- CS Project Final Report -

Game Level Editor & Assist Tools

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Contents

Introduction

Problem: The chart (level) file is complicated to modify and difficult to preview

Goal:

1. Develop a user-friendly editor for my game
2. Design assist tools inside the editor
   - BPM Estimation
   - Main Melody Onset Detection

Hand Tracker Mount

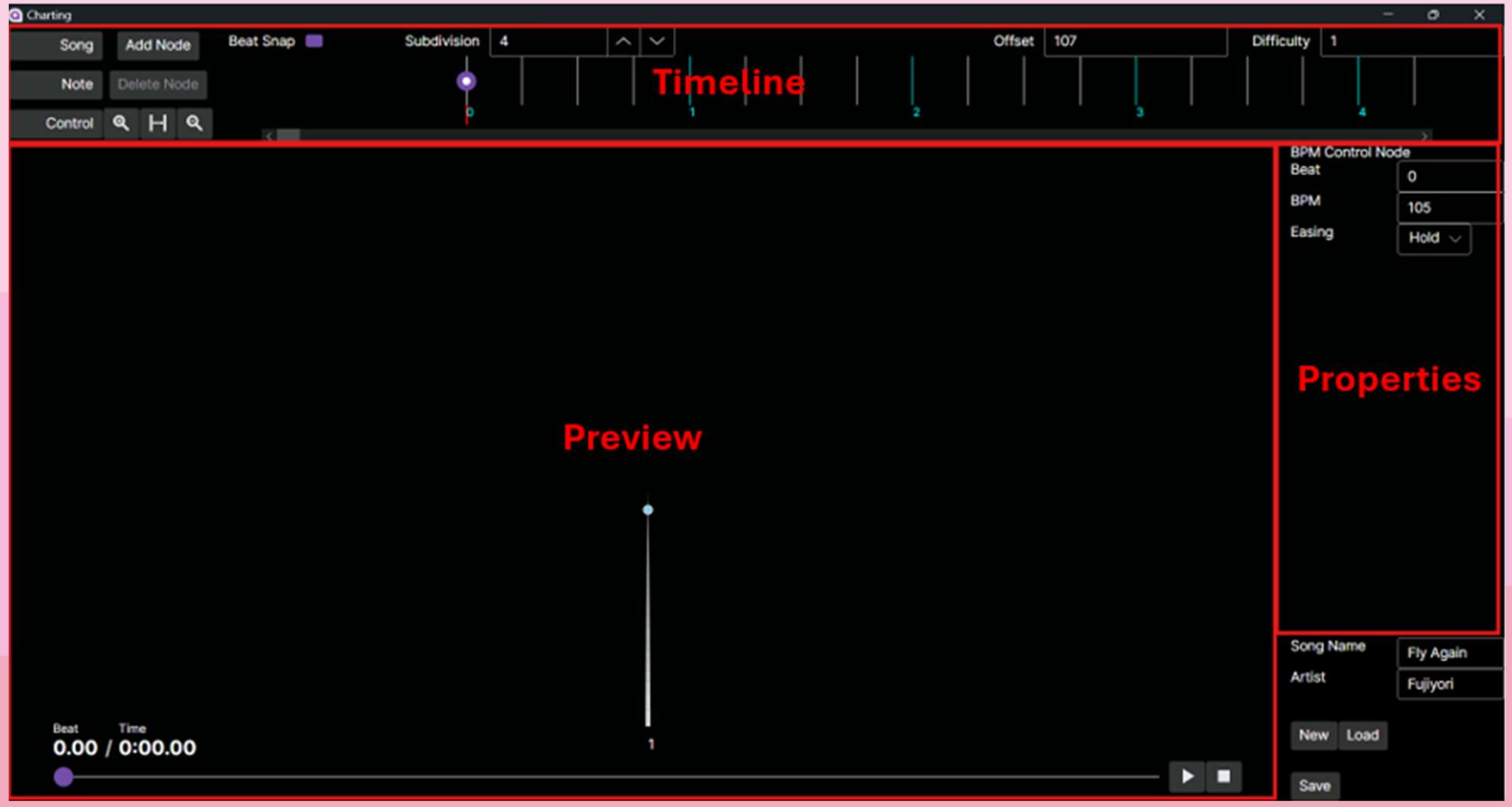
Problem: Hand may be obstructed by the other during gameplay and make it undetectable to the tracker

