

# Tempo adjustment of two successive songs

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- What is the tempo of a song ?
  - A song is composed of beats (e.g. drum kick)
  - The frequency of the beats define the tempo of a song  
⇒ BPM (Beats per Minute)

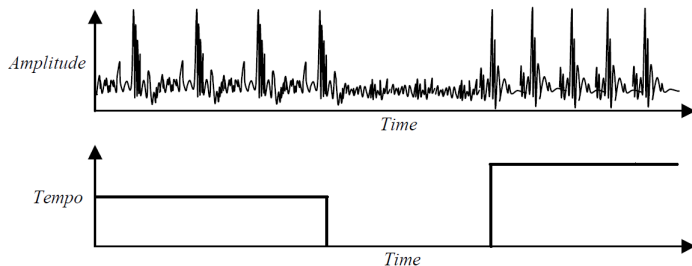


Figure 1: Beats defining the tempo of a song [3]

- Adjusting a tempo means increasing or decreasing the playing speed of a song
- Tempo may vary throughout a song (e.g Accelerando)
- **Goal** : adjust the tempi of two successive songs to create a smooth transition
- 3 main steps:
  - 1 Tempo estimation/extraction
  - 2 Adjusted tempo computation
  - 3 Tempo modification

- The idea of changing a tempo has existed since the creation of music
- Adjusting tempo has been done by disc jockeys for a long time
- Research about using a computer system to replace DJs began in the 1990s
- Most research about tempo adjustment has been conducted between 2000-2010

HERE:

- Paper : Full-Automatic DJ mixing system with optimal tempo adjustment based on measurement function of user discomfort. KDDI R&D Laboratories Inc. ISMIR. 2009
- KDDI R&D Laboratories Inc: Japanese corporate specialised in computer science research and development

# Problem

- Conventional song-to-song transition: cross-fade playing technique (CFP)
- Two successive songs may have different tempi at the time of transition  $\Rightarrow$  Causes discomfort

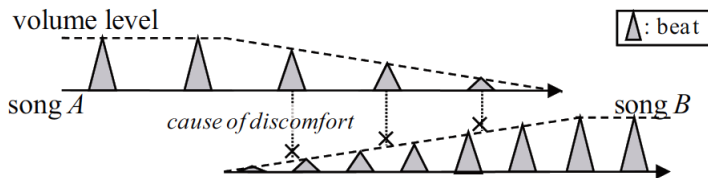


Figure 2: Cross-fade transition [1]

# Objective

- Speed-up / Slow down the tempo
- Typical tempo adjustment: change tempo of one song (DJs usually adjust the second song to match the tempo of the first one)

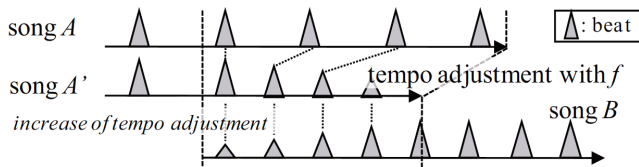


Figure 3: Naive DJ mixing [1]

- Adjust the the tempo of the two consecutive songs  
⇒ match the timing of the beats
- Naive solution: set target tempo as the mean of the two tempi

# Tempo extraction

- Determine the tempo of a song before being able to adjust it
- General tempo extraction scheme:

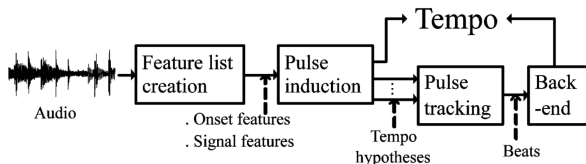


Figure 4: Tempo estimation procedure scheme [3]

- If the tempo is almost constant throughout a song: accuracy of the tempo estimation is around 80%
- To improve performance: add beat-tracking block



# Approach Goal

- Different from the traditional tempo adjustment, the proposed method adjusts the two tempi

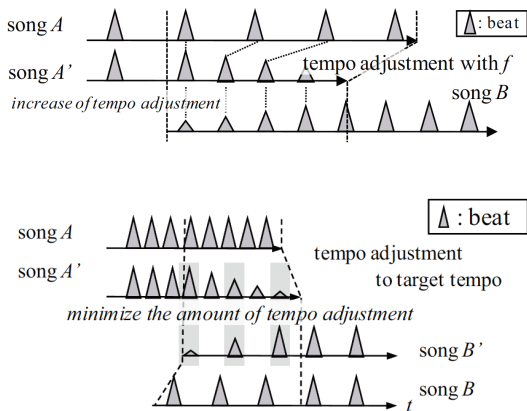


Figure 5: Naive and dual tempo adjustment [1]

