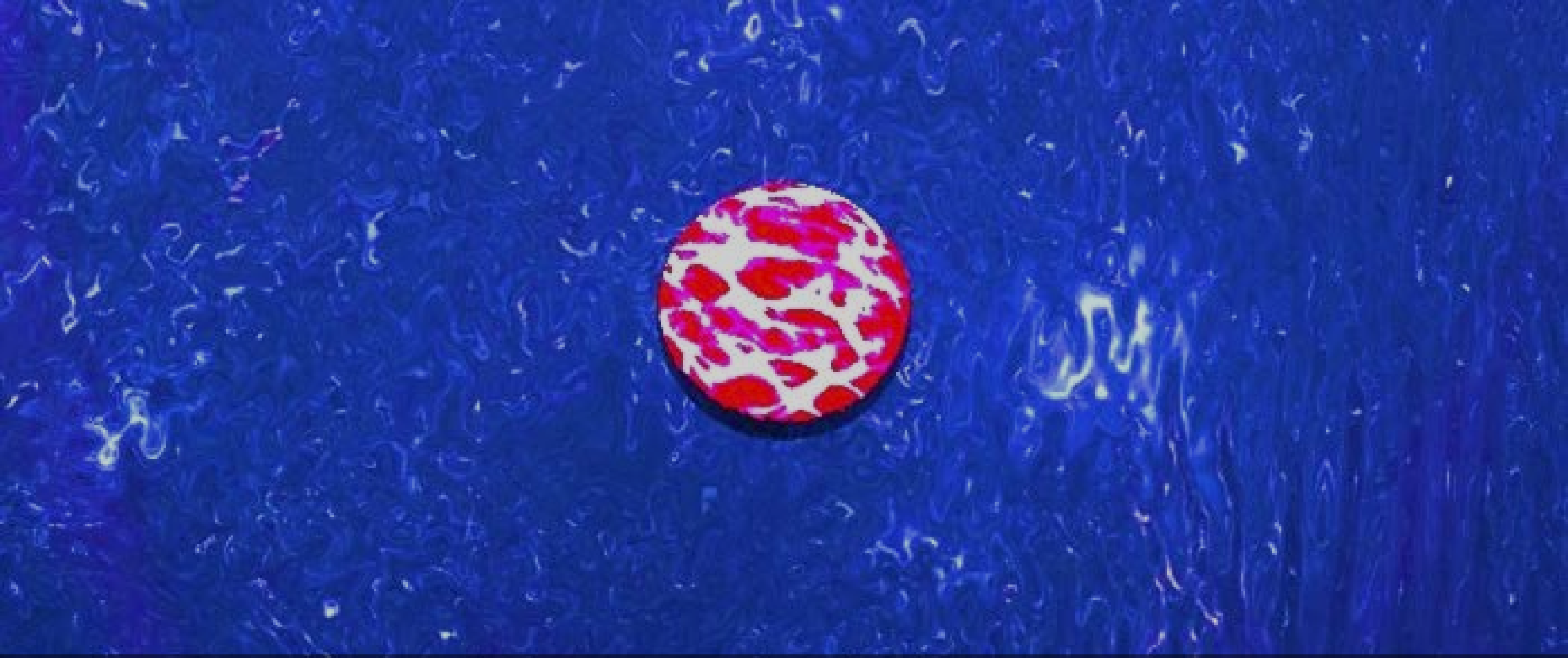


Synthesia

Timbral Classification and Visualization of Synthesized Music

David Hodgson, Qisen Cheng,
Han Shen, Aishwarya Kasa

Background

Motivation - Synesthesia

Audio to light frequency mapping