Solution: The tracker is now mounted on a LEGO headset

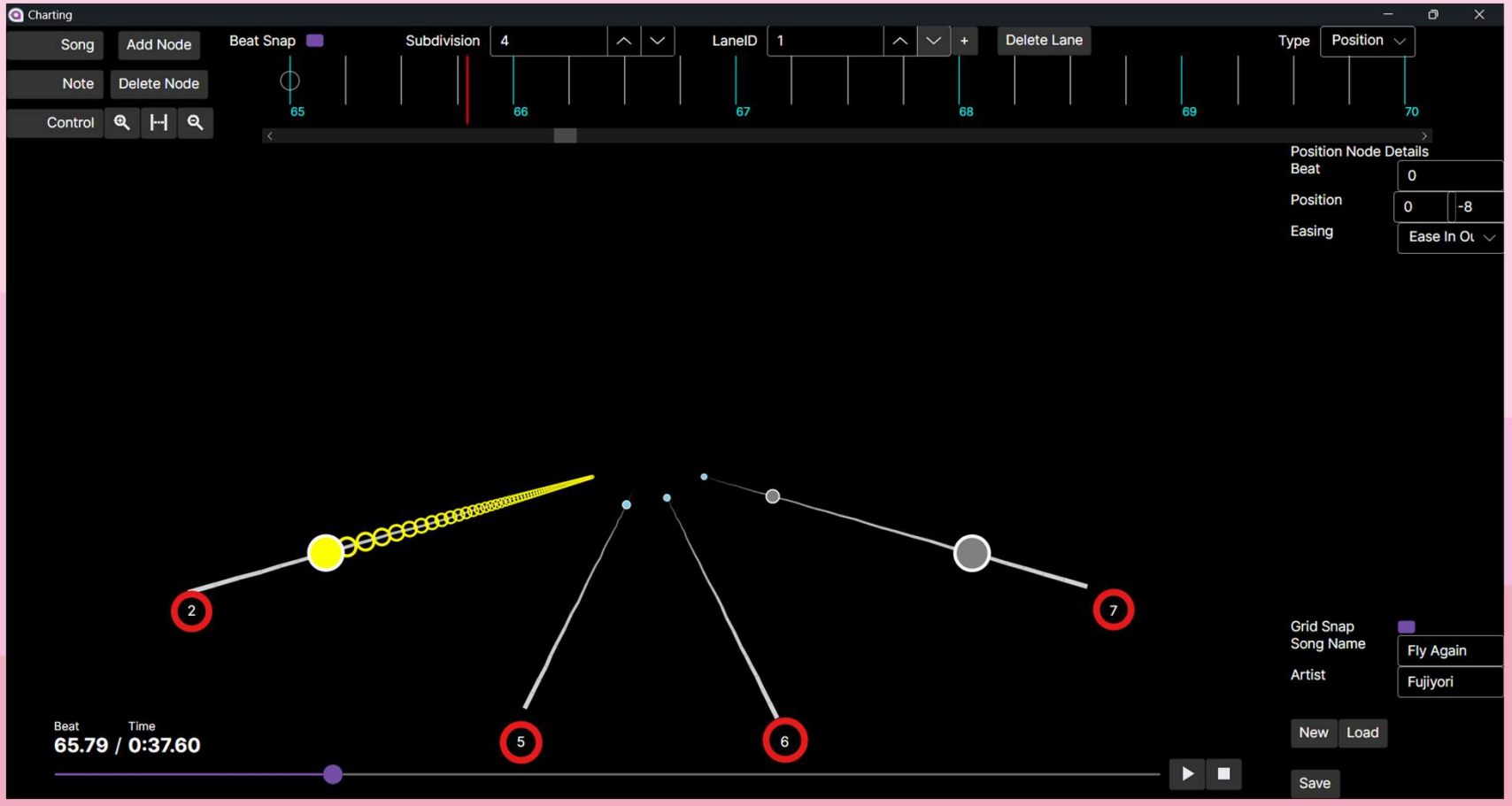
- sponge is taped to make it more comfortable to wear

