Low level Audio Features

by Nimesh Gautam

Dimensions of Types of Audio Features

- Level of abstraction
- Temporal Scope
- Musical aspect
- Signal Domain
- ML approach

LEVEL OF ABSTRACTION

1. HIGH LEVEL FEATURES

   CHORDS, RHYTHM, MELODY, GENRE, ETC

2. MEDIUM LEVEL FEATURES

   PITCH, NOTE ONSETS, MFCC, ETC

3. LOW LEVEL FEATURES

LOW LEVEL AUDIO FEATURES

- Typically Computed directly from raw audio waveform
- Simple statistical summaries of waveform

LOW LEVEL AUDIO FEATURES

1. Amplitude Envelope (TD)
2. RMS Energy (TD)
3. Zero- Crossing Rate (TD)
4. Band energy ratio (FD)
5. Spectral Centroid (FD)
6. Spectral Spread/ Bandwidth (FD)
7. Spectral flux, etc. (FD)

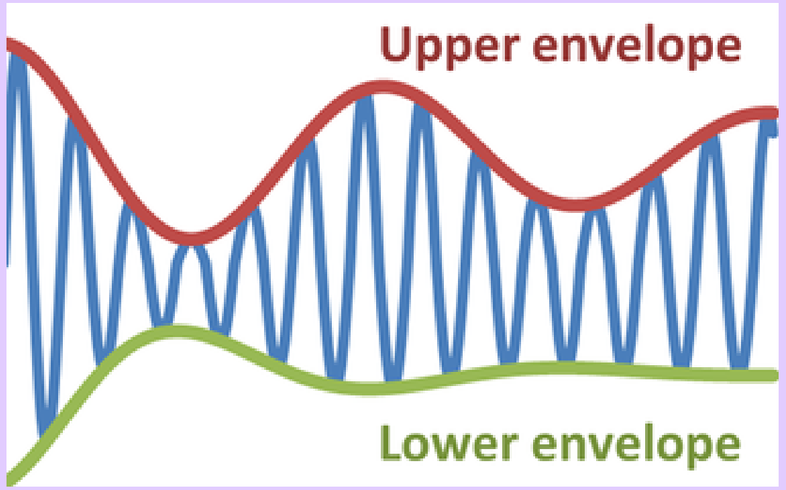
TD = Time Domain

FD = Frequency Domain

Amplitude Envelope

INTRODUCTION:

- Envelope is a smooth curve outlining extremes of an oscillating signal
- Maximum amplitude among all samples in a frame



