INTRODUCTION TO COMPUTER MUSIC

SPECTRAL CENTROID

An estimate of brightness

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Project 3

- Goal: Use spectral centroid to control FM synthesis parameters
- What's a spectral centroid?
- Example code

Discrete Fourier Transform

$$R_k = \sum_{i=0}^{N-1} x_i \cos(2\pi ki / N)$$

$$X_k = -\sum_{i=0}^{N-1} x_i \sin(2\pi ki / N)$$

How to Interpret a Discrete Spectrum

- These points X_k and R_k are evenly (linearly) spaced in frequency.
- Point $R_{N/2}$ is at SR / 2.
- Points X_k and R_k are at (*k* / (*N*/2)) * (SR / 2) = *k* * SR / *N* Hz.
- Frequency spacing (width of "bins") is SR / *N* Hz – the "bin width"
- Example: SR=44100 Hz, FFT size = 1024 points, bin size = 44100/1024 = 43.0664 Hz
- FFT takes in *N* samples and outputs *N values*
- This must be because FFT and Inverse FFT preserve information: *N*-dimensions in, *N*-dimensions out
- The output values are:
  - R_0 – the "DC" component
  - X_0 – always zero, not in output
  - R_1, X_1, R_2, X_2, … $R_{N/2-1}$, $X_{N/2-1}$
  - $R_{N/2}$ – the "Nyquist" component
  - $X_{N/2}$ – always zero, not in output
- Note there are *N* points as expected

Discrete Magnitude (or Amplitude) Spectrum

- Magnitude $A_k = \text{sqrt}(R_k^2 + X_k^2)$
- The magnitude spectrum is:
  - $A_0 , A_1 , \ldots , A_{N/2}$
- Note there are $N/2+1$ points.
- How can this be? There are only $N/2-1$ non-zero phases, so we still have N total dimensions.

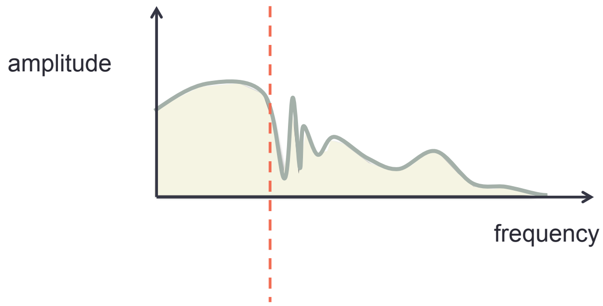
Spectral Centroid

- Weighted average of the magnitude (amplitude) spectrum:

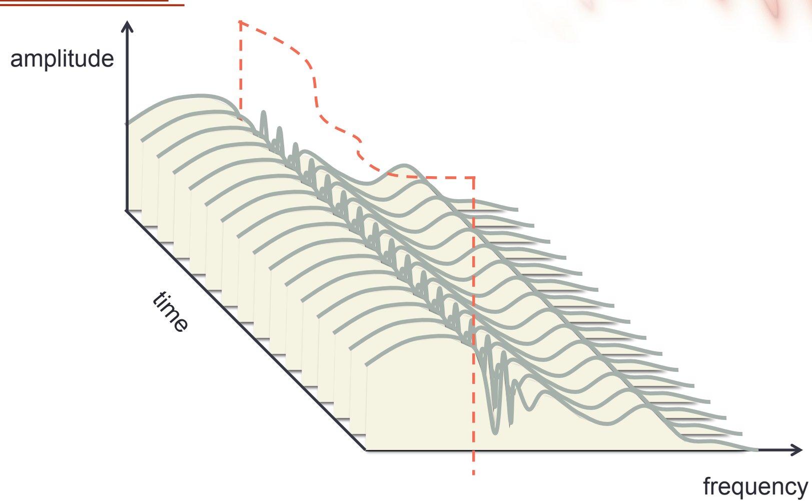
$$spectral\ centroid = \frac{\sum_{i=0}^{N} i \cdot w \cdot A_i}{\sum_{i=0}^{N} A_i}$$

- w is the width of each spectral bin in Hz
- w = sample rate / size of the FFT in samples

Spectral Centroid



Time-Varying Spectral Centroid



Review Project 3 Code Examples