- tracker is slightly tilted down to make the hand movements more natural

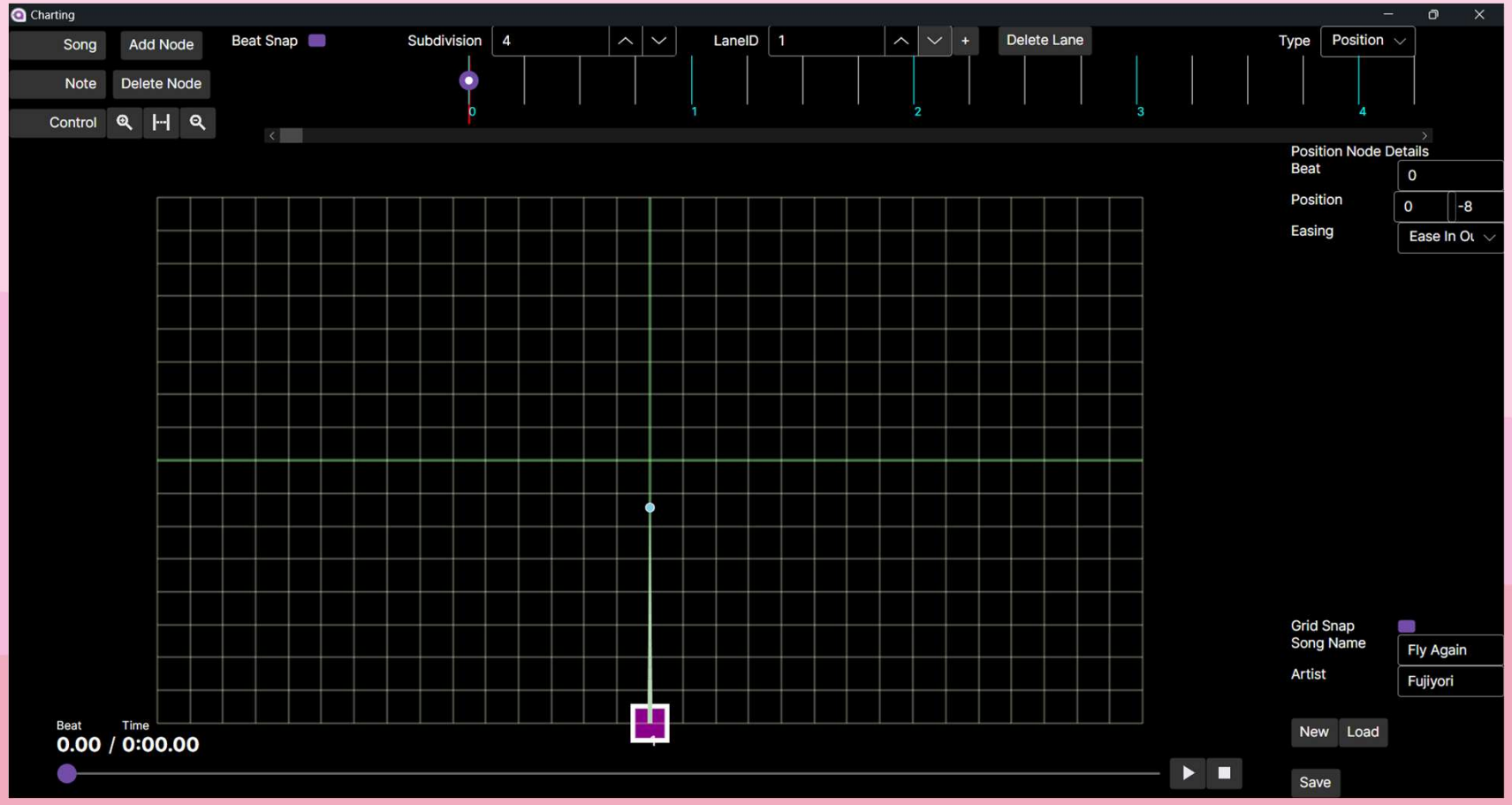
Level Editor – Interface



Level Editor – Interface

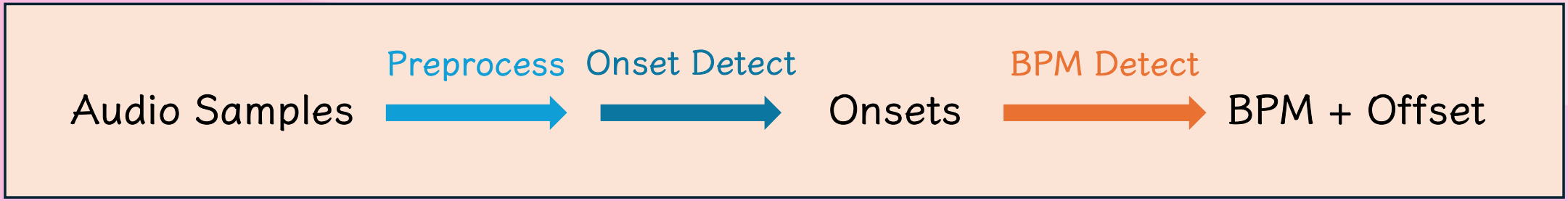


Level Editor – Interface



BPM Estimation – Overview

Goal: Find the drum onsets (time when the drum hit begins) and calculate the most possible BPM



BPM Estimation – Preprocess

Percussion instruments have spectrum with rapid broadband onset

Perform STFT
(Size=4096, Hop=512)

Audio Samples → → <To Next Step>

Compute Percussivity

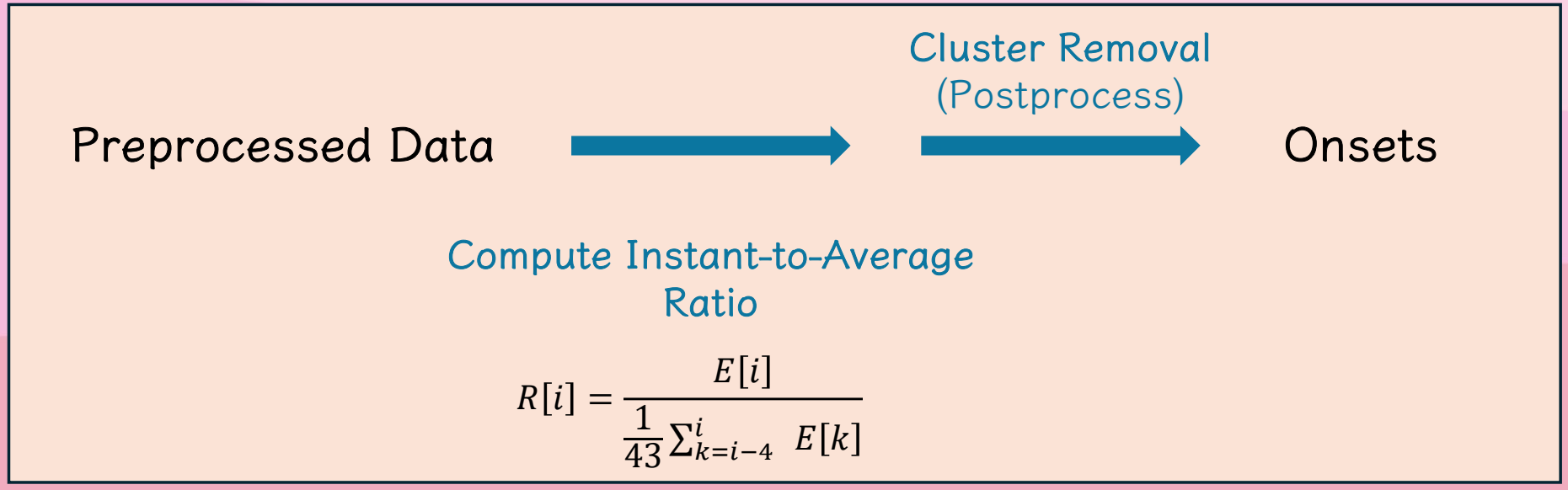
$$P[k] = \sum_{\mu=20}^{2048} \begin{cases} 1, & if \ \dfrac{|x[k,\mu]|}{|x[k-1,\mu]|} > 5 \\ 0, & otherwise \end{cases}$$

