Time-domain features

- Amplitude envelope (AE)
- Root-mean-square energy (RMS)
- Zero-crossing rate (ZCR)
- ...

Amplitude envelope

- Max amplitude value of all samples in a frame

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Amplitude of *k*th sample

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Amplitude envelope at frame *t*

Frame size

Amplitude of *k*th sample

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Amplitude envelope at frame *t*

First sample of frame *t*

Amplitude of *k*th sample

Amplitude envelope

- Max amplitude value of all samples in a frame

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Amplitude envelope at frame *t*

First sample of frame *t*

Last sample of frame *t*

Amplitude of *k*th sample

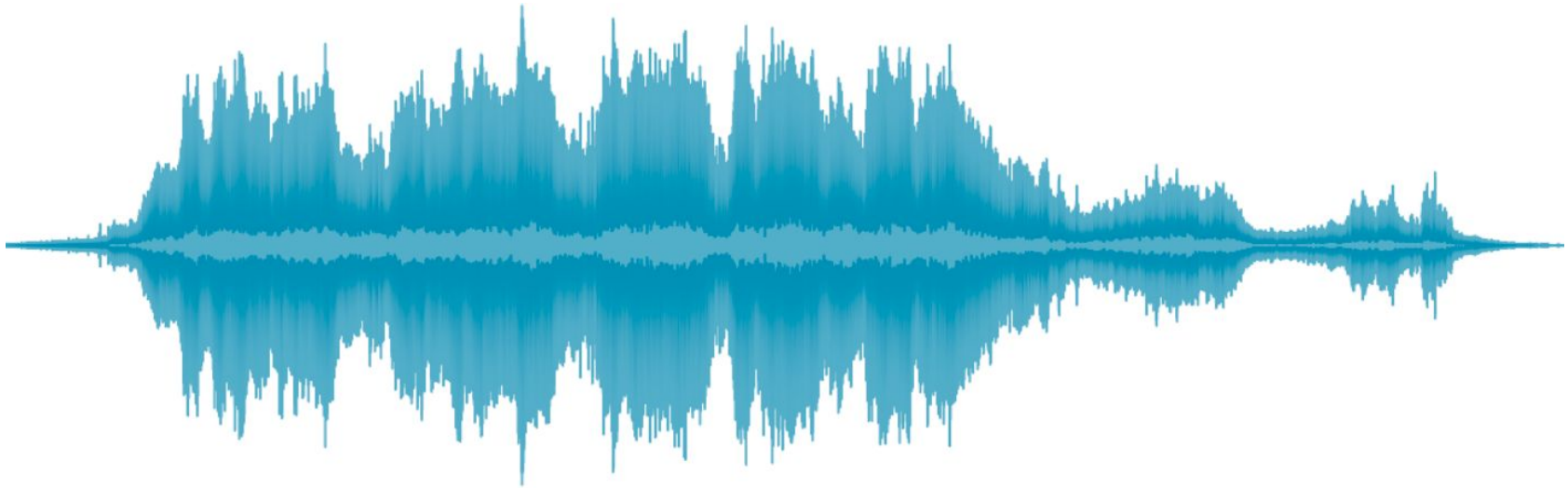
Amplitude envelope

- Max amplitude value of all samples in a frame

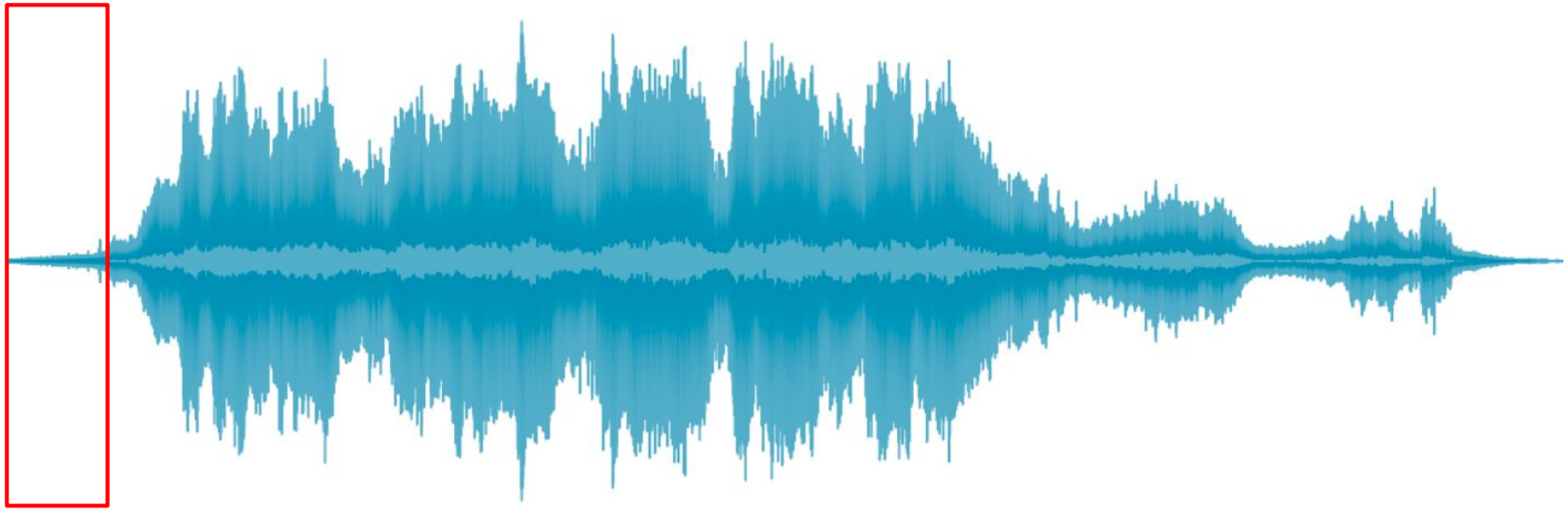
$$AE_t = \max_{k=t\cdot K}^{(t+1)\cdot K-1} s(k)$$

