How do we extract audio features?

Valerio Velardo

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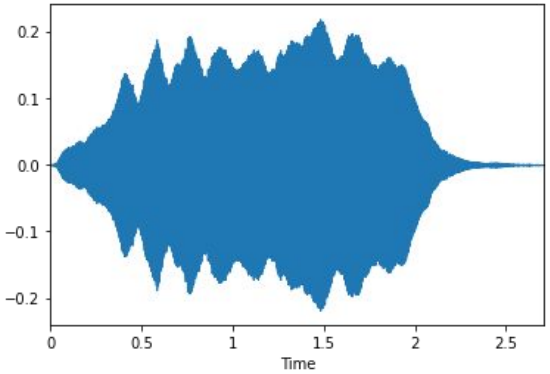
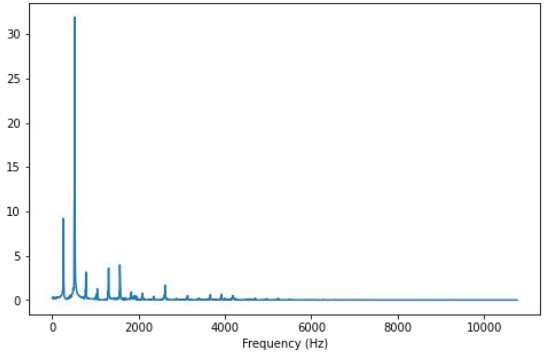
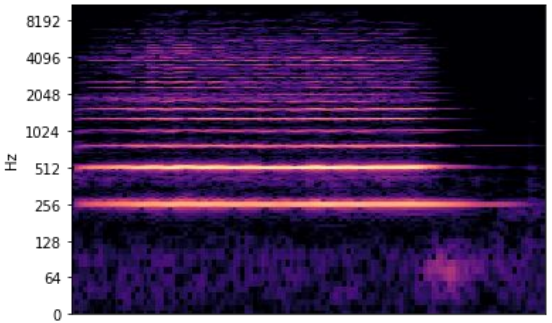
Previously on Audio Processing for ML

- Time-domain features
- Frequency-domain features
- Time-frequency domain features

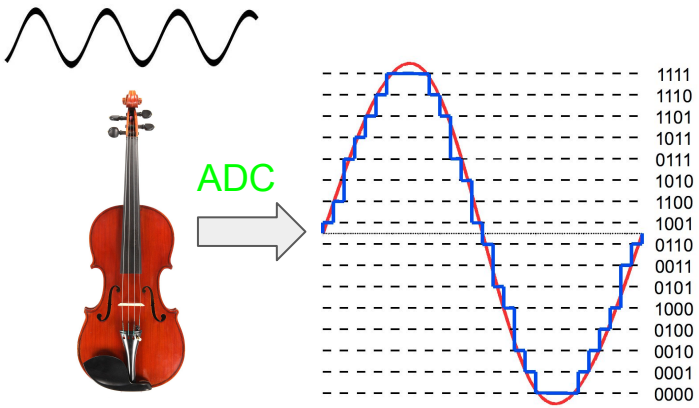






Time-domain feature pipeline

Time-domain feature pipeline



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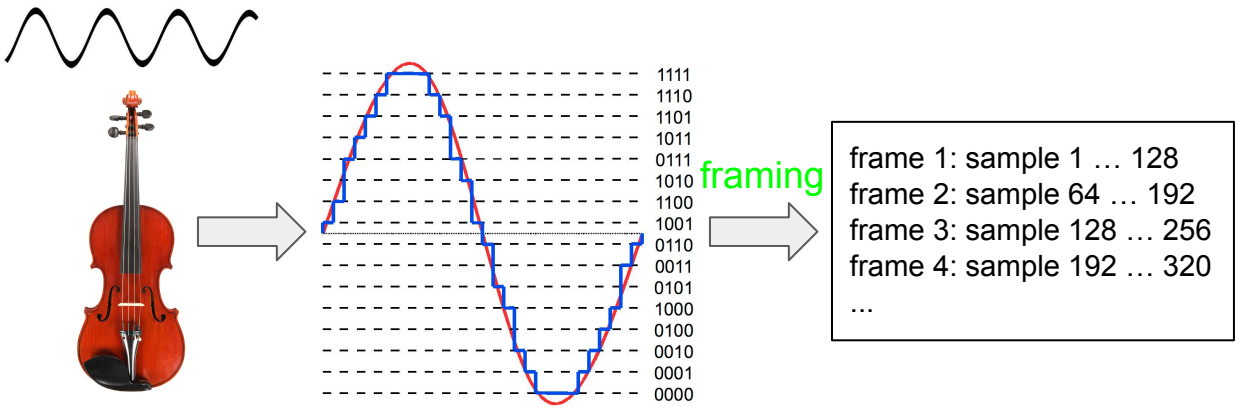

Frames

- Perceivable audio chunk

Frames

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1 sample @44.1KHz = 0.0227ms

Frames

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Duration 1 sample << Ear’s time resolution (10ms)

Frames

- Perceivable audio chunk
- Power of 2 num. samples

Frames

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- Typical values: 256 - 8192