Barry et al., Drum Source Separation using Percussive Feature Detection and Spectral Modulation, 2005

BPM Estimation – Onset Detect

Compare the current value with the average of the past 0.5 seconds

The timing is considered an onset if the ratio is above the threshold

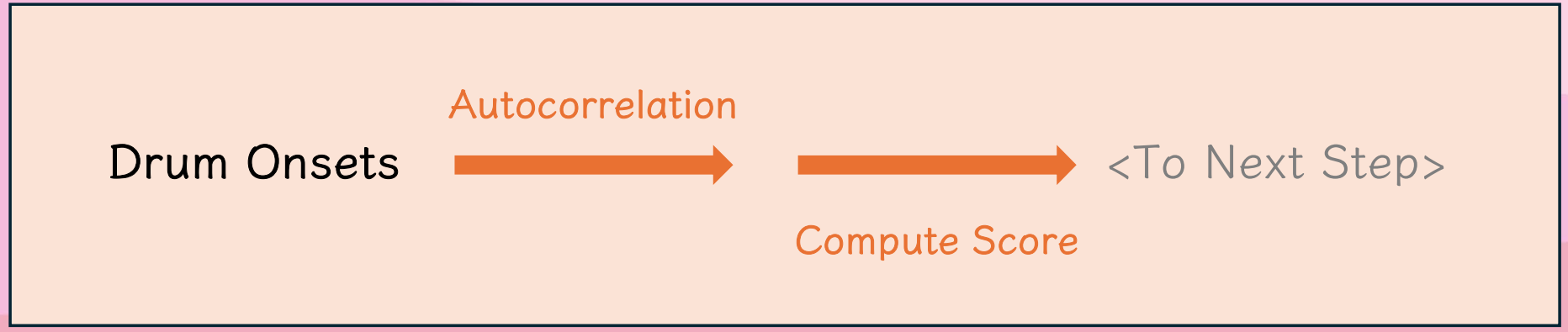


https://archive.gamedev.net/archive/reference/programming/features/beatdetection/index.html

BPM Estimation – Scoring

Old Method: Count the consecutive onsets that match with the BPM

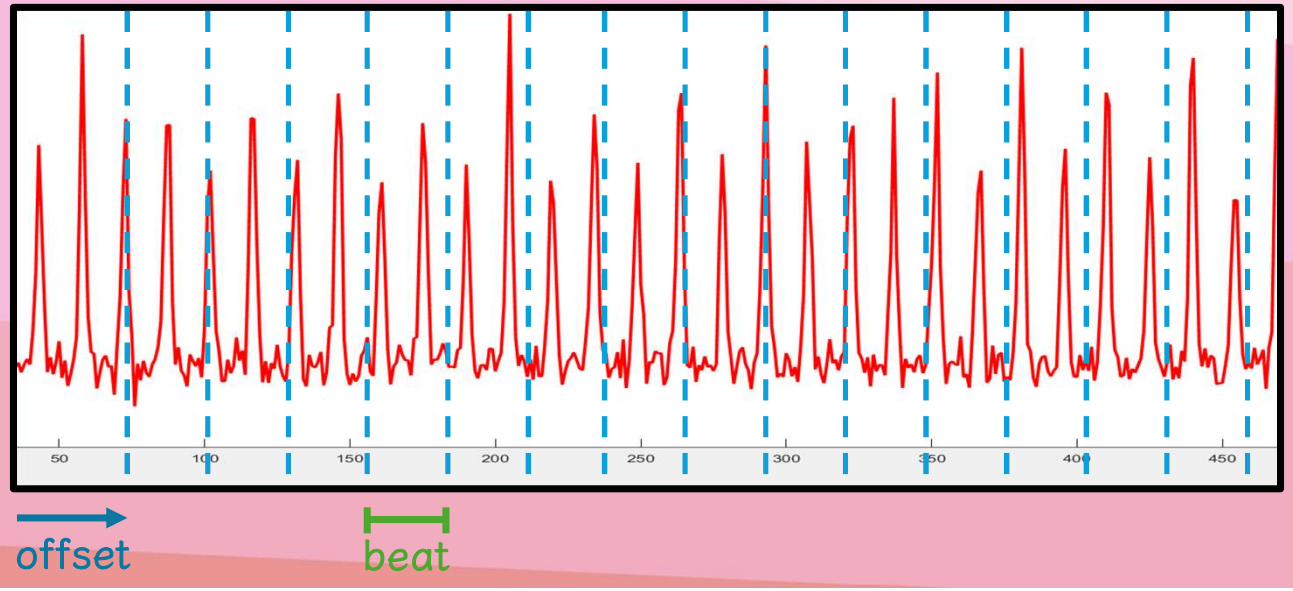
New Method: Apply autocorrelation to the onsets to check periodicity