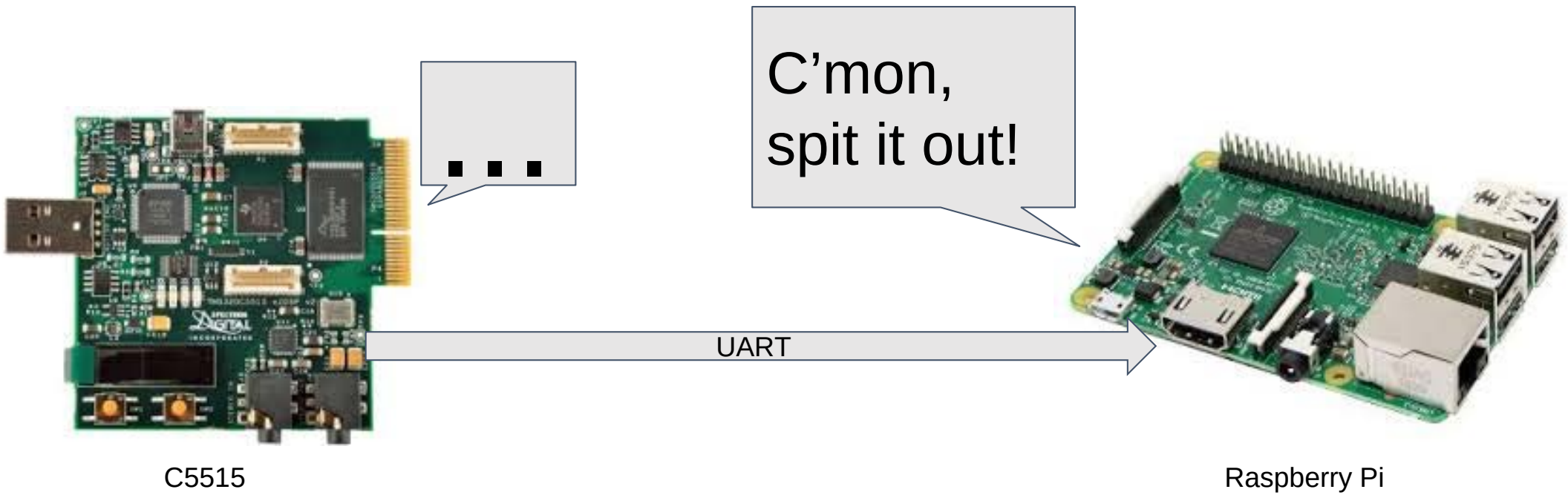
Objective

Visualize sound of an instrument playing in real time

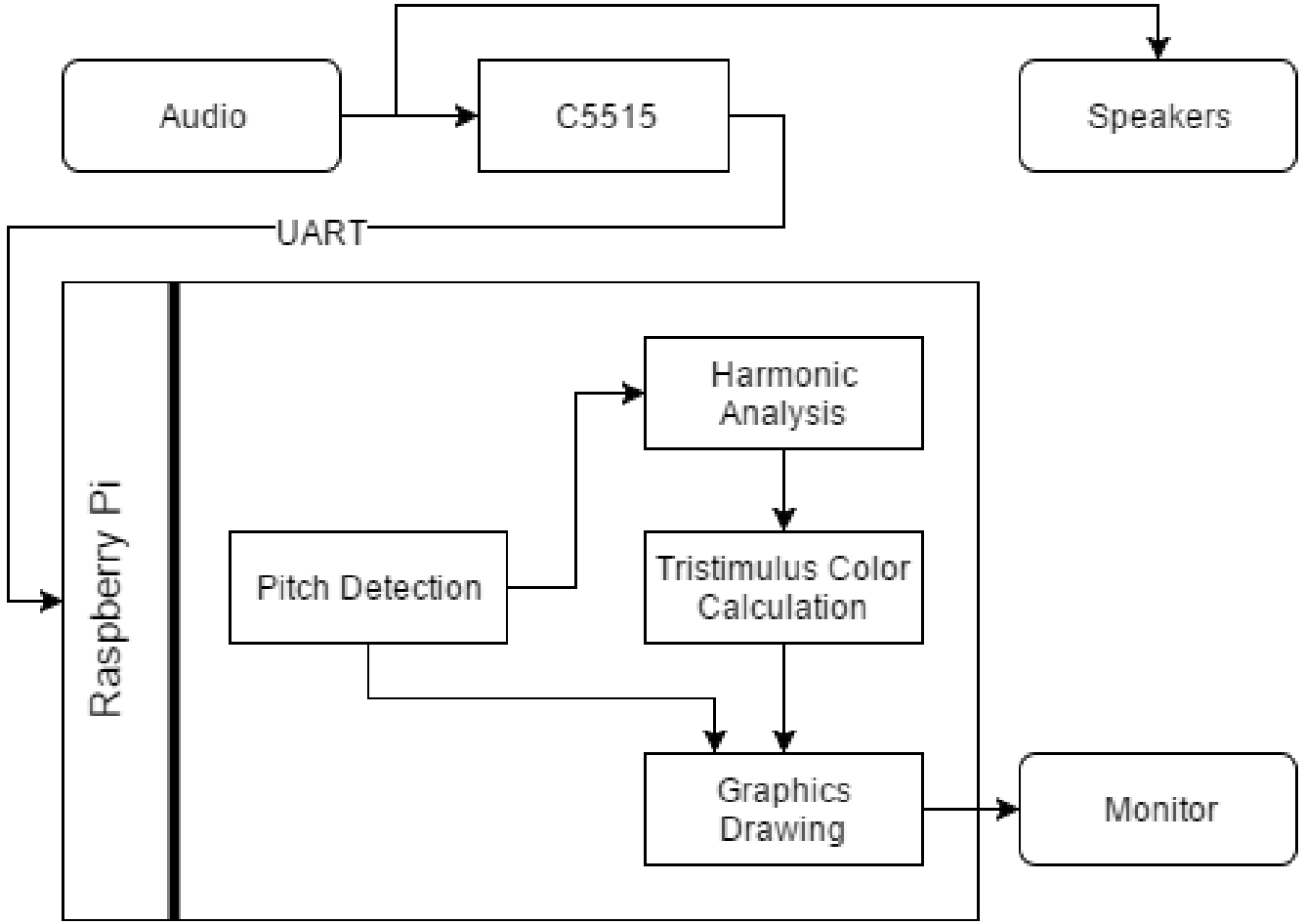
Hardware and Communication

C5515 processing limitations

- Praat / DFT
- FFT size