Calculate AE for all the frames

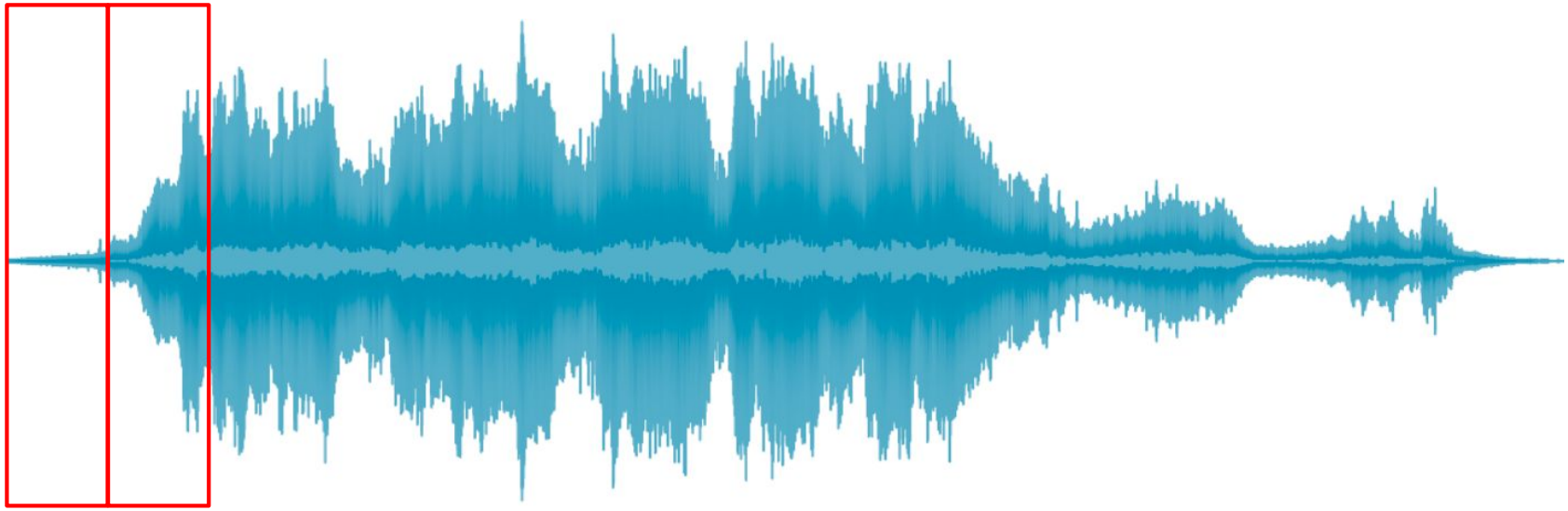
Amplitude envelope



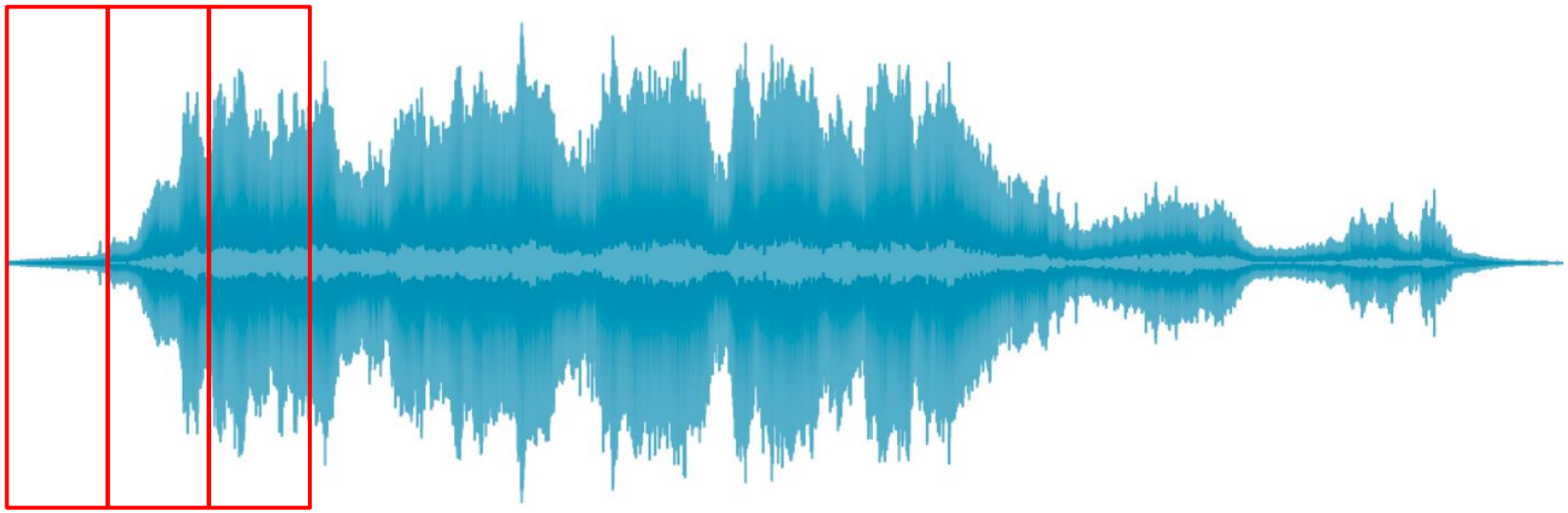