BPM Estimation – Scoring

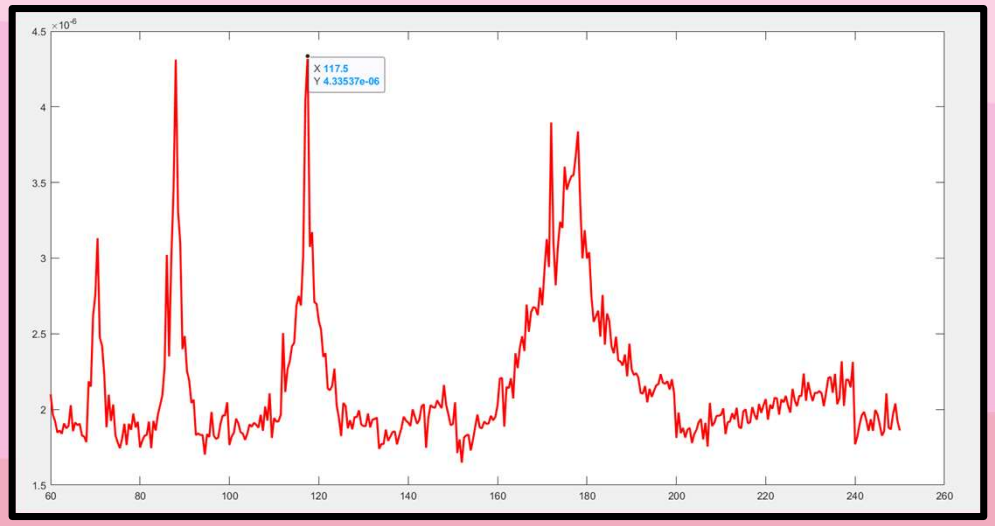
The score is computed through adding up the autocorrelation values with the hop size of one beat for a given BPM

The process is tested for all BPM and offsets, and the pair with the highest score is picked



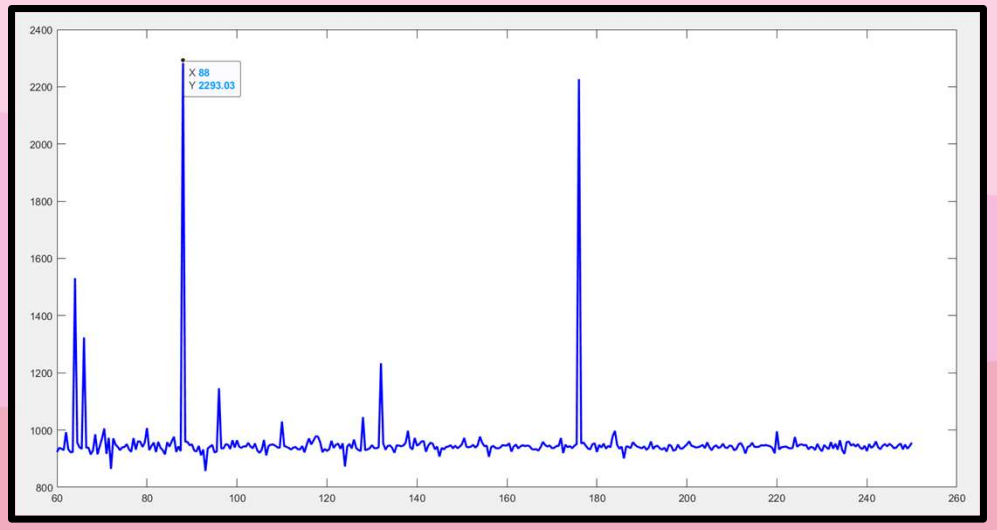
BPM Estimation – Result

The new method gives a more confident and accurate result than the previous method



Old Method
(117.5 bpm)

(PIKASONIC – heroine [176 bpm])

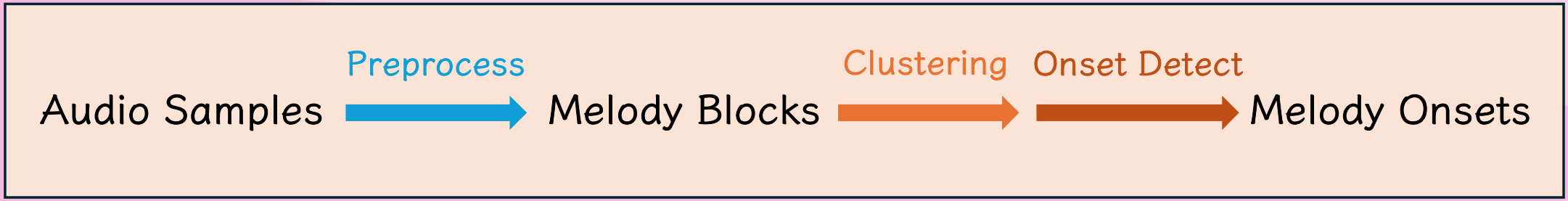


New Method
(88 bpm)

