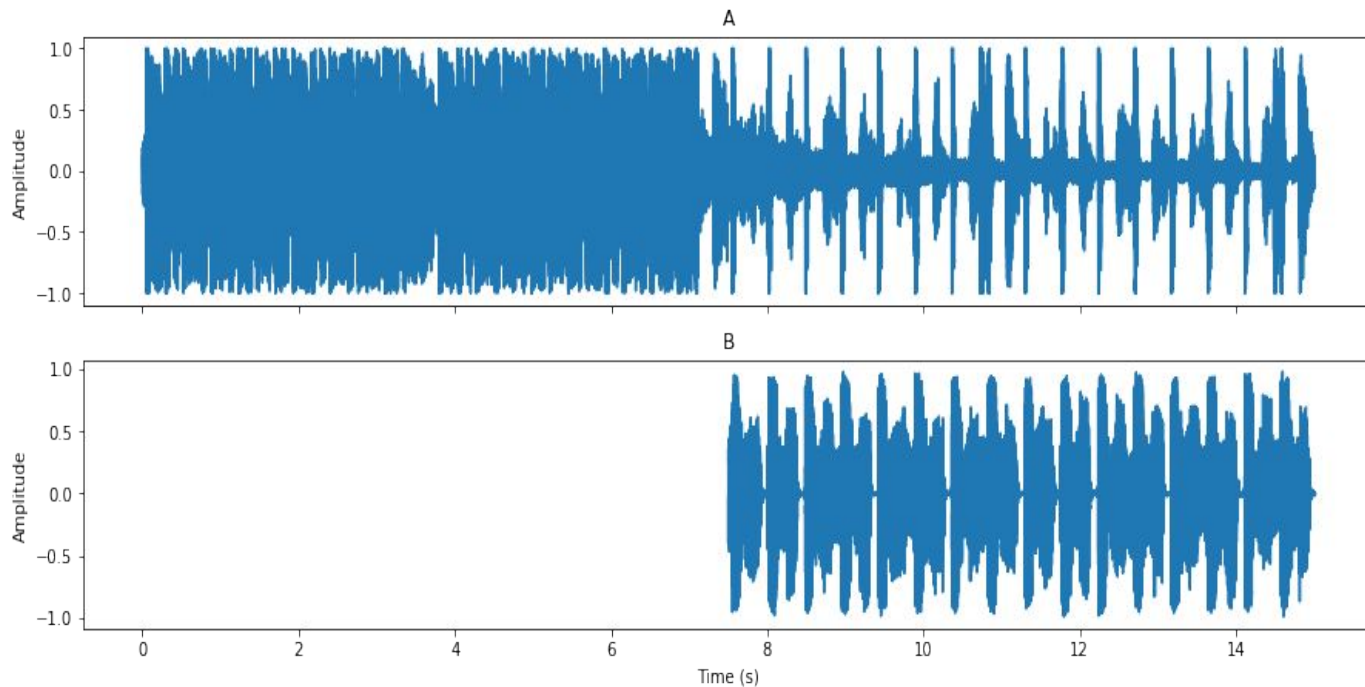
Structure analysis



Example

Rules

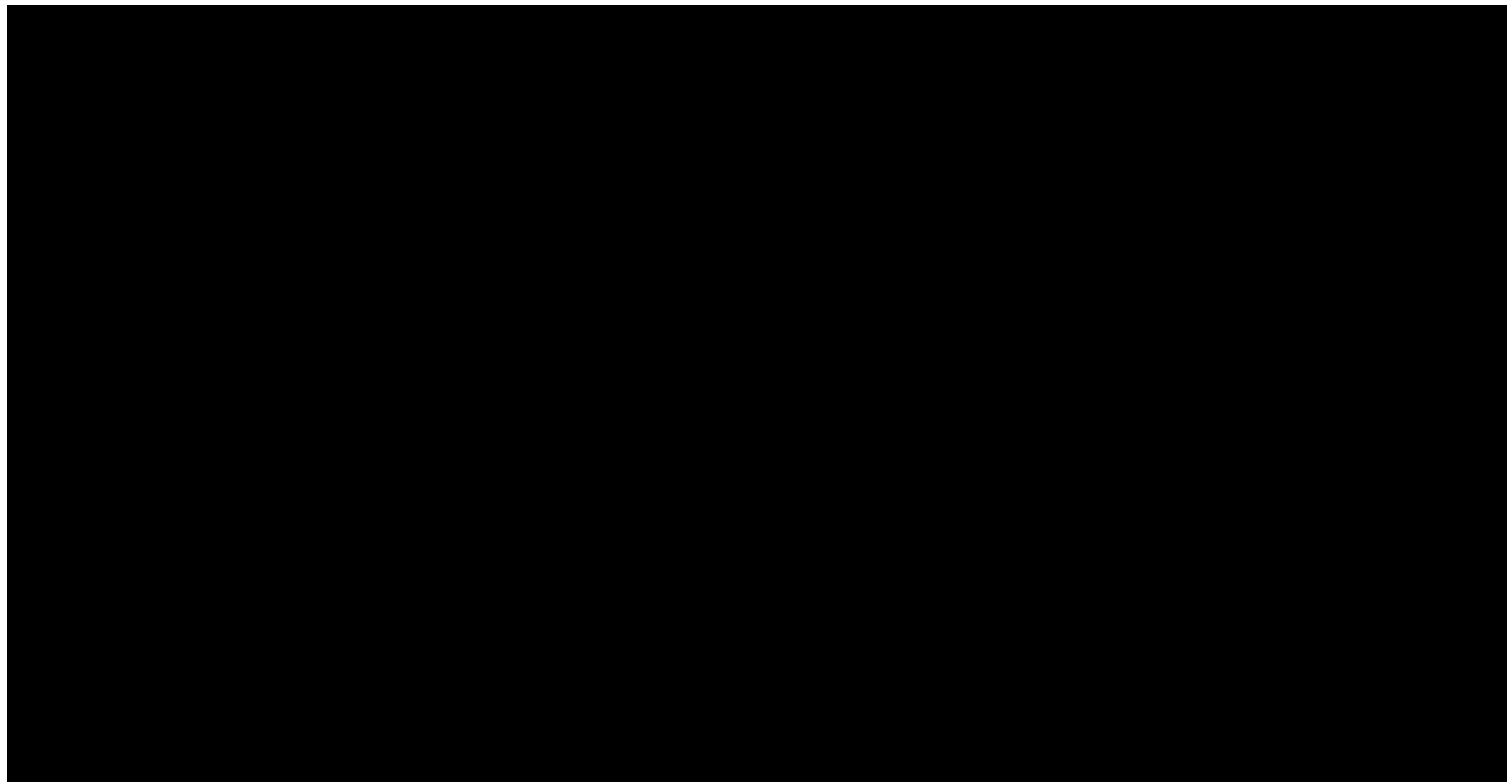
- Tempo matched
- Downbeat aligned