Amplitude envelope



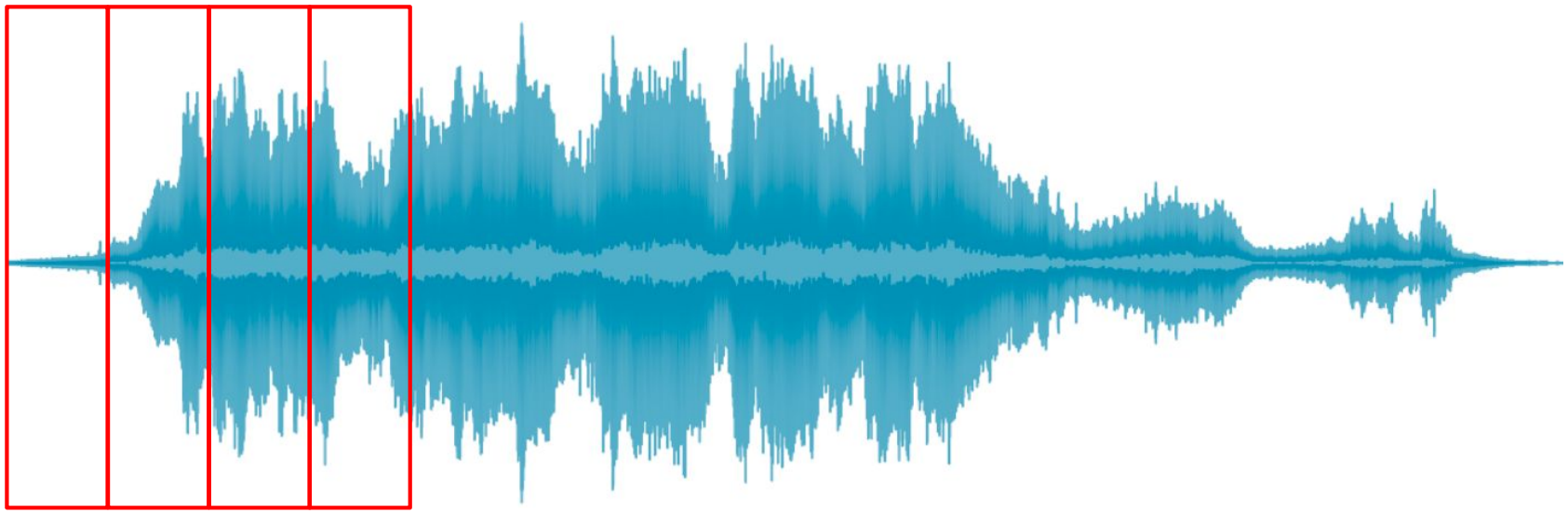
Amplitude envelope



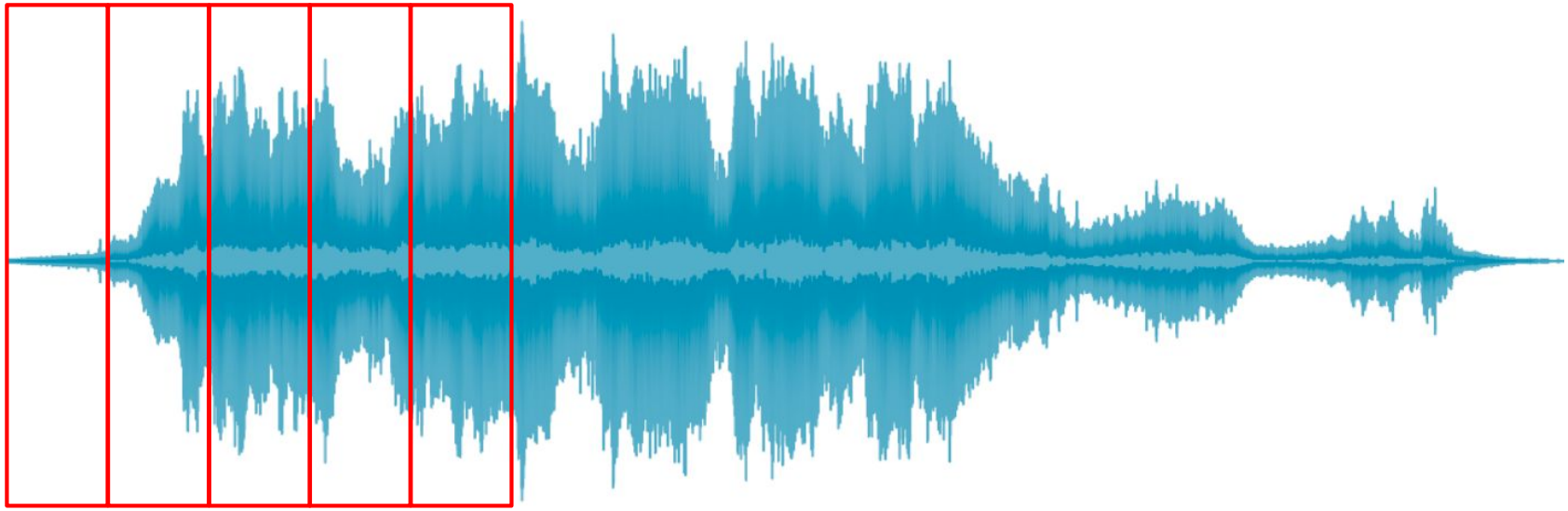
Amplitude envelope



