UROP RESEARCH PROJECTS

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

Play Guitar Hero on a REAL Guitar!

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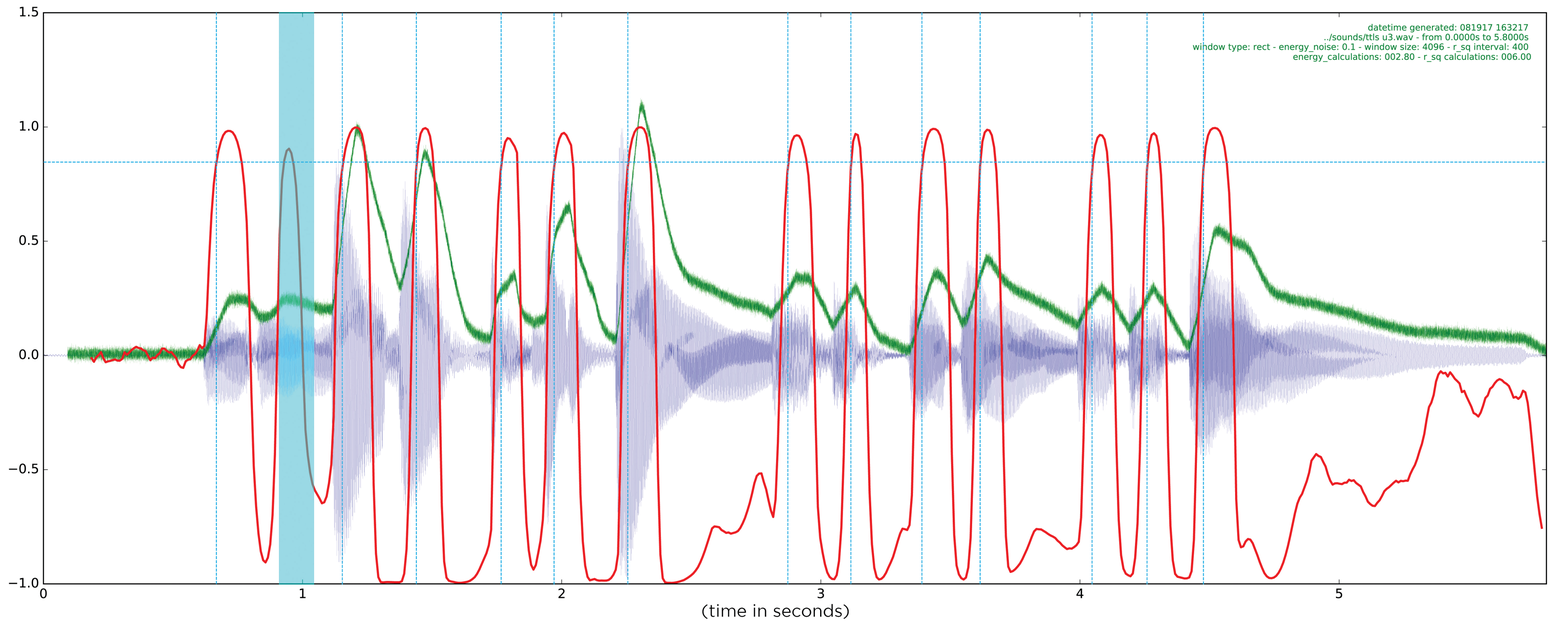
Step 1: When does the note start?

Given an audio piece (blue), determine all the times when a new note starts.



Calculate windowed energy (green)

$$E[t] = \frac{1}{N}\sum_{\tau=0}^{N-1} |s[t-\tau]|$$

Calculate and plot r-value (red)

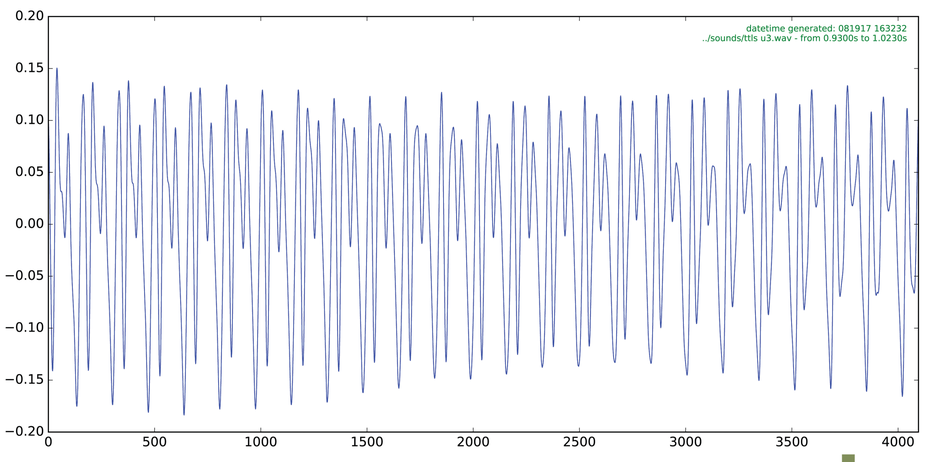
$$r[t] = \frac{\sum_{\tau=0}^{N-1}(E[t-\tau] - \overline{E[t-\tau]})(\tau - \bar{\tau})}{\sqrt{\sum_{\tau=0}^{N-1}\left(E[t-\tau] - \overline{E[t-\tau]}\right)^2}\sqrt{\sum_{\tau=0}^{N-1}(\tau-\bar{\tau})^2}}$$