Melody Onset Detection – Overview

Goal: Find the loudest melody and detect its onset

Aim to improve the detection method in both frequency and time domain



Melody Onset Detection – Preprocess

The harmonics of a base frequency make it brighter and louder

Also taking human hearing sensitivity ($W(\mu)$) into consideration

Perform STFT
(Size=2048, Hop=256)

Audio Samples → → <To Next Step>

Get Harmonic Sum

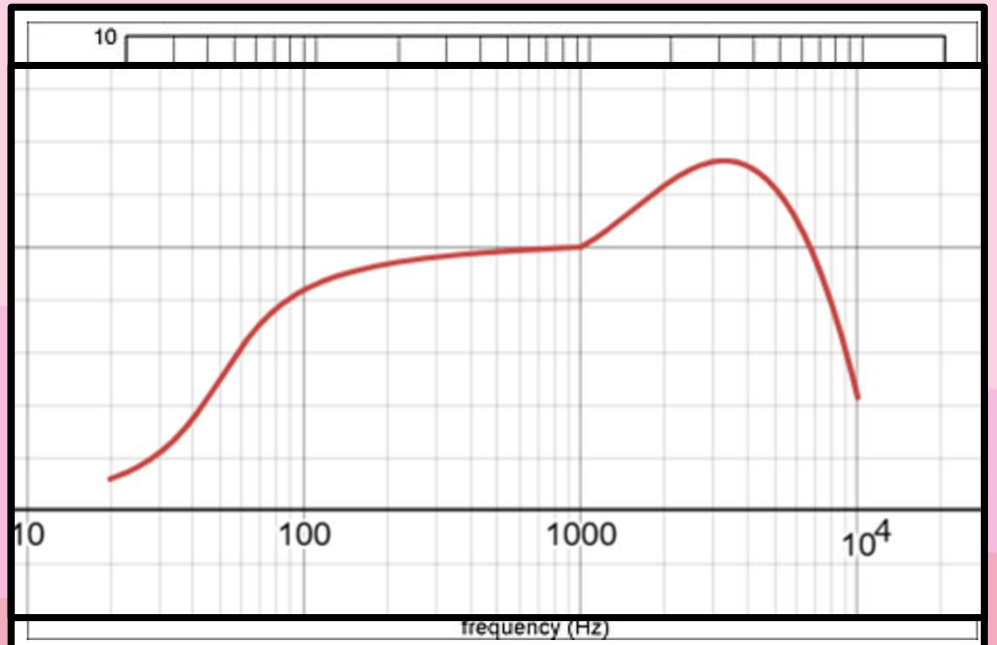
$$H(\mu, t) = \sum_{n=1}^{15} 0.84^{n-1} W(n\mu) A(n\mu, t)$$

Dik J. Hermes, Measurement of pitch by subharmonic summation, 1987

Melody Onset Detection – Preprocess

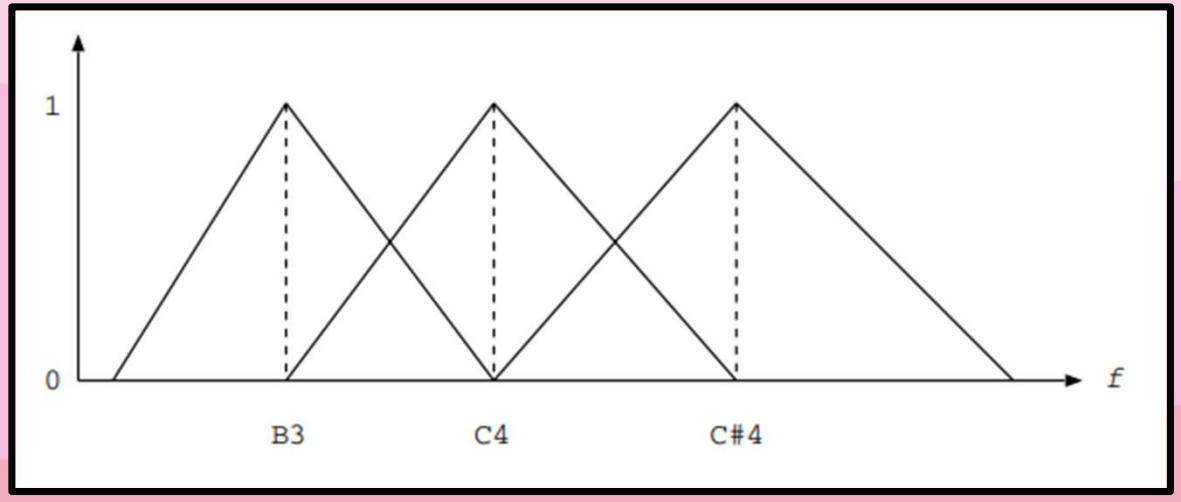
$$W(\mu) = \begin{cases} \dfrac{\operatorname{atan}\left(2\ln\left(\frac{\mu}{50}\right)\right)}{0.895\pi} + \dfrac{1}{2}, & if\ 20 \le x < 1000 \\ -t^3 - 2.2t^2 - t + 1.2, & if\ 1000 \le x < 10000 \end{cases}$$