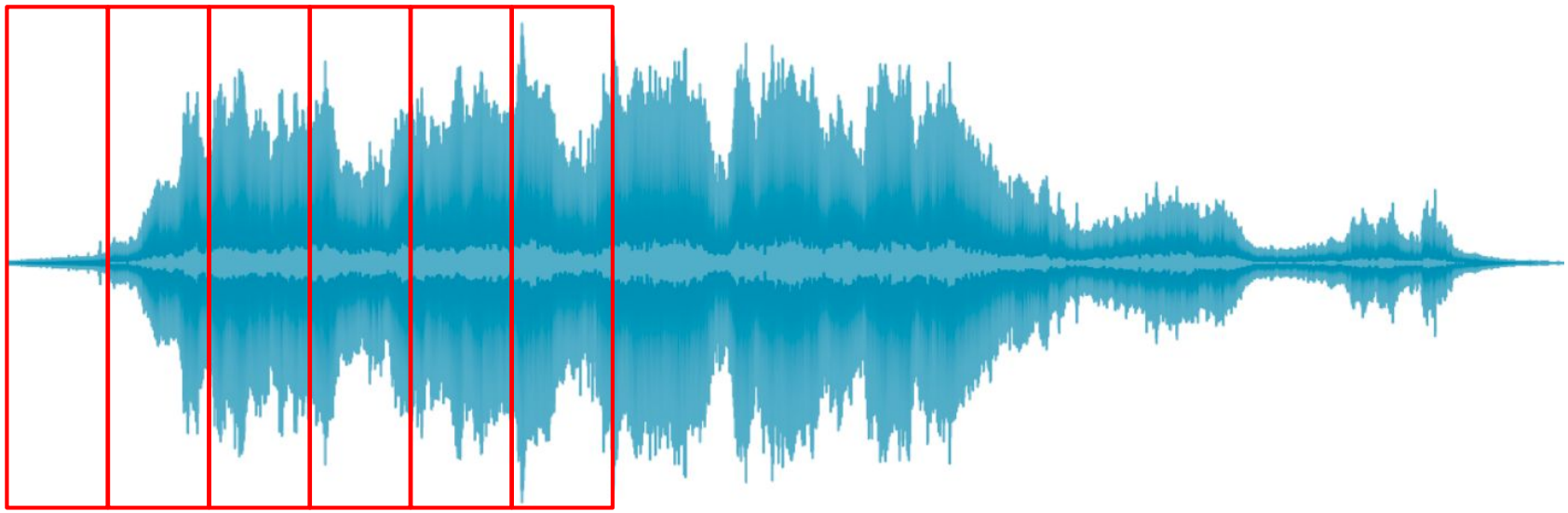
Amplitude envelope



Amplitude envelope



Amplitude envelope



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