Source: Wikipedia

TD

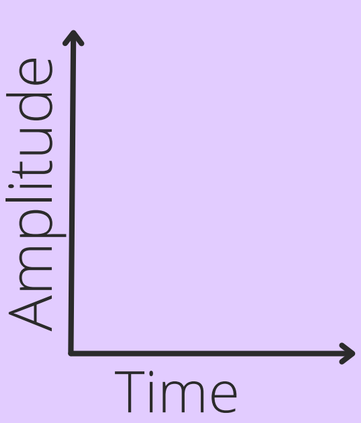
Amplitude Envelope

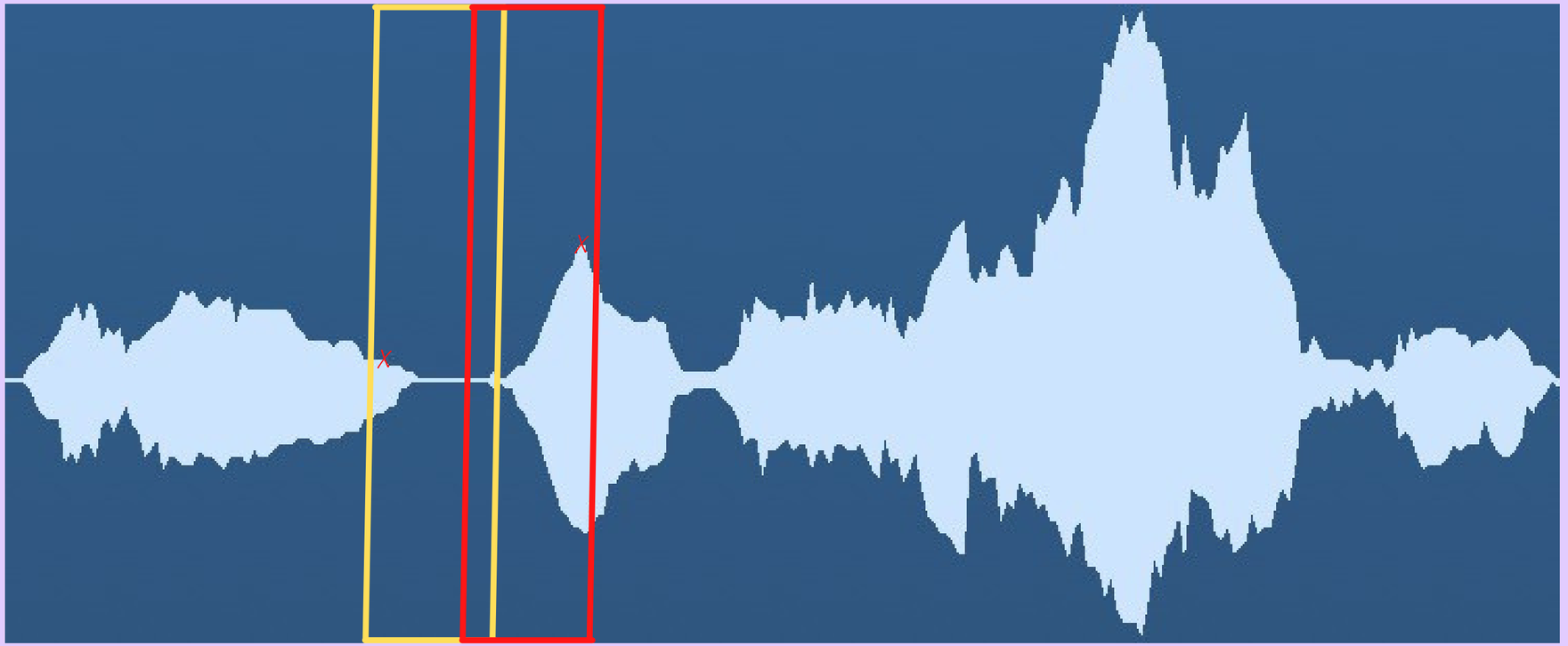
COMPUTATION

$$AE(t) = \max_{k=t.K}^{(t+1).K-1} s(k)$$

K = Frame size

s(k) = Amplitude of kth sample

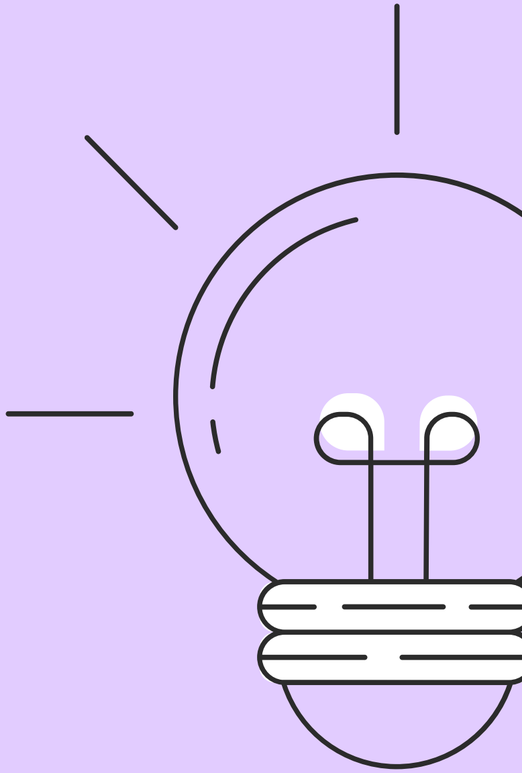




Amplitude Envelope

USES:

- Onset Detection
- Music Genre classification
- Gives rough idea about loudness

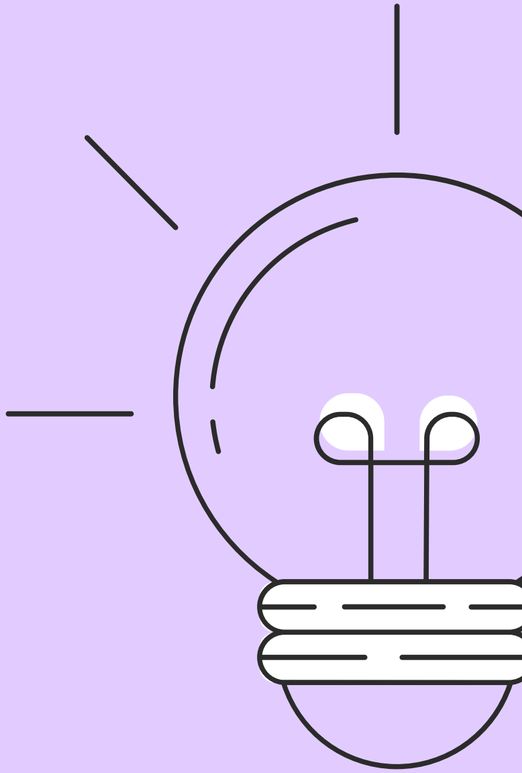


TD

RMS Energy/ Power/ Level

INTRODUCTION:

- Root Mean Square Energy
- Indicator of loudness
- Less sensitive to outliers than Amplitude Envelope



TD

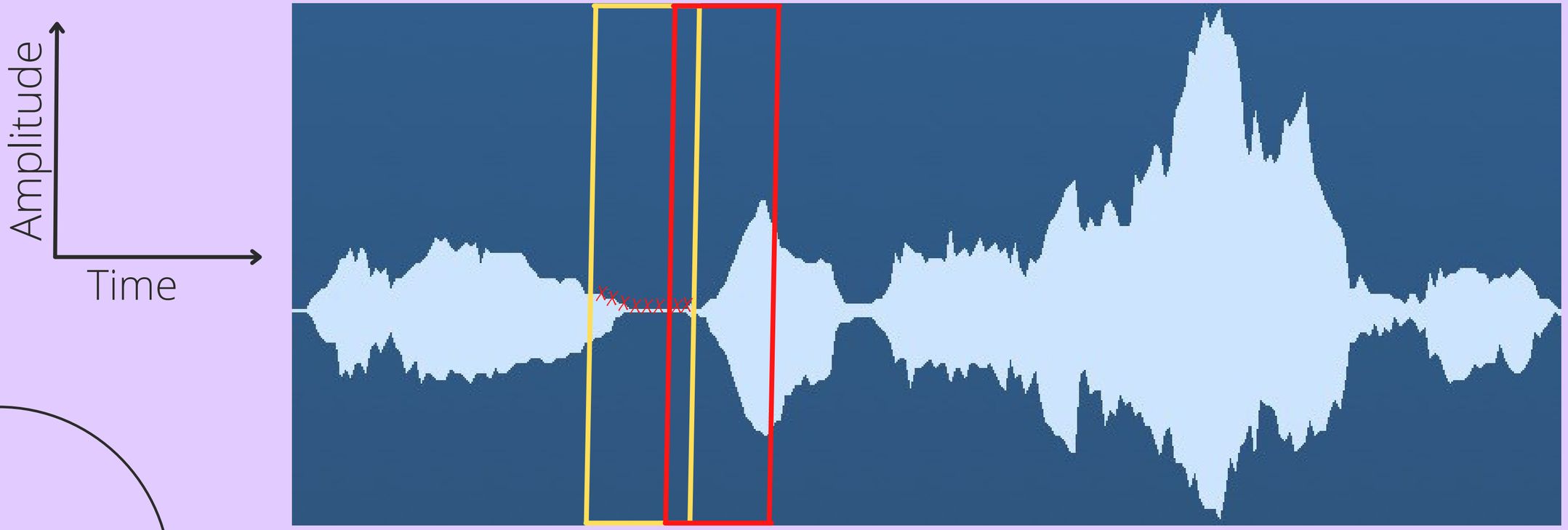
RMS Energy

COMPUTATION

$$RMS_t = \sqrt{\frac{1}{K} \cdot \sum_{k=t \cdot K}^{(t+1) \cdot K - 1} s(k)^2}$$

K = Frame size

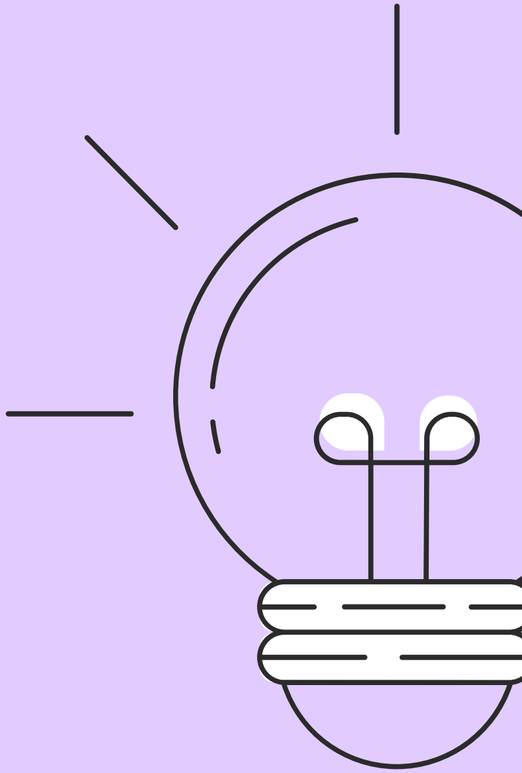
s(k) = Amplitude of kth sample



RMS Energy

USES:

- Indicator of loudness
- Audio segmentation
- Music Genre classification

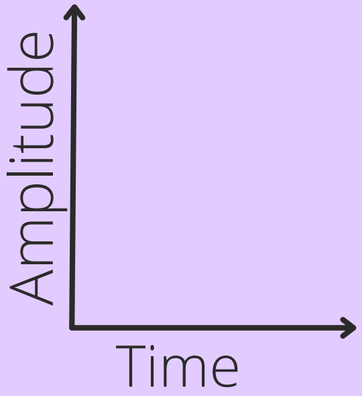


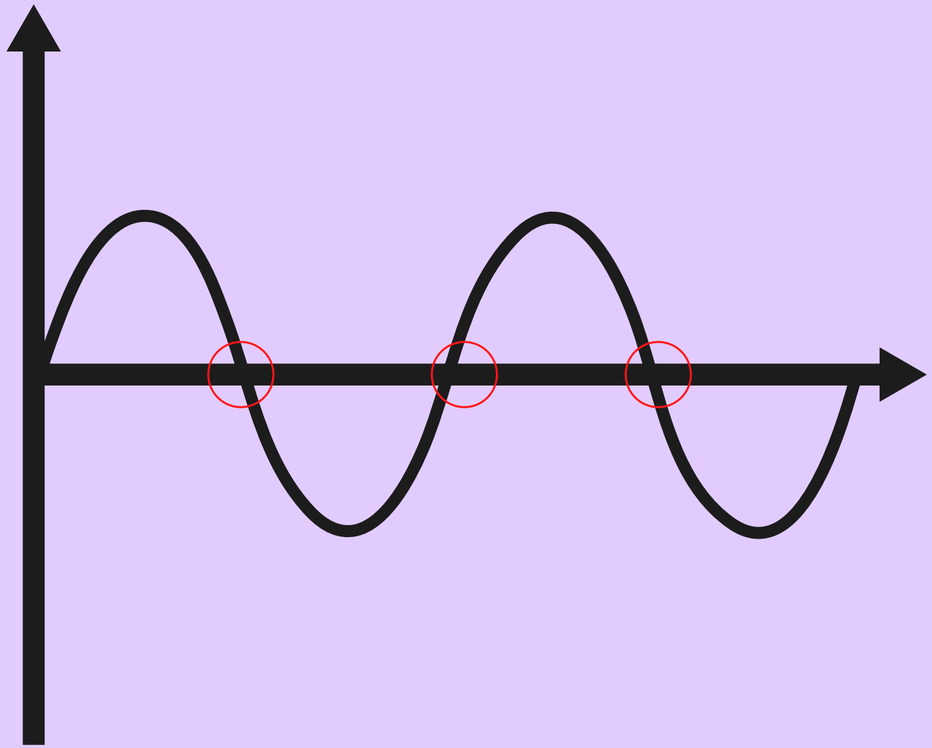
TD

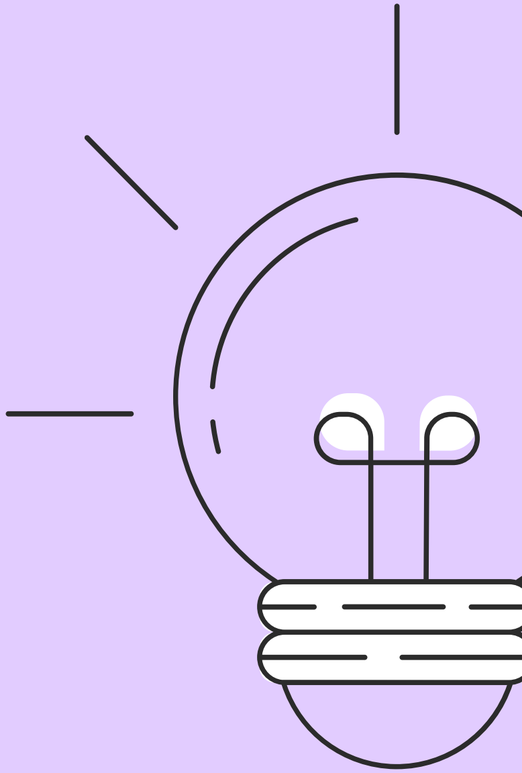
Zero Crossing Rate

INTRODUCTION:

- No of times a signal crosses the Horizontal Axis





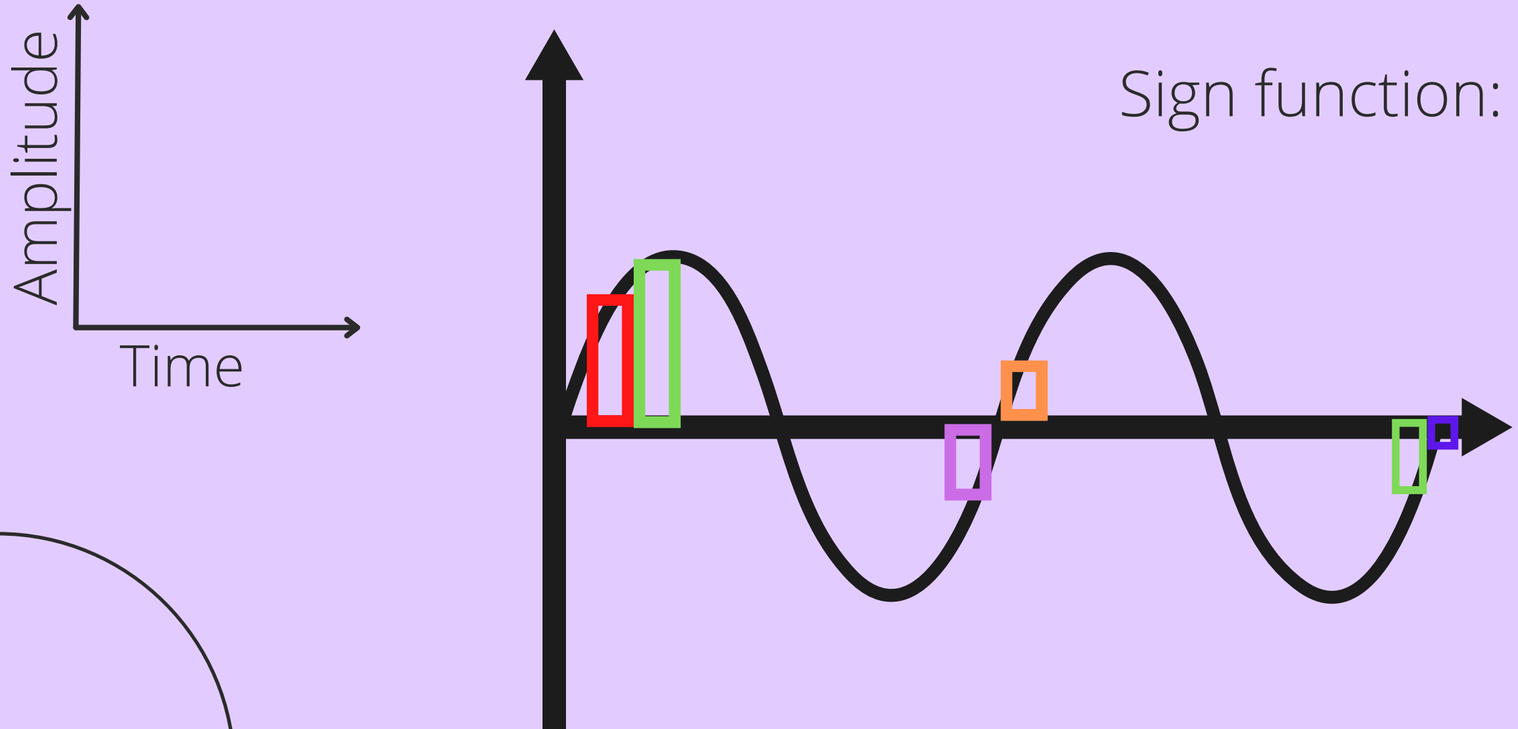


TD

Zero Crossing Rate

COMPUTATION

$$ZCR_t = \frac{1}{2} \cdot \sum_{k=t \cdot K}^{(t+1) \cdot K - 1} |\operatorname{sgn}(s(k)) - \operatorname{sgn}(s(k+1))|$$



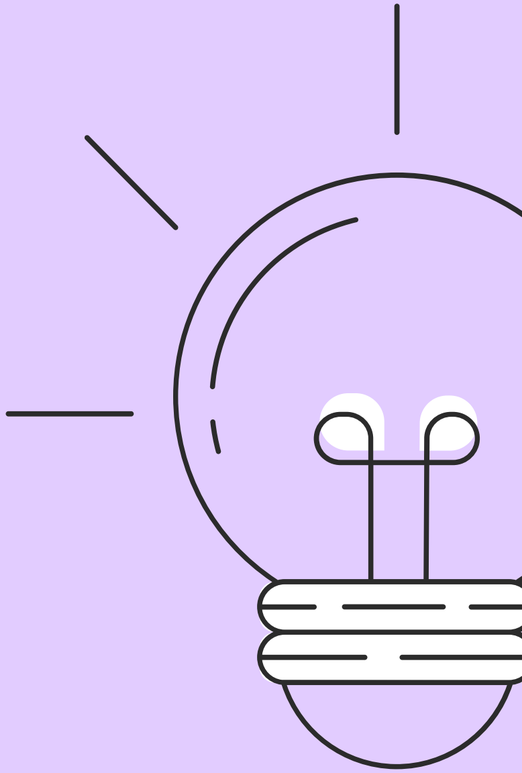
Sign function:

s(k) > 0	+1
s(k) < 0	-1
s(k) = 0	0

Zero Crossing Rate

USES:

- Recognition of percussive vs pitches sounds
- Monophonic pitch estimation
- Voice/ unvoiced decision for speech signals

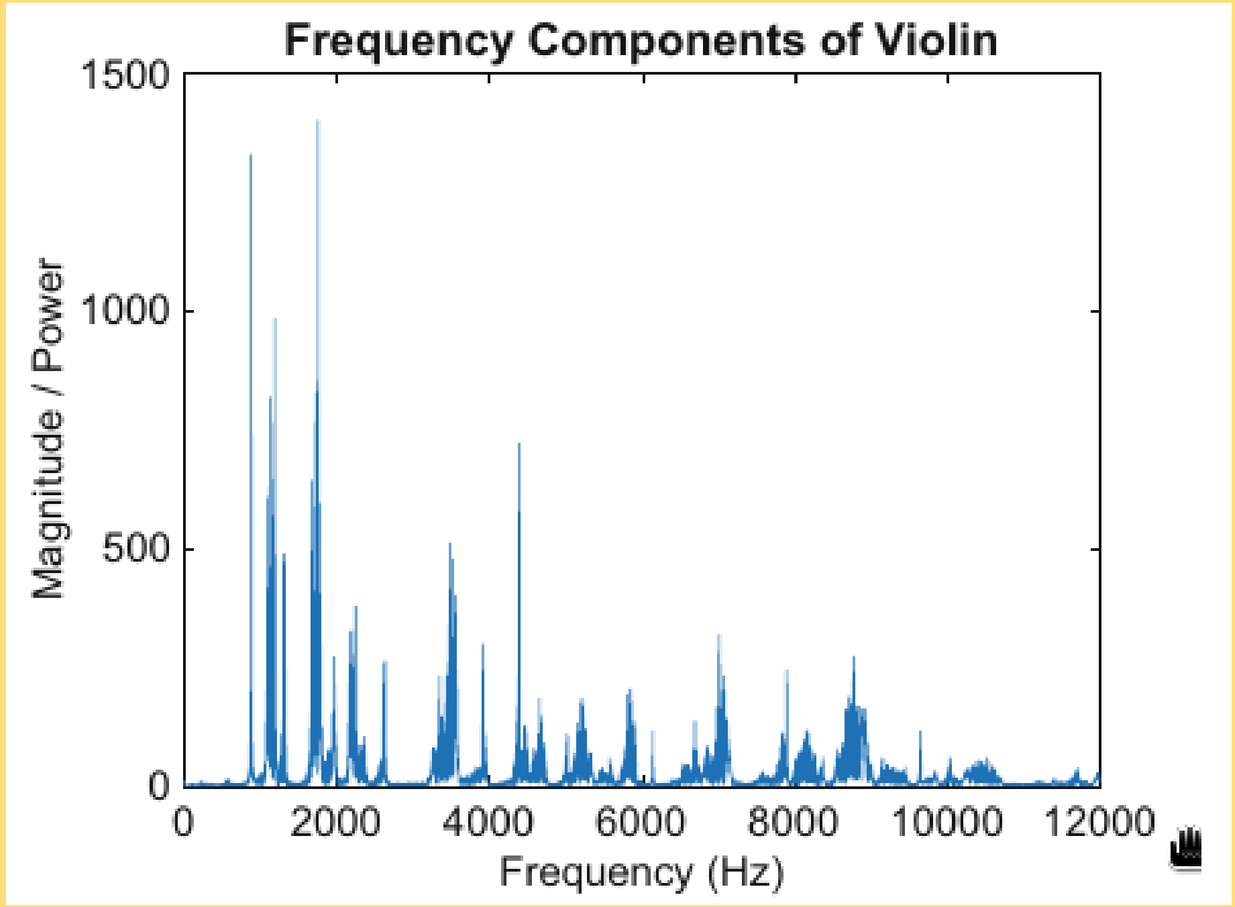


TD

Frequency Domain Plot

Time Domain Plot

Fourier Transform

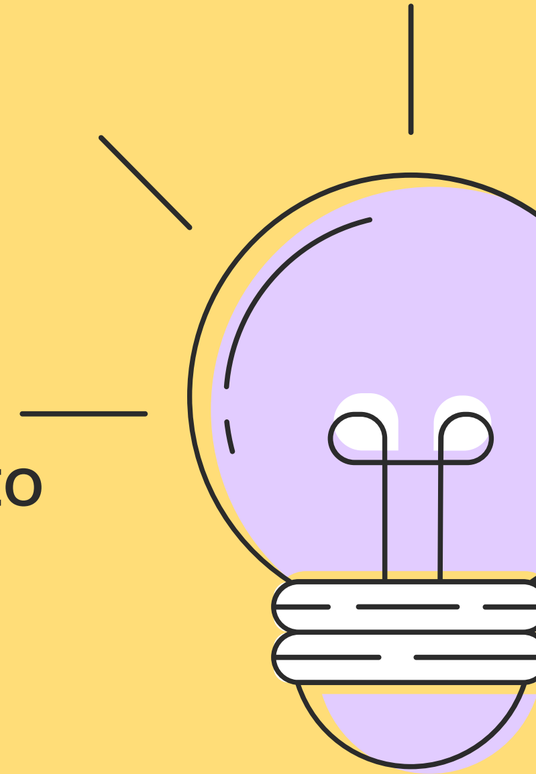


source(book): Music SImilarity and Retreival, Peter Knees, Markus Schedl

Band Energy Ratio

INTRODUCTION:

- Relates the energy in the lower frequency bands to the energy in higher bands.
- Measure of how dominant low frequency are



FD

Band Energy ratio