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$$d_f = \frac{1}{s_r} \cdot K$$

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$$d_f = \frac{1}{s_r} \cdot K$$

512

44100

Frames

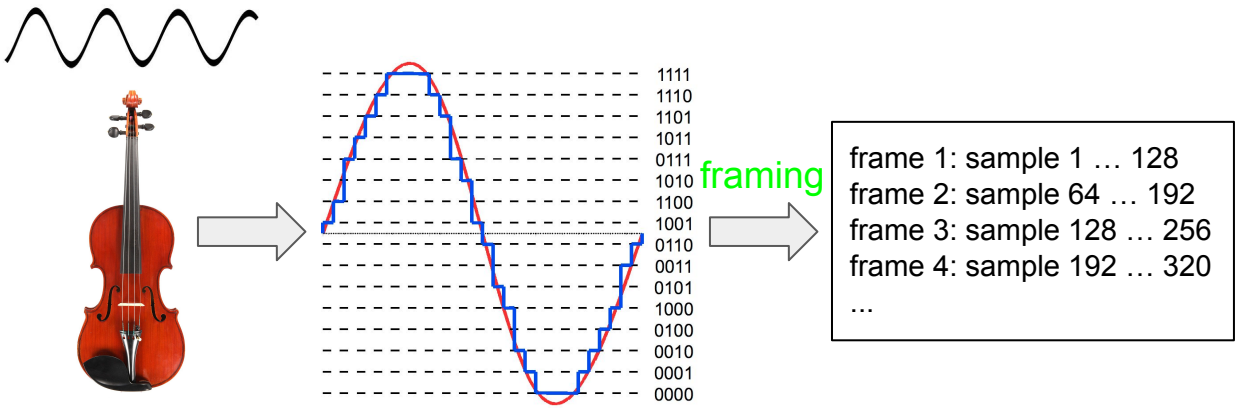
- Perceivable audio chunk
- Power of 2 num. samples
- Typical values: 256 - 8192

$$d_f = \frac{1}{s_r} \cdot K = 11.6\text{ms}$$

512

44100

Time-domain feature pipeline



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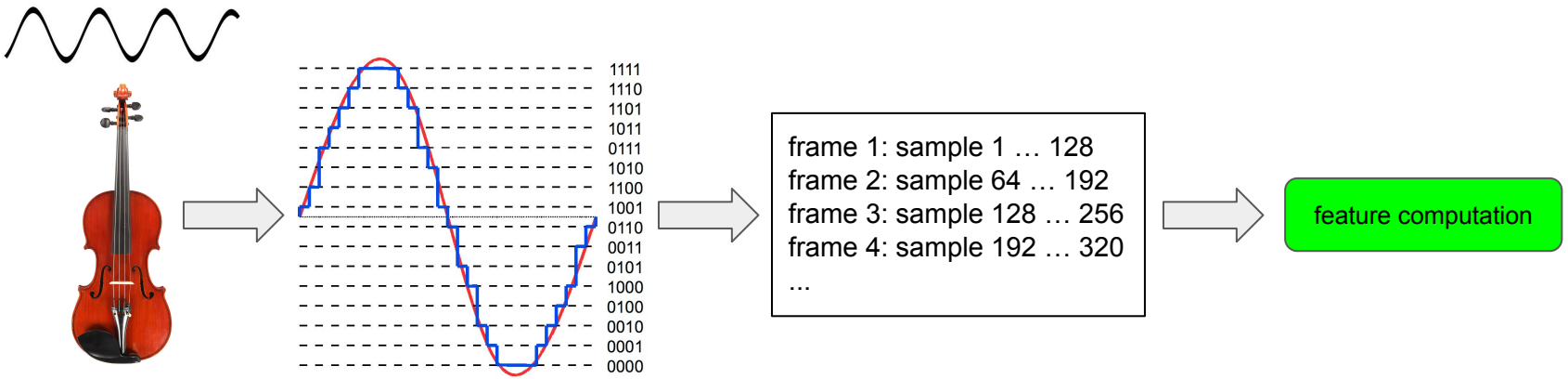
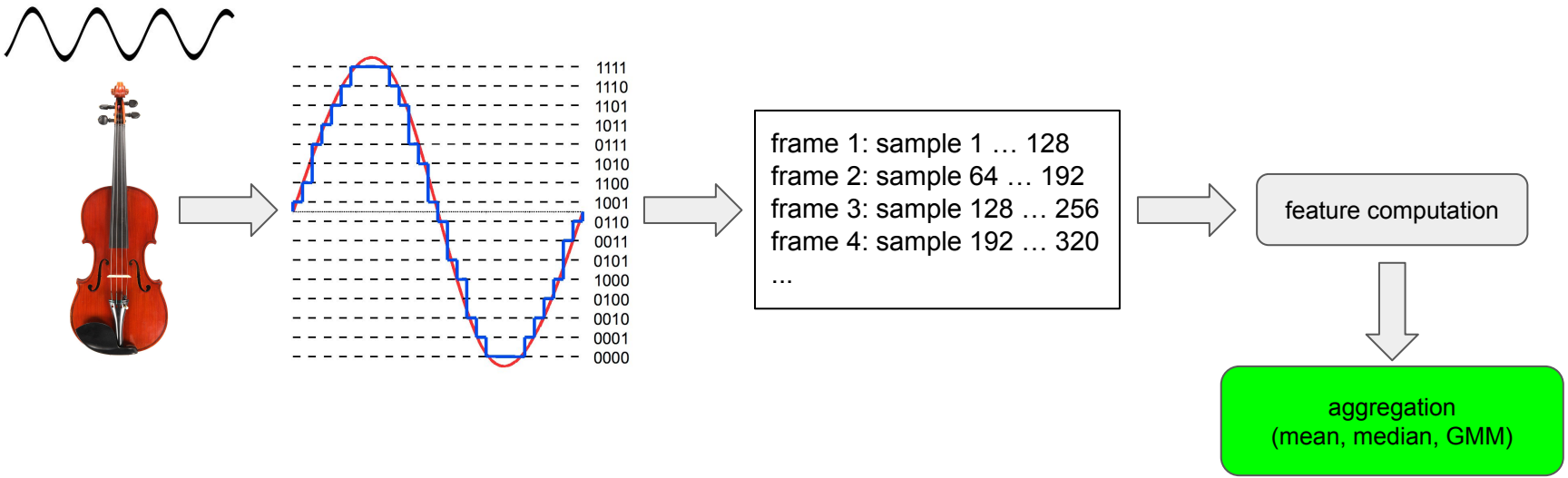