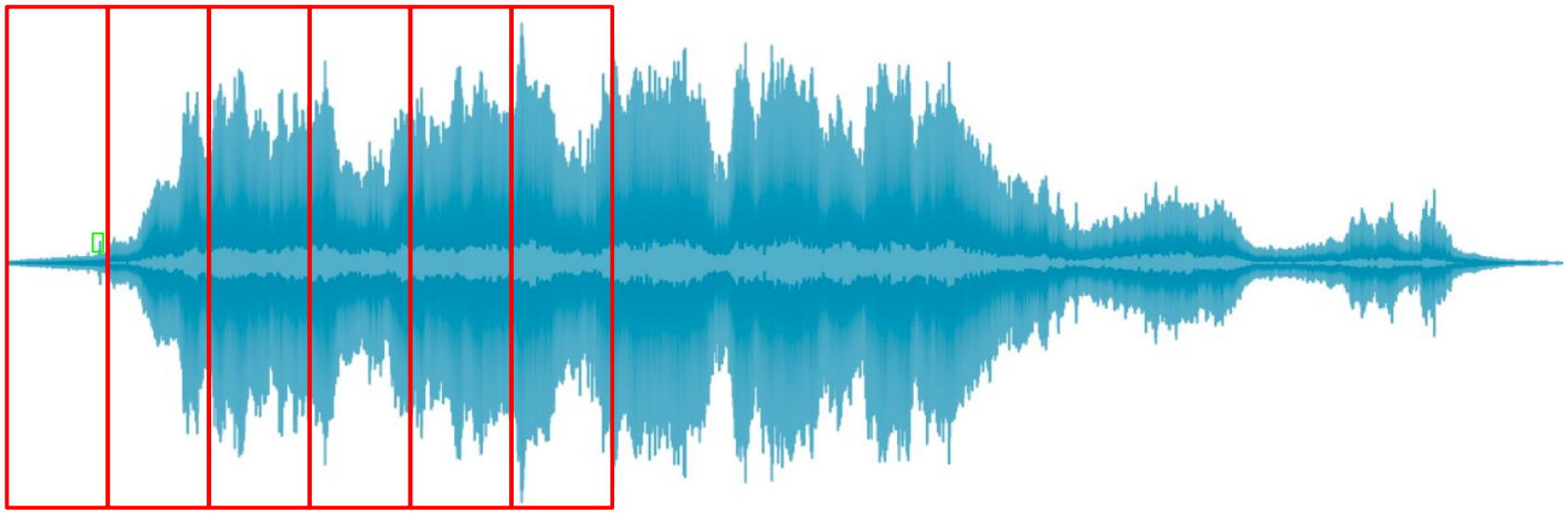
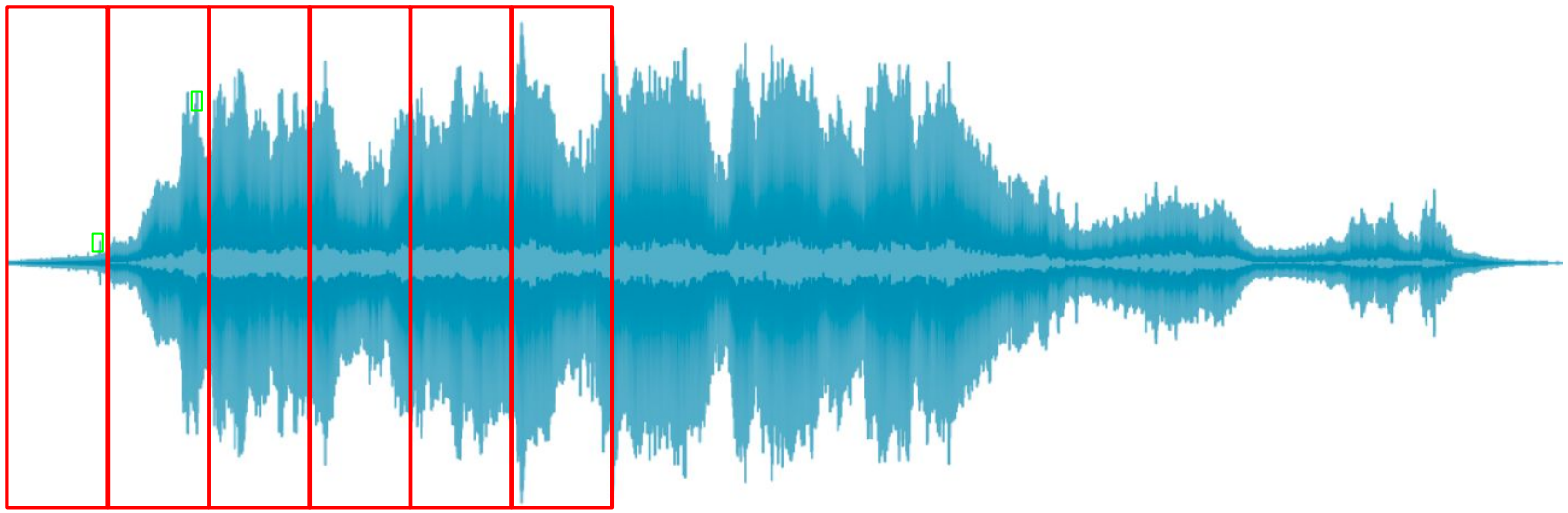
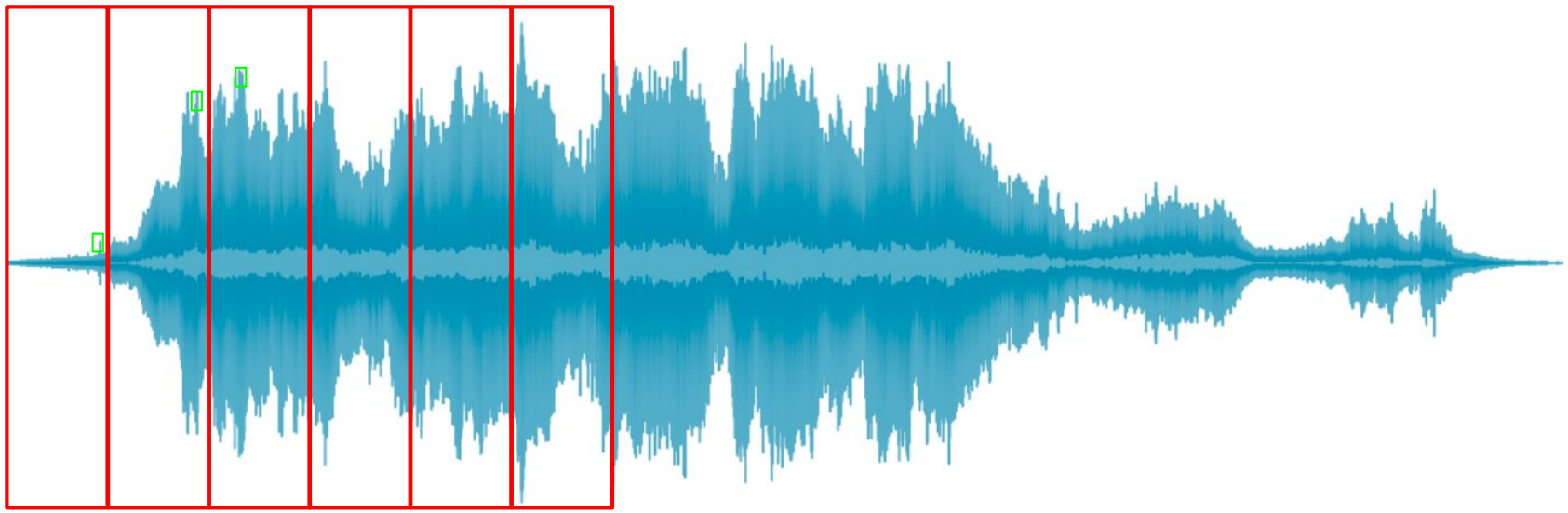