$$t = 0.6\ln\left(\frac{\mu}{5260}\right)$$



Melody Onset Detection – Preprocess

The frequency axis is then converted to semitone band

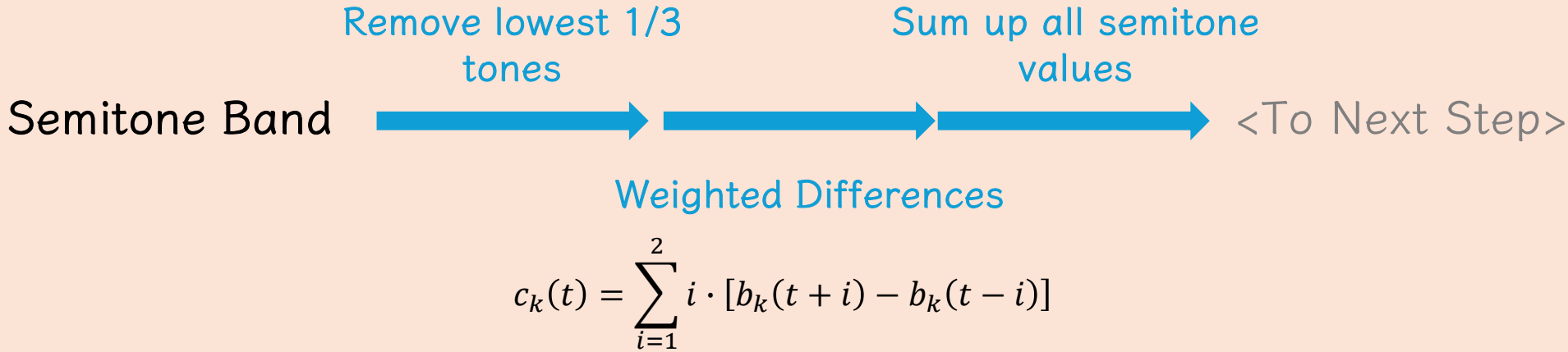


Antonio Pertusa et al., Recognition of Note Onsets in Digital Music Using Semitone Bands, 2005

Melody Onset Detection – Preprocess

The lowest 1/3 tones (in values) are discarded

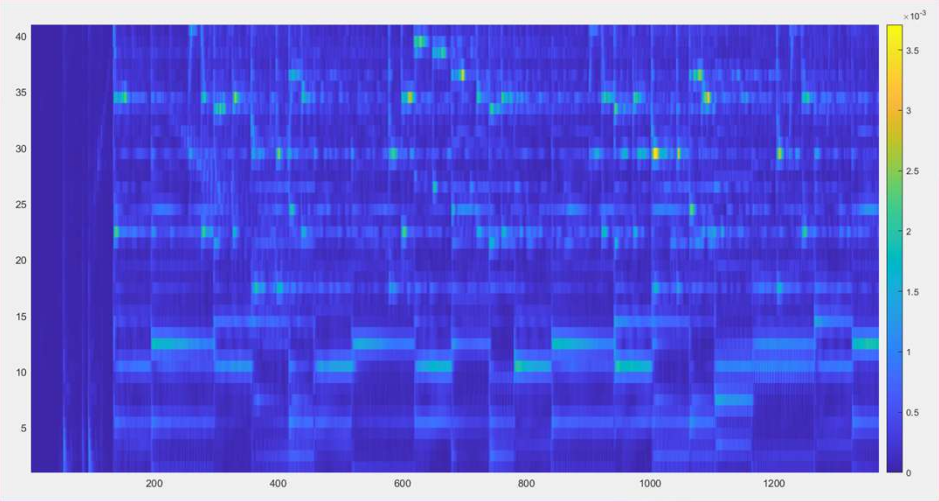
To better detect soft onsets, differences of more time frames are considered

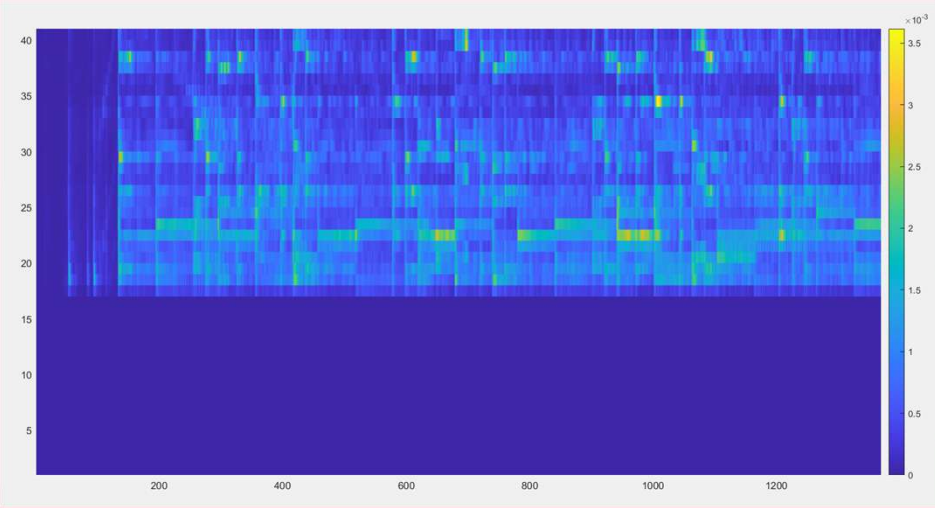


$$c_k(t) = \sum_{i=1}^{2} i \cdot [b_k(t+i) - b_k(t-i)]$$

Antonio Pertusa et al., Recognition of Note Onsets in Digital Music Using Semitone Bands, 2005

