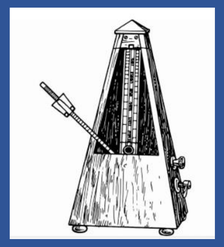

Tap To Tempo: BPM Detector and Signal Modifier

Keon Garrett and Austin Votypka
Department of Electrical and Computer Engineering
University of Rochester

Motivation

- Logic Pro X

- Has BPM detector and signal modifier
  - Doesn't allow tap to tempo BPM change
- Something that we would use all the time if it was available
  - Don't want to buy a plug-in/DAW just for this
- Solution: make one ourselves!!

Goals

- Detect BPM of input audio signal
- Various Methods of BPM input
  - Clap
  - Tap
  - Direct Input
  - Song Comparison
- Alter BPM of Signal
  - Alter pitch and speed independently

What's Required

- BPM detection
  - MIT Media Lab algorithm Modifications
- Individual Functions
  - Clap
  - Tap
- User interface
  - Direct Input
  - Song Comparison
- Alter BPM of Signal
  - Modify Speed & Pitch change Algorithm from HW

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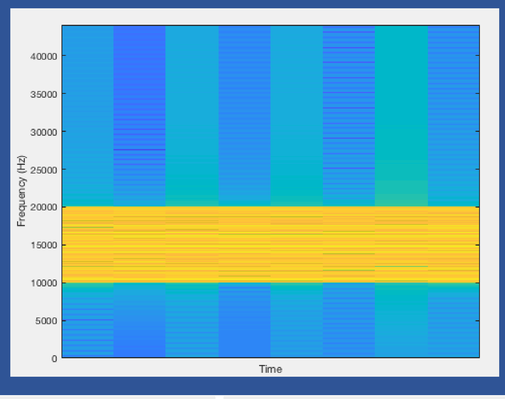
BPM Detection

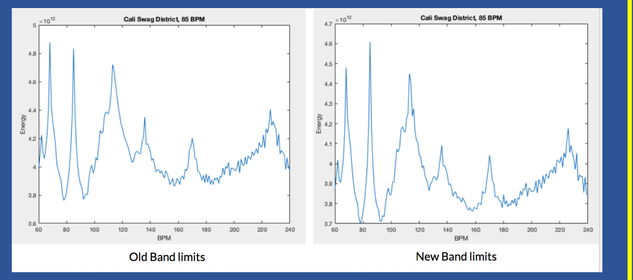
Filter-bank

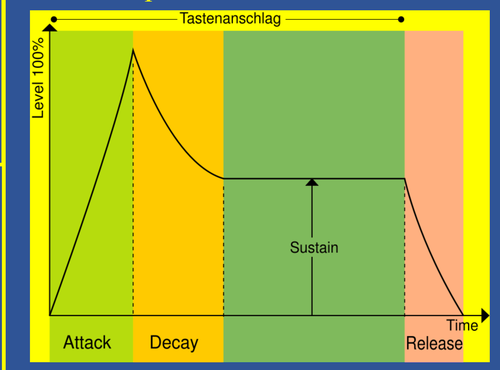
- Filters input into Frequency Bands
- Uses Fourier transform, sample rate, and signal length to determine the length and samples for each band



Signal Smoothing

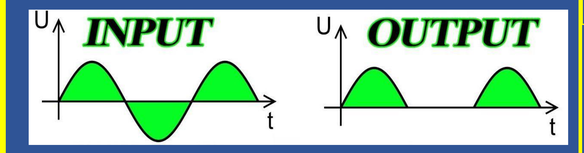
- Use IFFT to bring each band into time domain
- The signal is full-wave rectified and FFT is applied to bring back into frequency domain
- Then a Hanning window is applied to reduce it to its envelope
- Finally another IFFT is applied to bring back into time domain with a smooth envelope





Differentiate and Half Wave Rectify

- Differentiate to find the amplitude difference between samples
- Apply half-wave rectification to get positive changes in amplitude only



Comb Filter Convolution

- The last step is to convolve the signal with comb filters impulse responses, each corresponding to a different BPM
- The energy output by each frequency band is then summed
- Whichever BPM comb filter impulse response that produces the highest energy output corresponds to the BPM of the signal

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Tap

- The tap function allows user to tap about a desired tempo using the spacebar.
- Tap for a 15 second duration
- The total number of taps in that Duration is converted to Taps/Min (BPM)

Clap

- The clap function sets up an audio device that records 10 seconds of claps
- We varied the Band limits of the clap signal (0-250|250-500|500-1000|1000-2500|2500-10000|10000-sampling frequency)Hz.
- To determine these band analyzed an exported clap signal Logic's Equalizer

Speed and Pitch Change

Mono/Stereo Change:

- Split the 2D [stereo] matrix created when audioread() is used, into 2 separate mono files.
- Those files are then ran through the same algorithm, independently, and put back together at the very end to create a stereo output.

Demonstration

User has option to either alter or simply find the BPM of an input signal

Alter

- First, import desired audio file
- If you know the BPM enter, if not it finds the BPM
- Now choose input method(Tap, Clap, Song)
  - ○ The tap function allows user to use the spacebar
  - ○ The clap function requires user clap into microphone
  - ○ The song bank displays a list of BPMs available for comparison
    - ■ A snippet from a popular song at that BPM will be played
- User has option to use that BPM as the alteration factor
- If no change in BPM is desired the program also offers the ability to change pitch independently of speed

Find

- Functions the same as alter with no alteration of a signal