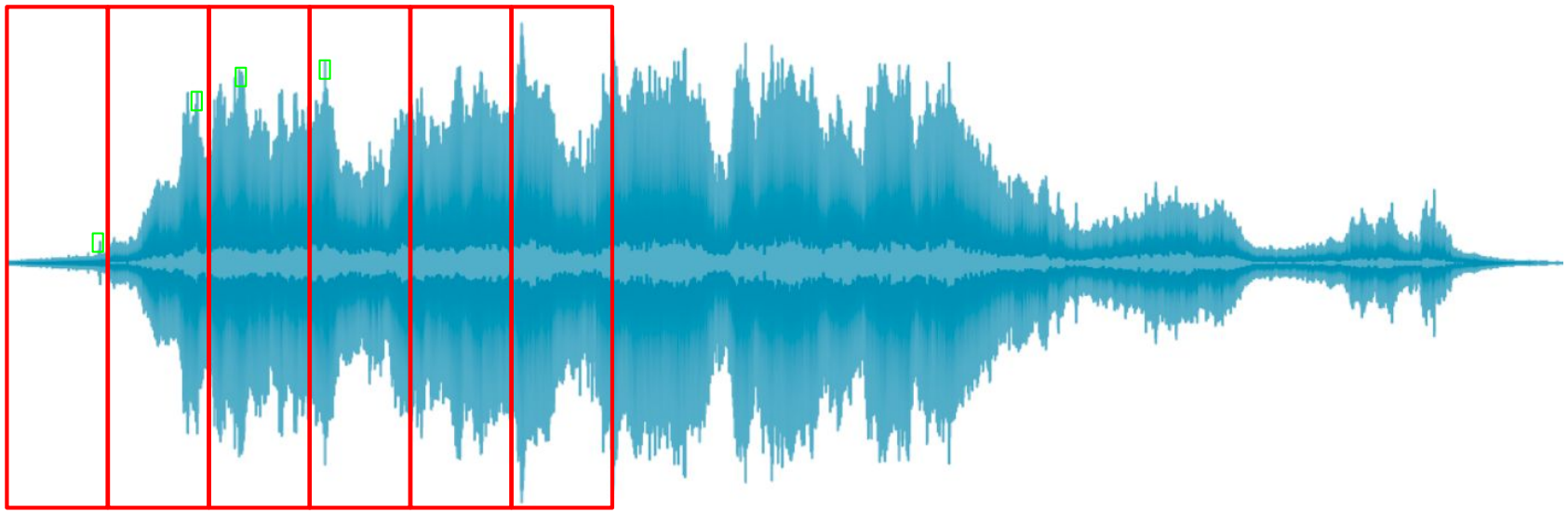
Amplitude envelope



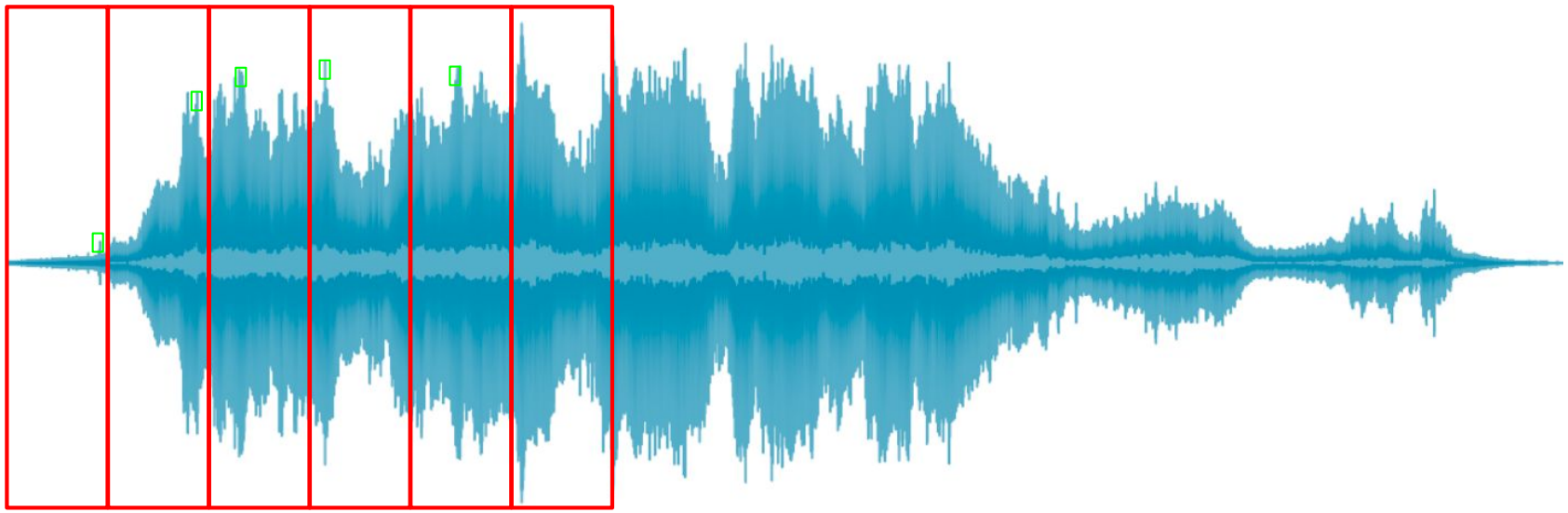
Amplitude envelope



Amplitude envelope



Amplitude envelope



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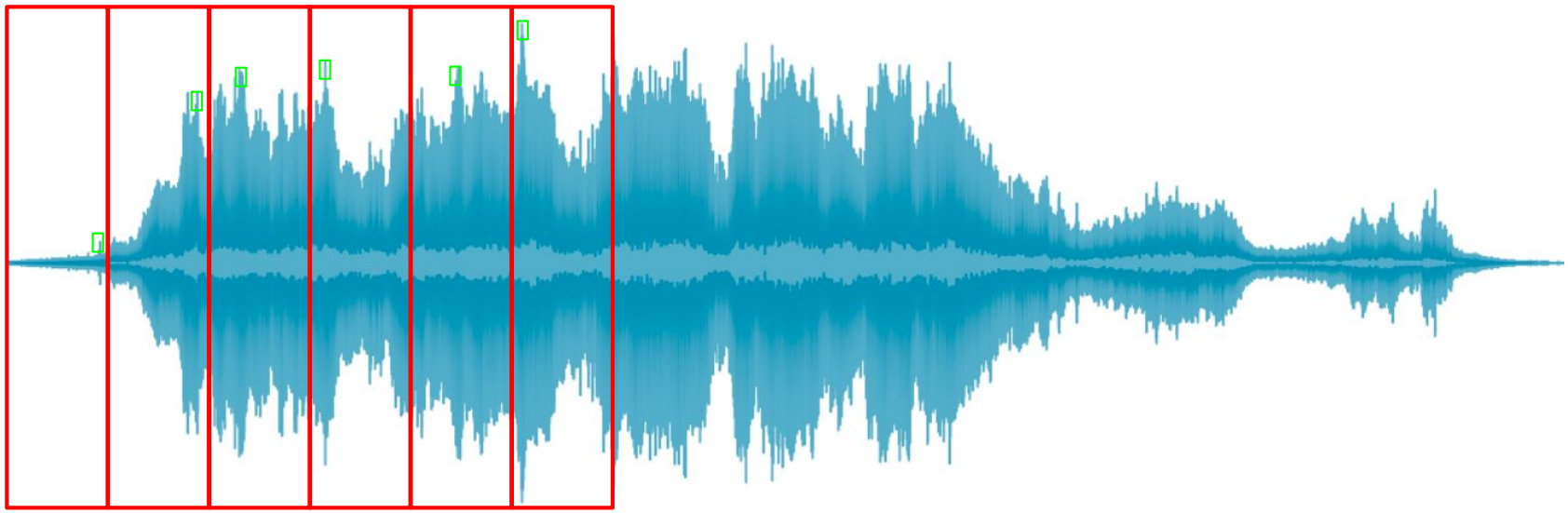

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- Sensitive to outliers
- Onset detection, music genre classification

Root-mean-square energy

- RMS of all samples in a frame

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

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Energy of *k*th sample

Root-mean-square energy

- RMS of all samples in a frame

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

Sum of energy for all samples in frame *t*

Root-mean-square energy

- RMS of all samples in a frame

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

Mean of sum of energy

Root-mean-square energy

- RMS of all samples in a frame
- Indicator of loudness

Root-mean-square energy

- RMS of all samples in a frame
- Indicator of loudness
- Less sensitive to outliers than AE

Root-mean-square energy

- RMS of all samples in a frame
- Indicator of loudness
- Less sensitive to outliers than AE
- Audio segmentation, music genre classification