COMPUTATION

$$BER_t = \frac{\sum_{n=1}^{F-1} m_t(n)^2}{\sum_{n=F}^{N} m_t(n)^2}$$

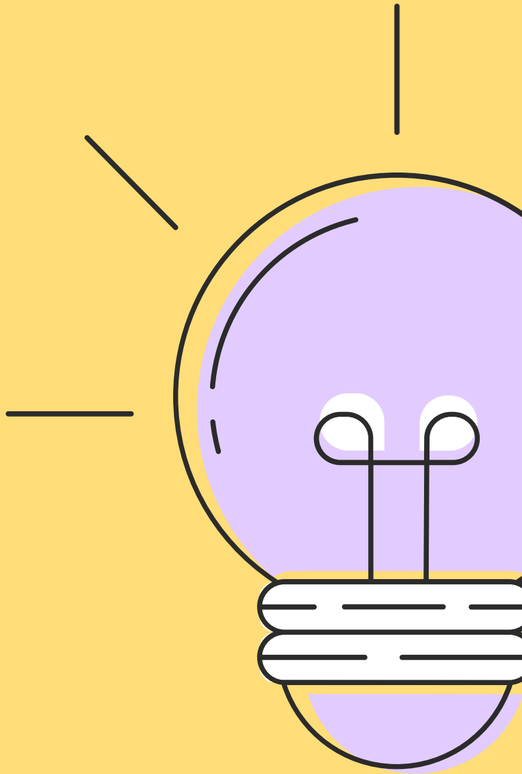
F = split frequency band

mt(n) = Magnitude of signal in frequency domain in frequency band n

Band Energy Ratio

USES:

- Speech/ Music discrimination
- Music Genre classification

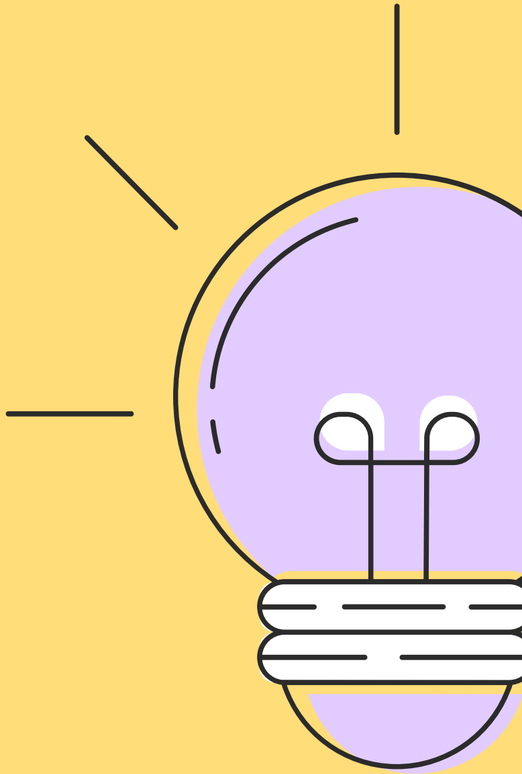


TD

Spectral Centroid

INTRODUCTION:

- Center of gravity of the magnitude spectrum
- Frequency band where most of the energy is concentrated
- Measure of brightness of sound