Identify all the starting points t_s (cyan) where $r[t_s] > 0.85$ and $r[t_s - 1] < 0.85$

Step 2: What is the note?

Given a section of an audio (cyan), determine its pitch.

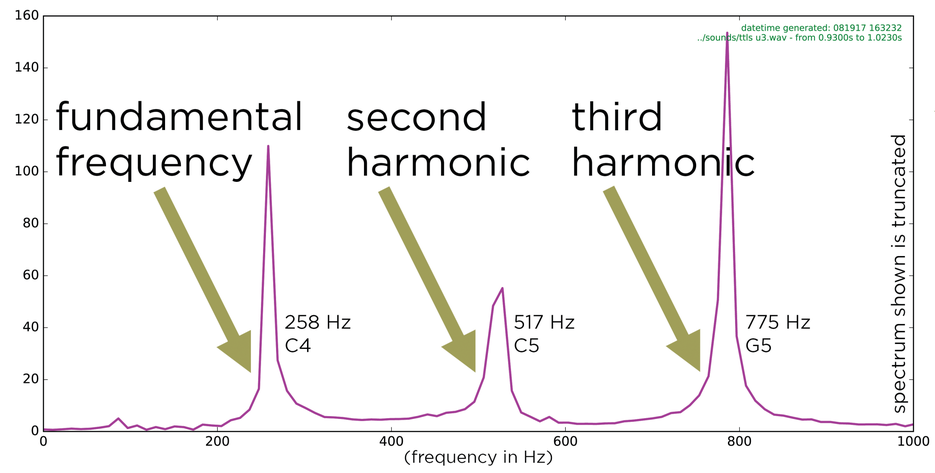
Time domain



Discrete Fourier Transform

$$|FFT(s[t])| = |\hat{s}[k]| = \frac{1}{\sqrt{N}}\left|\sum_{t=0}^{N-1} s[t]\, e^{-2\pi i k t/N}\right|$$

Frequency domain



Harmonic Product Spectrum

To find the fundamental frequency

downsampling

$\hat{s}[k/1]$

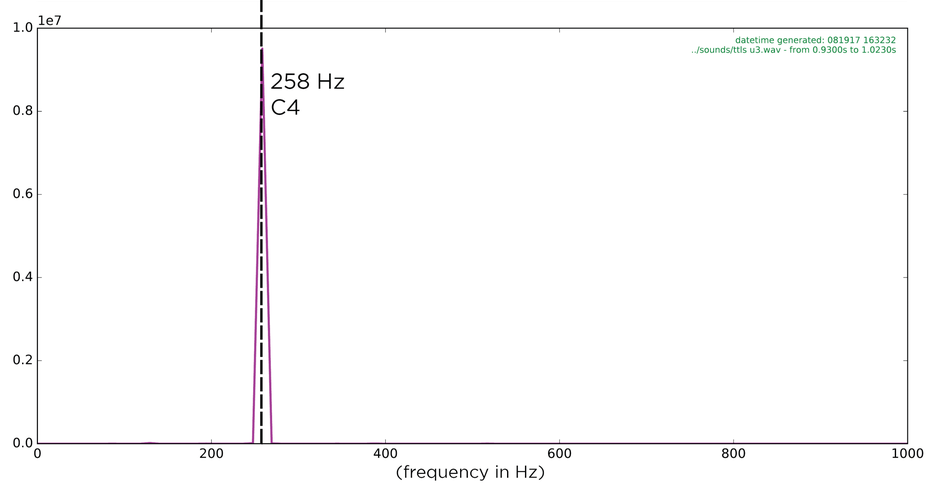
$\hat{s}[k/2]$

$\hat{s}[k/3]$

$\hat{s}[k/4]$

multiply

$$\prod_{b=1}^{4} \hat{s}[k/b]$$



Now try hitting the notes!

APPLICATIONS

For music education.
Review the notes you have played to improve your skills on the instrument.

For learning music theory.
Analyse trends and predict what characteristics do people like.

FUTURE WORK

Polyphonic sound analysis.
Analyse audio with multiple notes playing at a time and determine them.

Optimisation.
Make our methods lightweight with efficient algorithm and code.

RECRUITING

Mathematician.
Champion the understanding of relevant mathematical texts.

App developer.
Implement our algorithms in an app, or web app, and distribute it.