Zero crossing rate

- Number of times a signal crosses the horizontal axis

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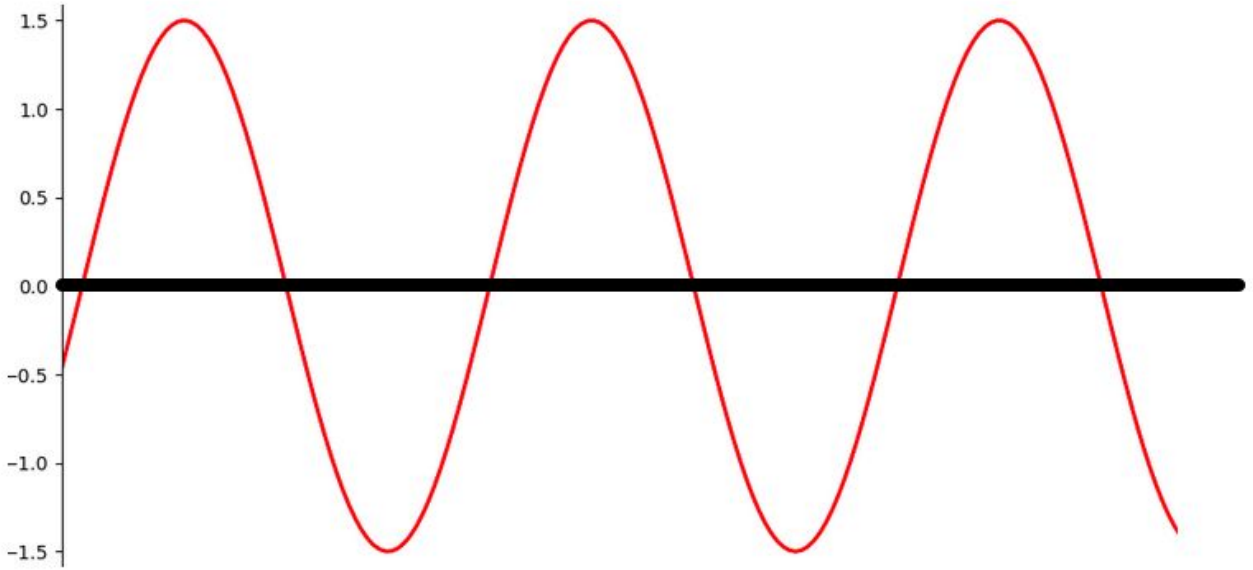

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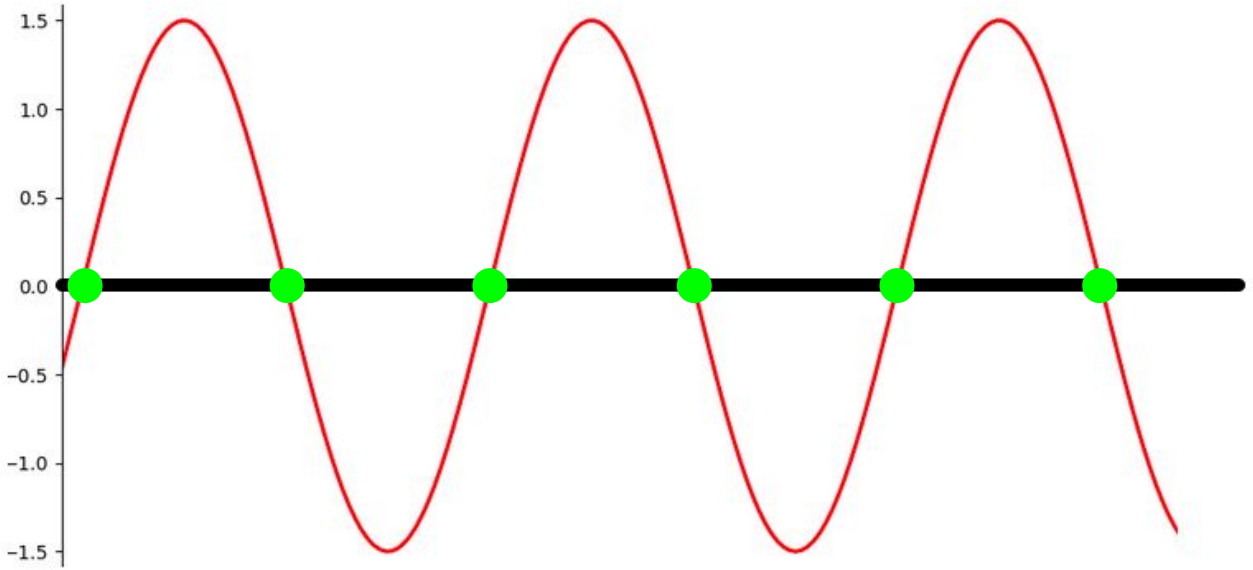

Zero crossing rate

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Sign function:

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

Zero crossing rate

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+ + 0

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+

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2

Zero crossing rate applications

- Recognition of percussive vs pitched sounds

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- Monophonic pitch estimation

Zero crossing rate applications

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

What’s up next?

- Implement amplitude envelope
- Visualise amplitude envelope for different music genres