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

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● **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

- Tracks
- Rules
- Expert knowledge
- Recommender System
- Transition engine
A rule based approach

- DJ language
  - Semi-structured interviews
  - Loosely defined language

- Pseudo code
  - Structure and factorize
  - High level

- Implementation
  - High accuracy
  - Limit false positive
Example: naive overlap

Rules = {}
Example: click on the box to access the video

Rules = {}
Track’s beat

Perceptual: Beat or tactus

Physical: Waveform

Audio track

Onsets
Beat detection

Beat detection: Short-time Fourier transform
Beat detection

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

Picture: https://en.wikipedia.org/wiki/Beatmatching
Beat alignment

\[
\delta_{A1} \delta_{A2} \ldots \quad \text{Tempo mismatch}
\]

\[
\delta_{B1} \delta_{B2} \ldots
\]

\[
\text{PlaybackRate}_B = \frac{\Delta_B}{\Delta_A}
\]
Beat alignment

\[ \text{Phase mismatch} \]

\[ d_1 \quad d_2 \quad \ldots \]

\[ \text{Phase}_B = -\bar{D} \]
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

Perceptual:
- Beat or tactus
- Downbeats

Physical:
- Waves
- Waveform

Audio track
Downbeat

Perceptual:
Beat or tactus

Physical:
Waveform

Audio
track

Downbeats

Beats
Downbeat detection

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

Mean amplitude per bar

Approximate derivative
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)
Future work

● Improved rules
  ○ Speed (Beat detection)
  ○ Low sensitivity (Structure analysis)

● More rules
  ○ Voice overlap, bass line overlap
  ○ Harmonic mixing

Picture: https://neelmodi.com/how-to-use-the-circle-of-fifths-to-write-songs/
Future work

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

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

- Recommender system

Thank you!