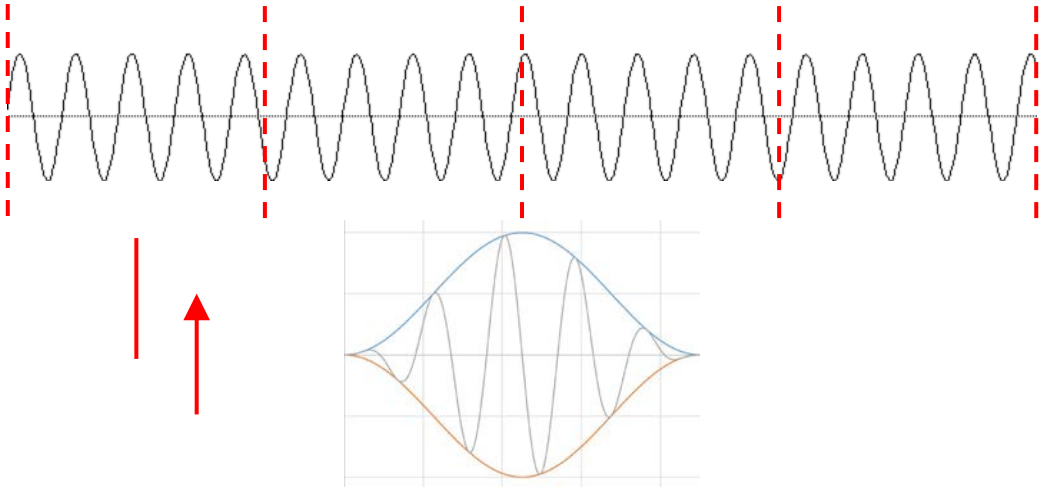
System Overview



Pitch Detection - Praat

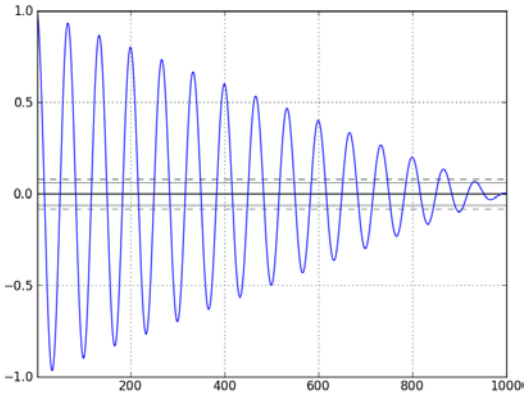
- Fundamental frequency detection
- Implemented in Pi using Python
- Switch to peak picker due to time of calculation (1-2s) of Praat in Pi