- Structure aligned



Example: click on the box to access the video

Rules

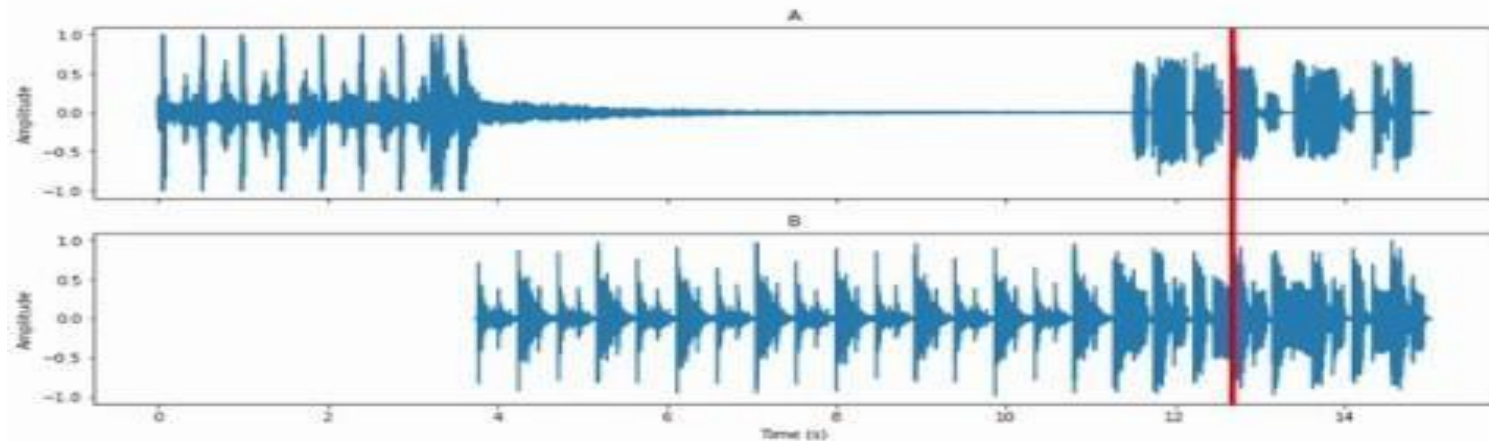
- Tempo matched
- Downbeat aligned
- Structure aligned