FD

Spectral Centroid

COMPUTATION

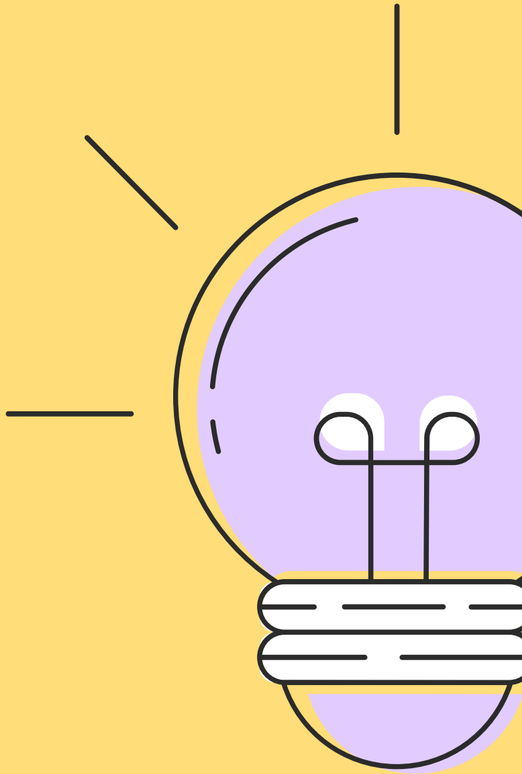
$$SC_t = \frac{\sum_{n=1}^{N} m_t(n) \cdot n}{\sum_{n=1}^{N} m_t(n)}$$

mt(n) = Magnitude of signal in frequency domain in frequency band n

Spectral Centroid

USES:

- Audio Classification
- Music Classification

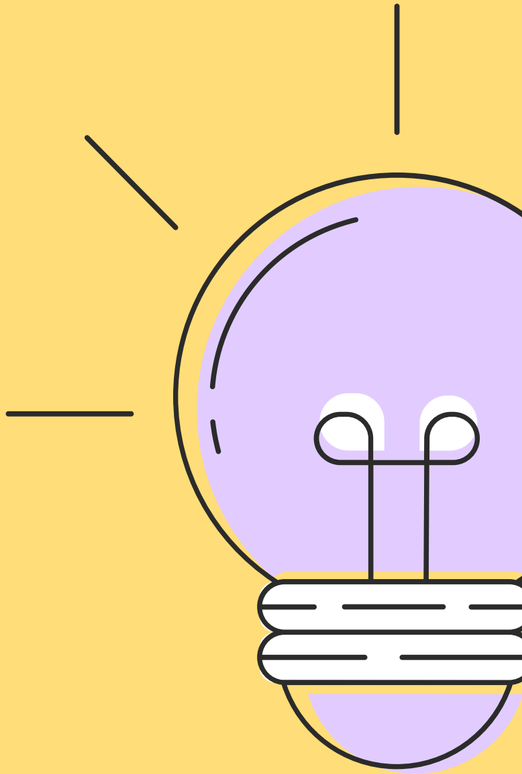


TD

Spectral Flux

INTRODUCTION:

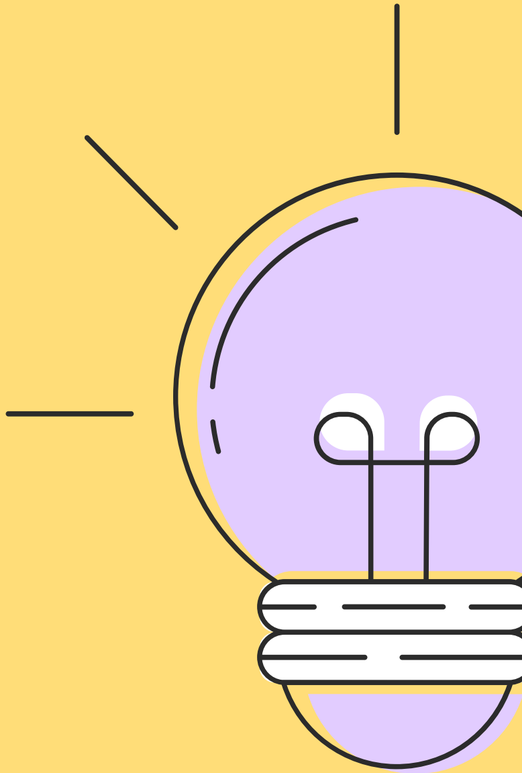
- Describes change in power spectrum between consecutive frames
- Used in onset detection, speech detector
- Describing timbre of an audio signal



FD

Spectral Flux

COMPUTATION



$$SF_t = \sum_{n=1}^{N} (D_t(n) - D_{t-1}(n))^2$$

Dt = frame by frame normalized frequency distribution in frame t

Thank You

by Nimesh Gautam