Cut audio sample into frames &
Apply hanning window



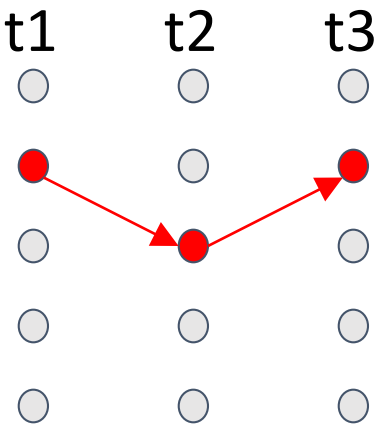
Autocorrelation

$$r_x \equiv \int x(t)x(t+\tau)dt$$



n candidate peaks per frame

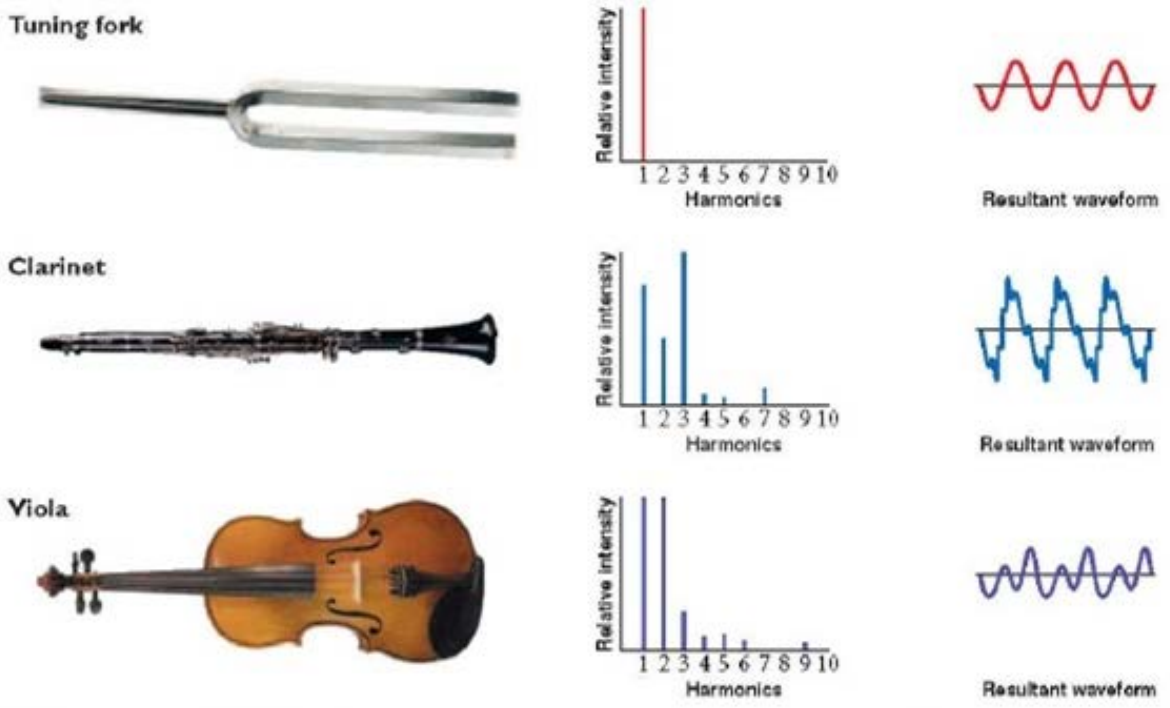
Viterbi
Algorithm



find the most likely
fundamental in each frame

Amplitude Detection

- Harmonics are multiples of fundamental frequency.
- Each instrument usually has unique spectrum (different harmonic amplitudes)
- DFT vs. FFT in C5515