Example: click on the box to access the video

Rules

- Tempo matched
- Downbeat aligned
- Structure aligned

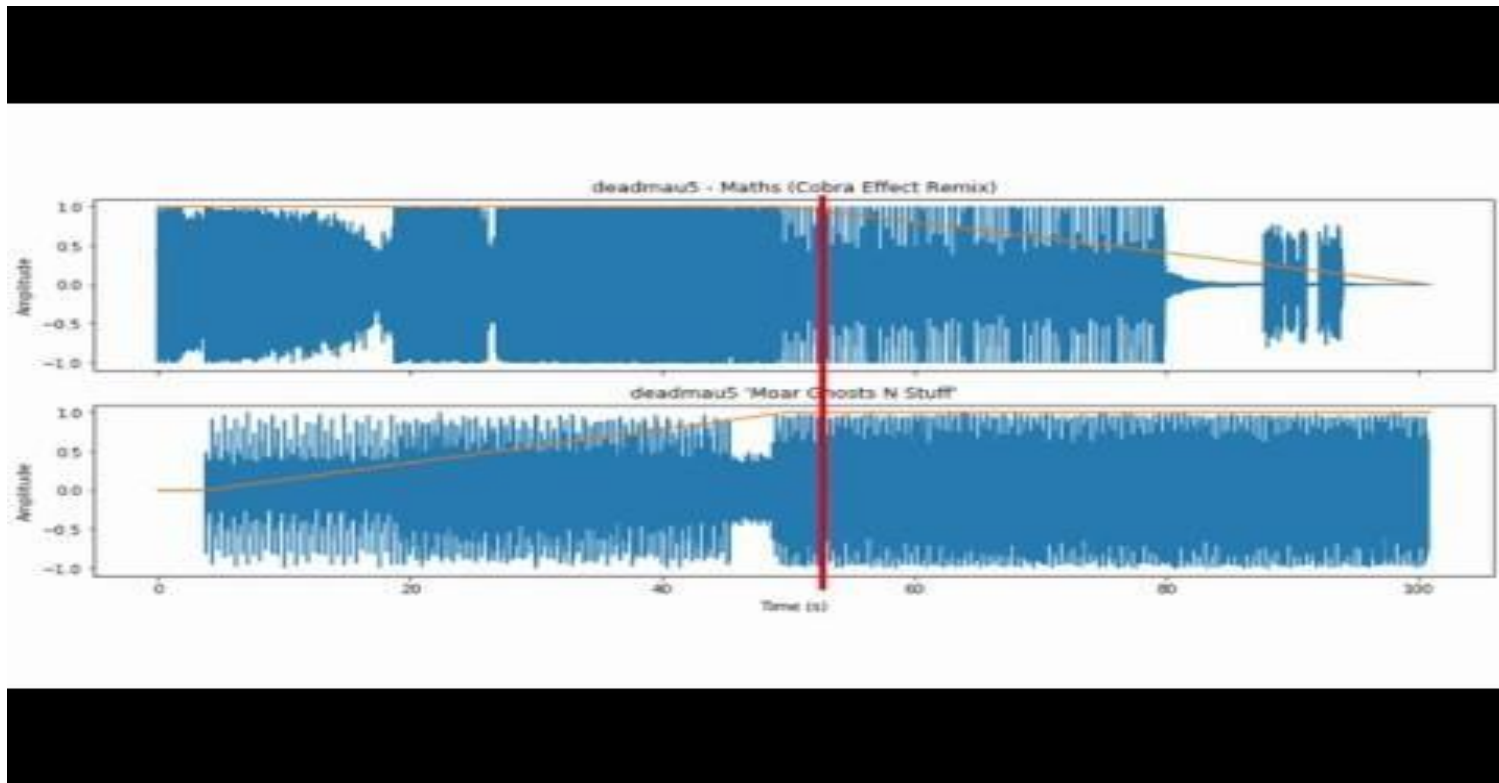


Evaluation