Melody Onset Detection – Preprocess





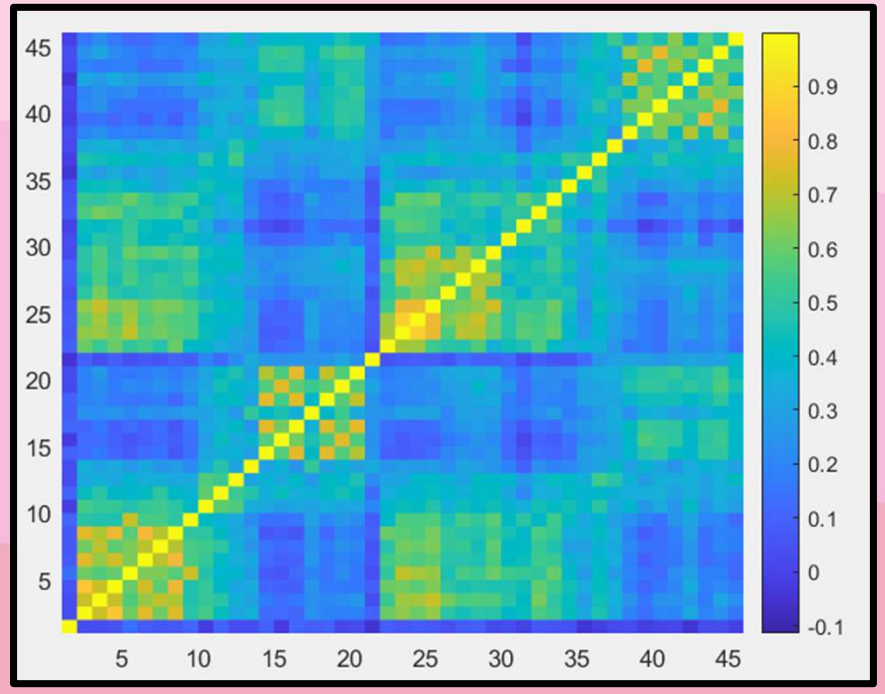
Melody Onset Detection – Melody Blocks

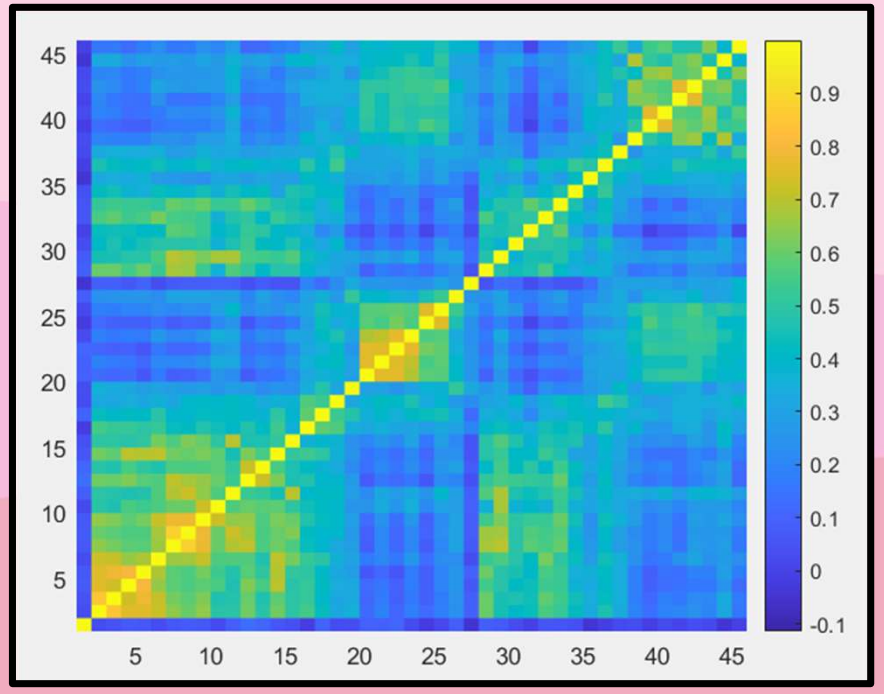
BPM is estimated first, then we apply autocorrelation to the processed samples

The best beat gap and offset is chosen to split the samples

Melody Onset Detection – Melody Blocks

The correlation matrix of all blocks are constructed, then we apply hierarchical clustering





Melody Onset Detection – Detection

The onsets in the same clusters are compared, and a melody is detected if over 2/3 of the blocks have onset at that point

Conclusion

BPM estimation overall does well on **EDM genre**.

Including machine learning into melody detection would greatly increase the performance

The game would be better to publish to the public if we can replace the tracker device

- Thank You -