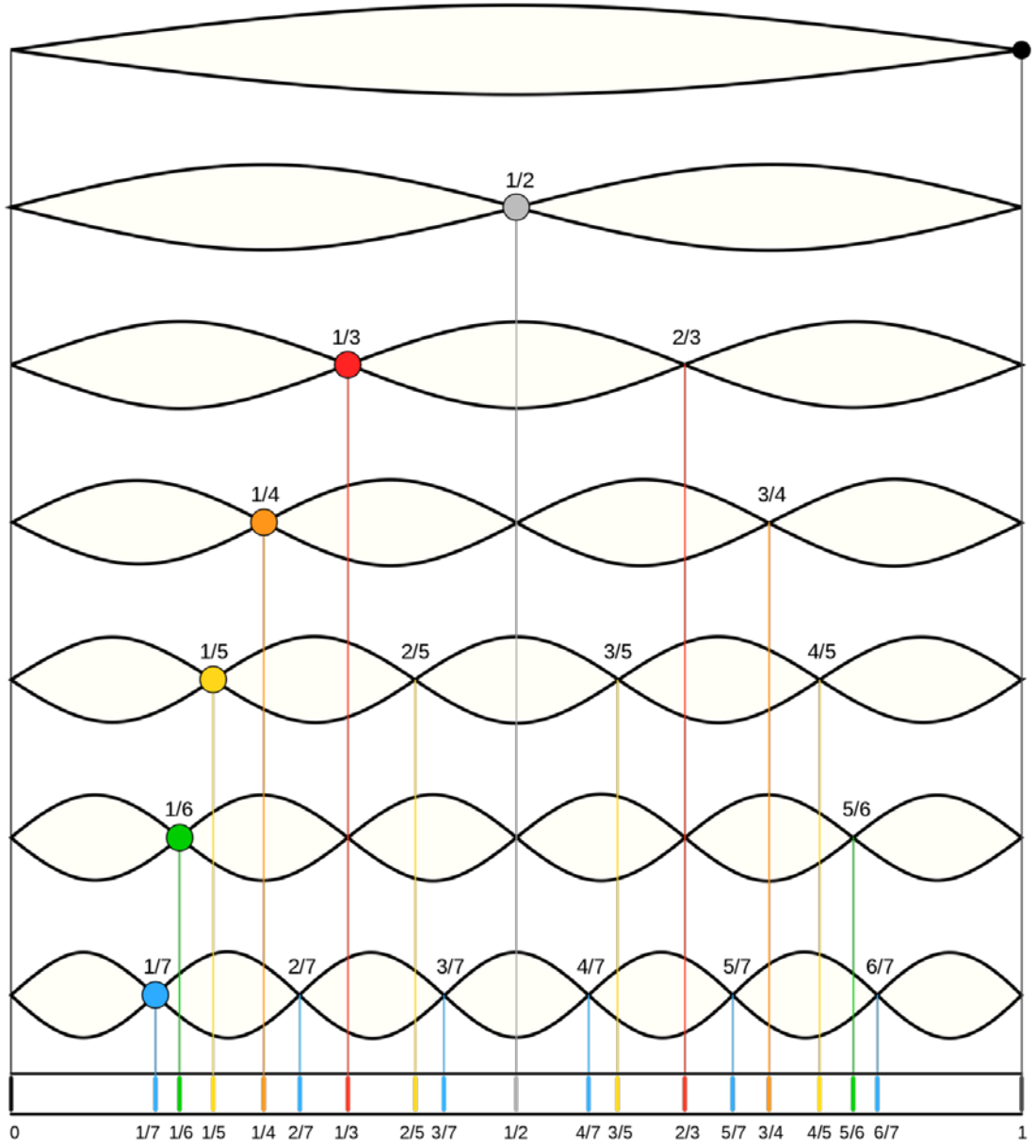
Color Calculation

- Pi3D - object oriented module