Result 1: click on the box to access the video

Rules

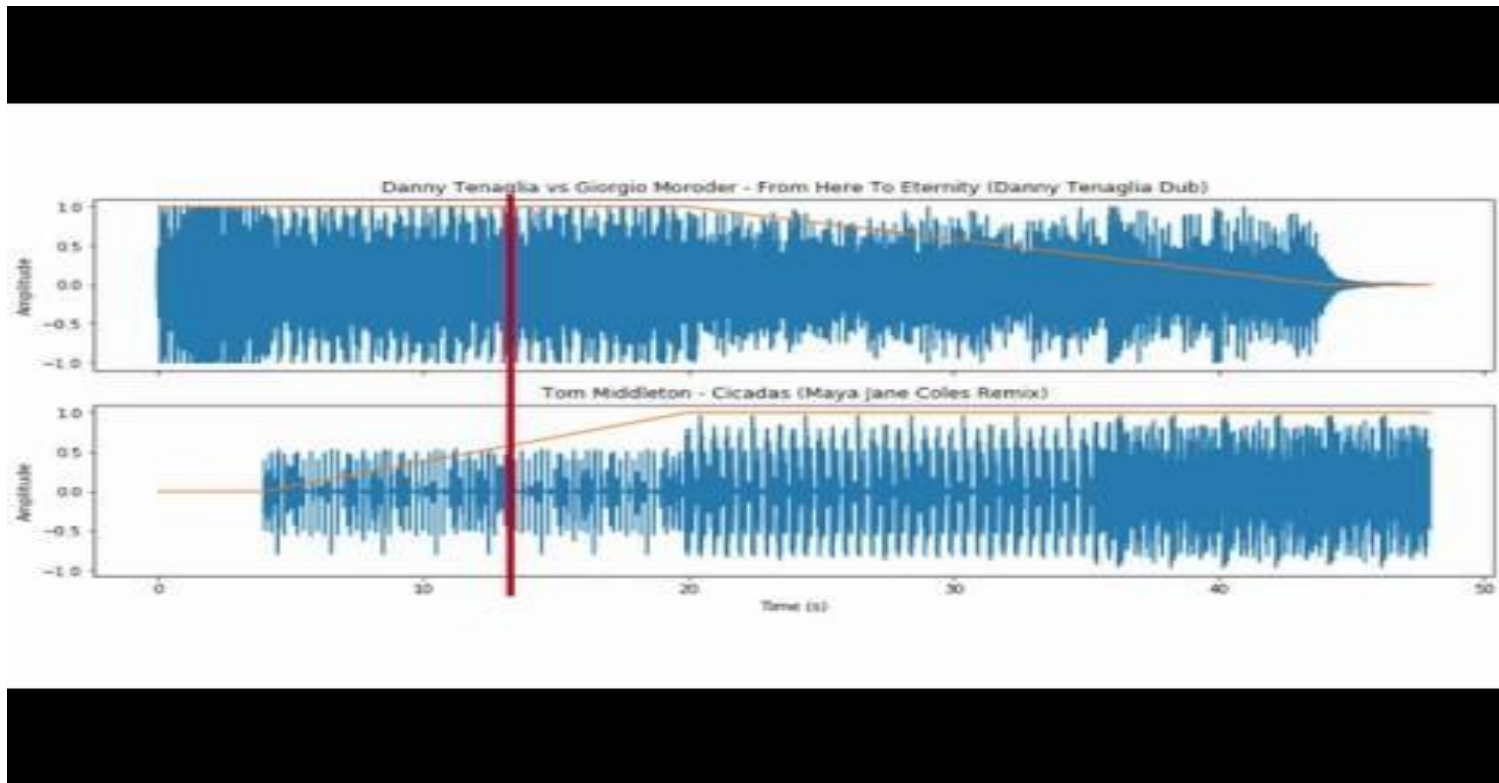
- Tempo matched
- Downbeat aligned
- Structure aligned
- Minimal activity