- Determine a relation between level of discomfort and tempo adjustment factor
- Define the level of discomfort as :

$$L_{dc}(f) = \begin{cases} a(f - 1), & f > 1(\text{speed-up}) \\ 0, & f = 1(\text{no change}) \\ b(\frac{1}{f} - 1), & f < 1(\text{slow-down}) \end{cases}$$

- After conducting some tests, the weights have been set as:

$$a = 0.852, \quad b = 1.000$$

- Slow-down causes more discomfort than speed-up

# Approach

- Goal is to adapt the tempi of two successive songs to get a smooth transition

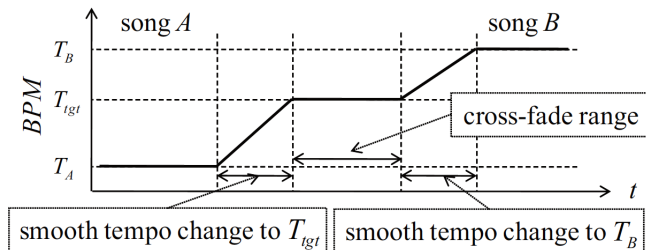


Figure 6: Shifts of tempi of target songs in StS transition [1]

- $\Rightarrow$  Determine the optimal tempo adjustment coefficients (OTACs) to match  $T_A$  and  $T_B$  to  $T_{tgt}$

# Approach

Here:  $T_A < T_B$  (where  $T_X$  defines the tempo of a song)

- 1 Compute some adjusted  $T_A$ s using the equation:

$$T'_A = 2^C \times T_A \text{ where } C \in \{-2, -1, 0, 1, 2\}$$

- 2 Pick one  $T'_A$  such that :

$$C_{opt} = \operatorname{argmin}(|T'_A - T_B|)$$

- 3 Compute the following parameter:

$$b_{opt} = 2^{C_{opt}} \times T_A$$

When several  $b_{opt}$  are the outcome, pick the one that minimizes  $|C_{opt}|$

- 4 Determine the target tempo :

$$T_{tgt} = \frac{(a-b)T_{low} + \sqrt{(a-b)^2 T_{low}^2 + 4abT_{high}T_{low}}}{2a}$$

- 5 Compute the tempi adjustment factors:

$$f_{optA} = \frac{T_{tgt}}{b_{opt}} \text{ (speed-up factor)} \quad f_{optB} = \frac{T_{tgt}}{T_B} \text{ (slow-down factor)}$$

- Combined into an automatic-mixing system

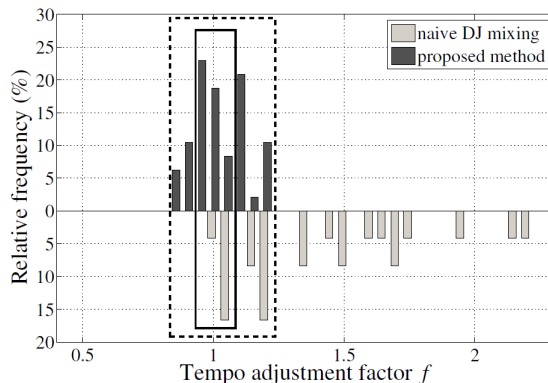


Figure 7: Histogram of the adjustment factors of the proposed and naive DJ mixing method [1]

- Capable of keeping tempo closer to original tempo

# Results

- Experiment: people subjectively had to evaluate the naive and the proposed mixing method
- A 30 second snippet of each song was used, which includes the chorus (songs extracted from an online library)

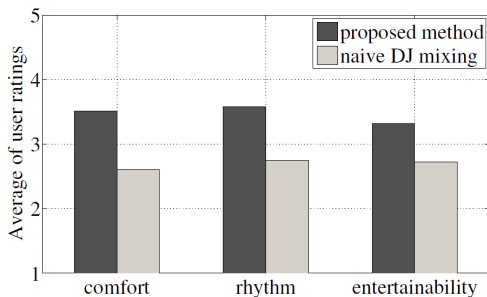


Figure 8: Average of user ratings in proposal and naive DJ mixing [1]

- Method increases the ratings compared to the naive mixing method

- Tempo adjustment is a subtask in automatic dj-mixing
- Performance is dependent on the tempo extraction algorithm
- Can be calibrated to different people's level of discomfort ( e.g different genres)  
⇒ adapted to different situation and different listeners



**Thank you!**



H. Ishizaki, K. Hoashi, Y. Takishima.

*Full-Automatic DJ Mixing System With Optimal Tempo Adjustment Based on Measurement Function of User Discomfort.*

ISMIR, 2009.



D. Cliff.

*Hand the DJ: Automatic Sequencing and Seamless Mixing of Dance-Music Tracks.*

HP Labs Technical Report ,2000.



F. Gouyon et al.

*An Experimental Comparison of Audio Tempo Induction Algorithms.*

IEEE ASLP ,2006.