- Tristimulus

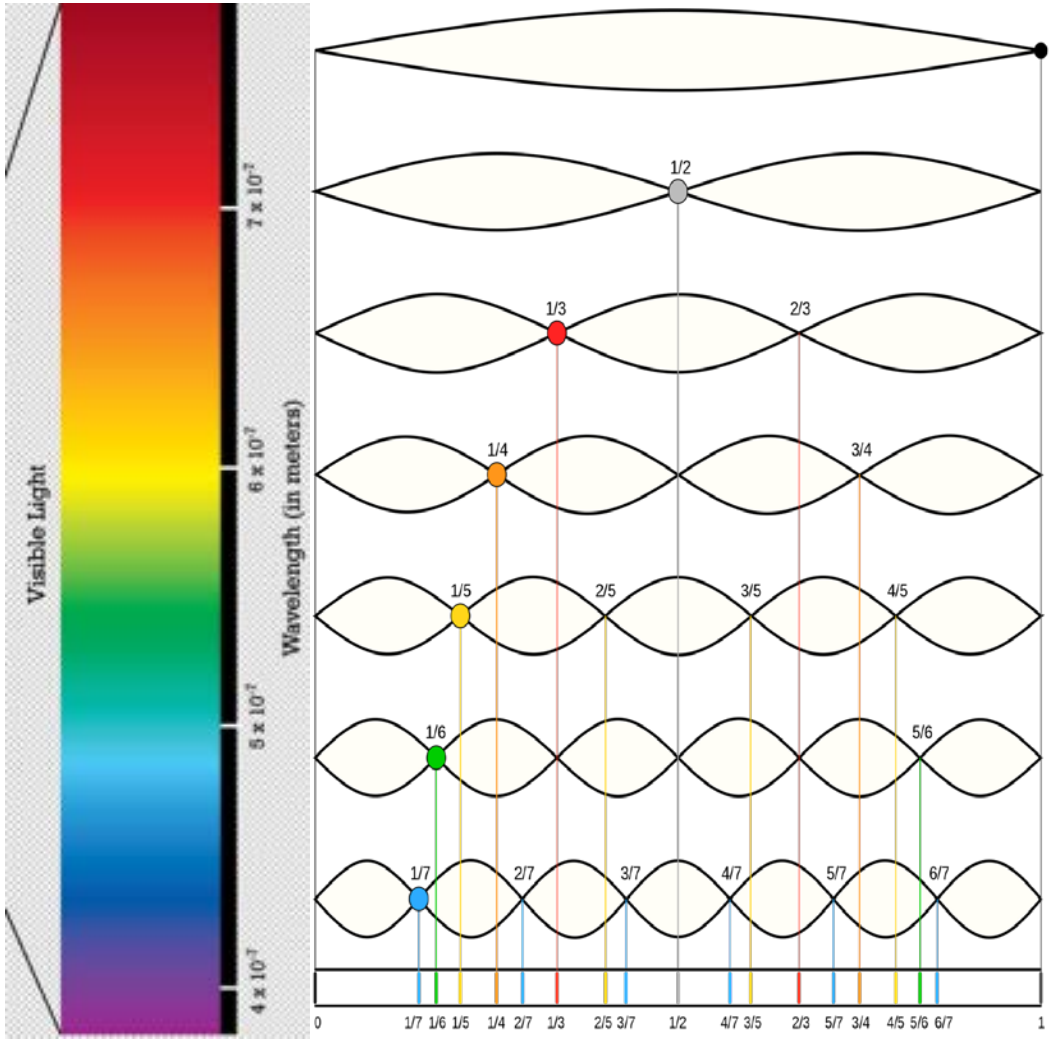
R = $$T1 = \frac{a_1}{\sum_{h=1}^{H} a_h}$$