Result 2: click on the box to access the video

Rules

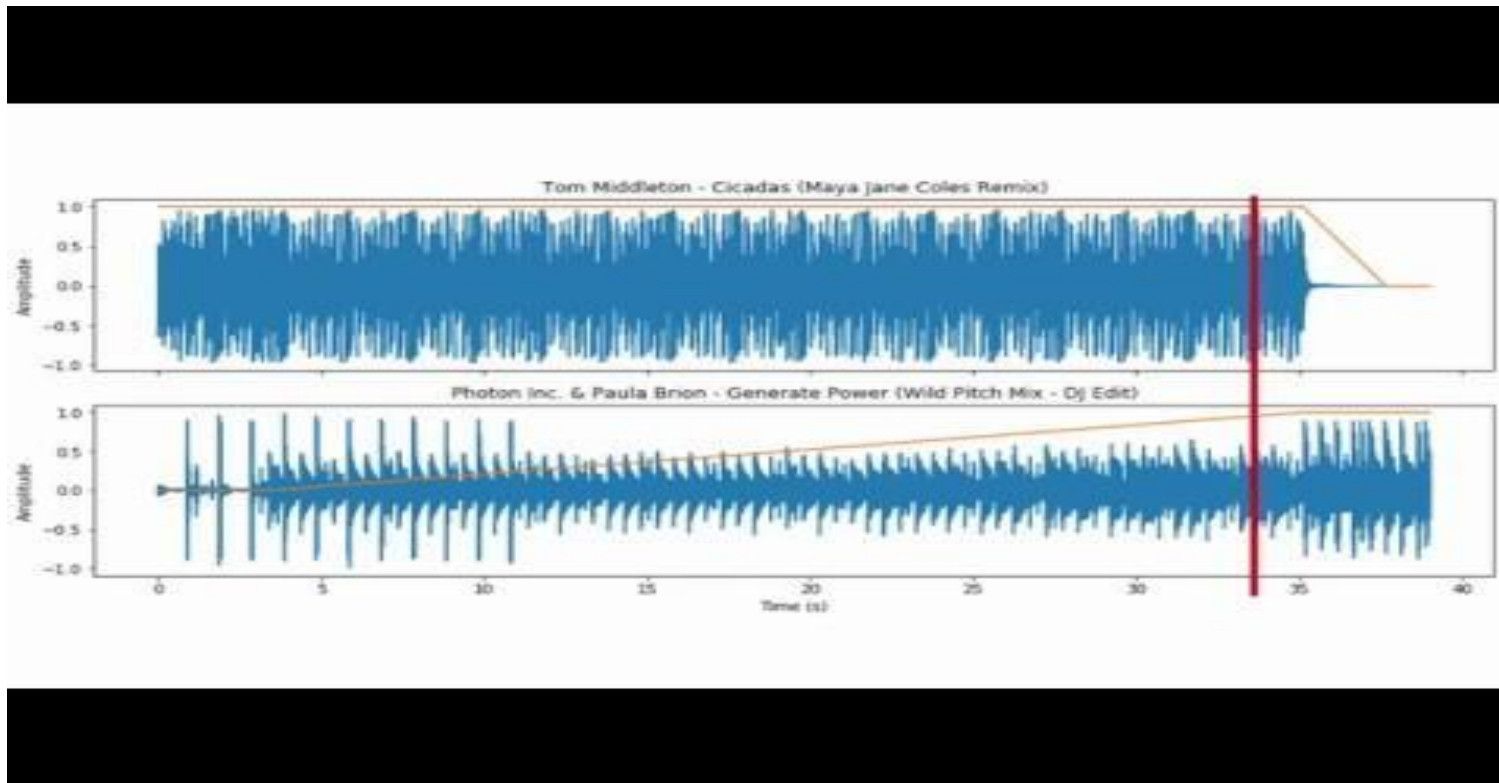
- Tempo matched
- Downbeat aligned
- Structure aligned
- Minimal activity