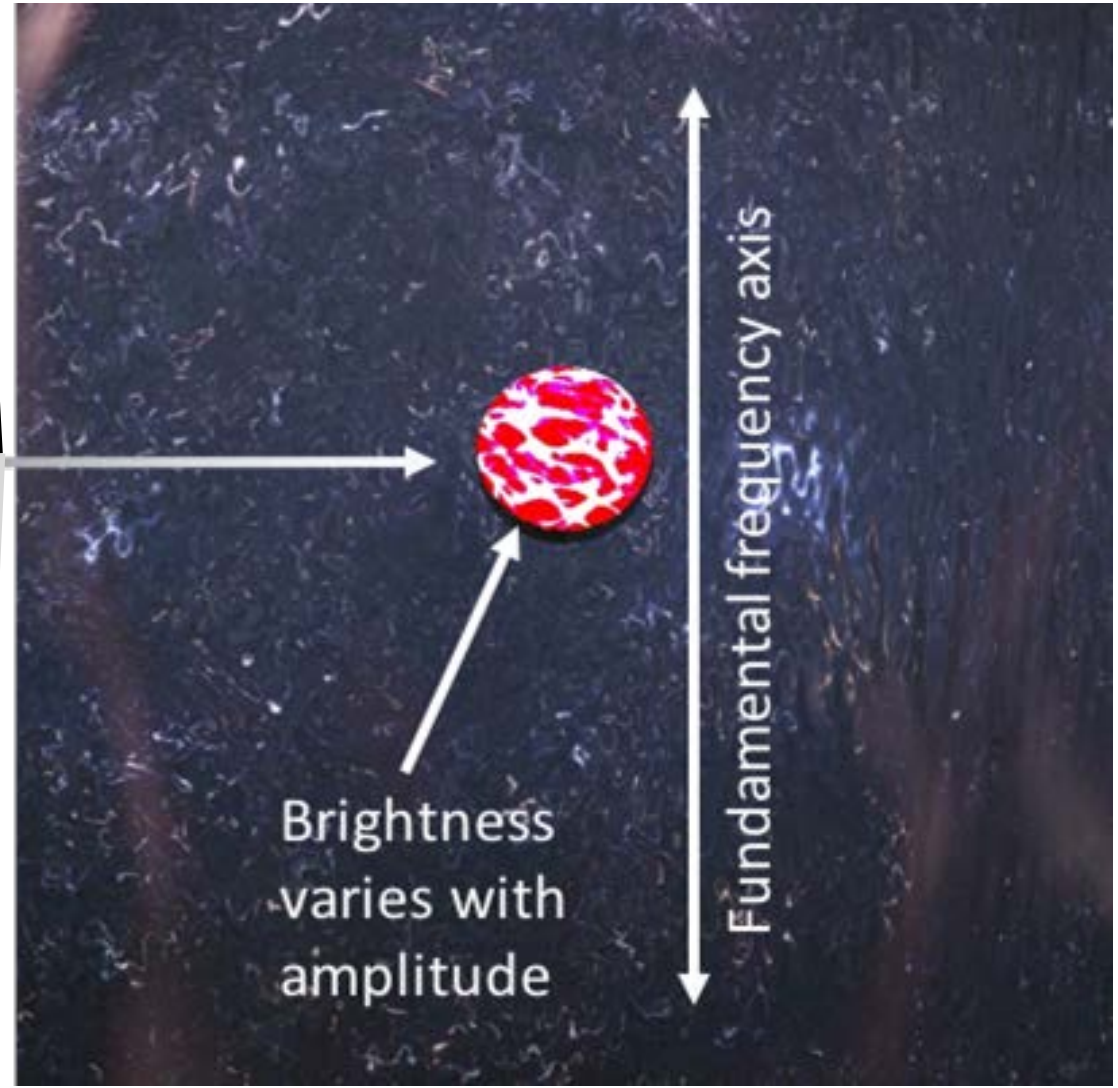
G = $$T2 = \frac{a_2 + a_3 + a_4}{\sum_{h=1}^{H} a_h}$$

B = $$T3 = \frac{\sum_{h=5}^{H} a_h}{\sum_{h=1}^{H} a_h}$$



Visualization





Sound Synthesis

- Using Ableton
  - why we couldn’t use real instruments
  - how harmonics were mapped - keyboard

Machine Learning – Instrument Classification

- 17 feature vector
  - LAT (Log Attack Time)
  - Harmonic deviation
  - Spectral flux D
  - Spectral Bandwidth M
  - MFCC [3,4,6,8] D
  - Zero Crossing D
  - Spectral Centroid D
  - MFCC [2,3,4,5,6,10] M
  - Temporal Centroid

Reference: J.D. Deng, C. Simmermacher, S. Cranefield, "A Study on Feature Analysis for Musical Instrument Classification", *IEEE Transactions on Systems Man and Cybernetics Part B: Cybernetics*, vol. 38, no. 2, pp. 429-438, 2008

Machine Learning

- Data : 2000 single instrument samples by IRMAS
- 3 instrument database
- training accuracy ~ 90% (SVM)
- Testing accuracy ~ 85% (SVM)
- Prediction time 3-7s (not fit for real time)

Reference: http://www.mtg.upf.edu/download/datasets/irmas

Progress

- Milestone #1
  - Finding fundamental for non-overlapping spectra
  - Working on machine learning algorithm for classification
- Milestone #2
  - Correctly analyze harmonics in C5515 based on given fundamental
    - To debug praat module for extracting fundamental
  - Sending and receiving data between C5515 and Pi over UART
  - Working on-screen graphic that reflects changes in harmonics
    - Using Tristimulus equation
  - Instrument classification using machine learning
    - To improve accuracy

References

- J.D. Deng, C. Simmermacher, S. Cranefield, "A Study on Feature Analysis for Musical Instrument Classification", *IEEE Transactions on Systems Man and Cybernetics Part B: Cybernetics*, vol. 38, no. 2, pp. 429-438, 2008
- Sang Hyun Park," Musical Instrument Extraction through Timbre Classification", NVIDIA Corporation Santa Clara, CA 95050
- http://www.mtg.upf.edu/download/datasets/irmas
- Professor Wakefield for Praat Matlab code

Questions?