Result 3: click on the box to access the video

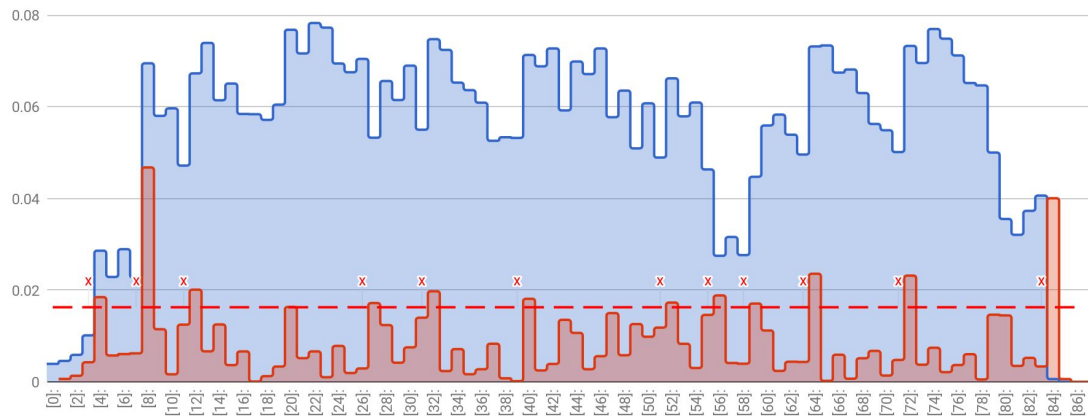
Rules

- Tempo matched
- Downbeat aligned
- Structure aligned
- Minimal activity



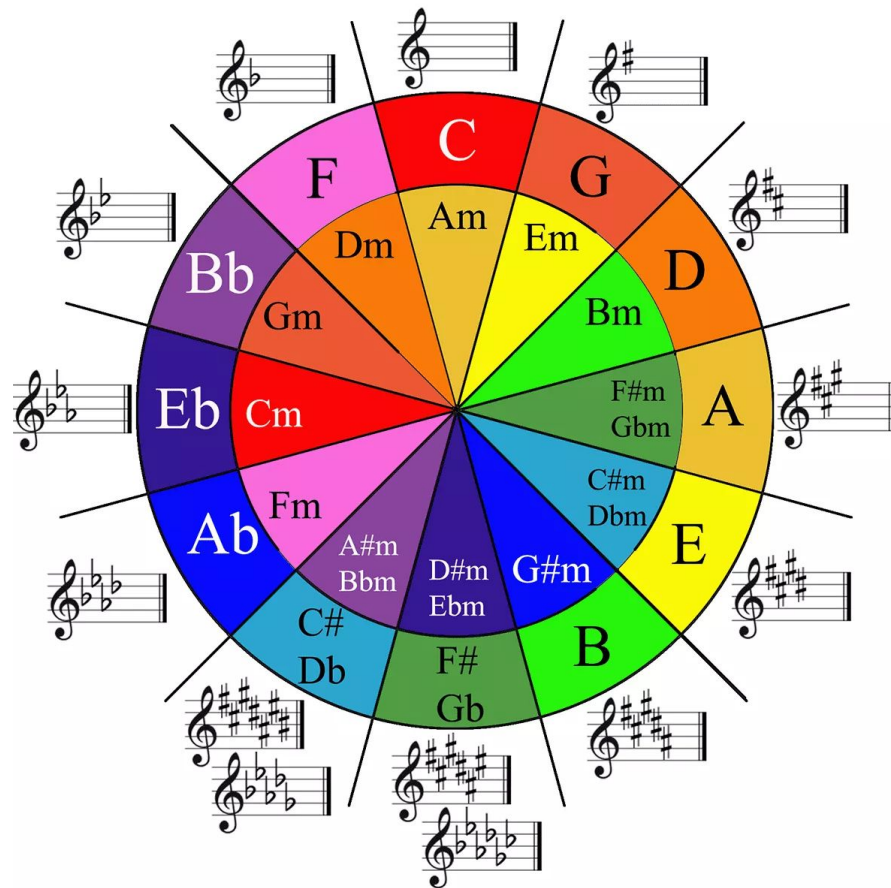
Future work

- Improved rules
 - Speed (Beat detection)
 - Low sensitivity (Structure analysis)



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 - Speed (Beat detection)
 - Low sensitivity (Structure analysis)
- More rules
 - Voice overlap, bass line overlap
 - Harmonic mixing



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- Improved rules
 - Speed (Beat detection)
 - Low sensitivity (Structure analysis)

- More rules
 - Voice overlap, bass line overlap
 - Harmonic mixing

- Recommender system

Thank you!