Time-domain feature pipeline



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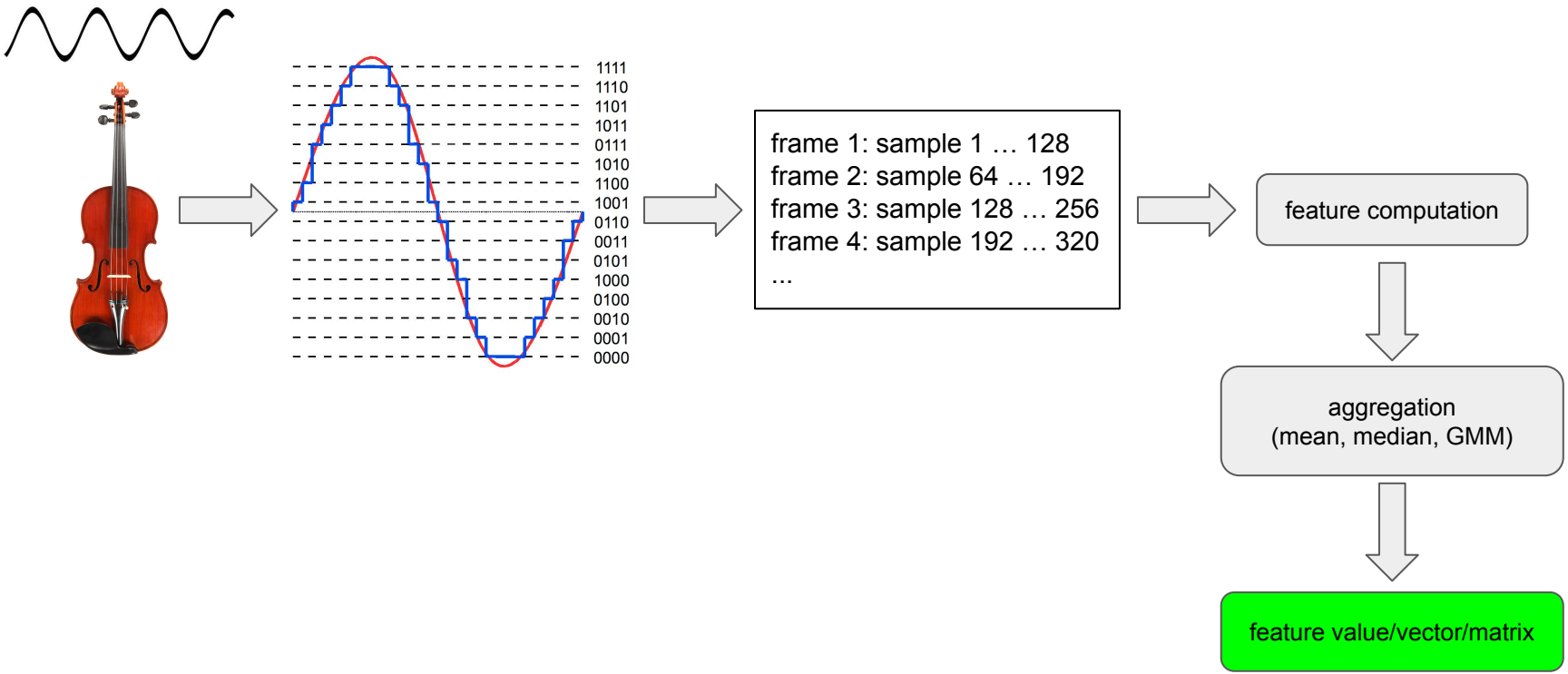

Frequency-domain feature pipeline

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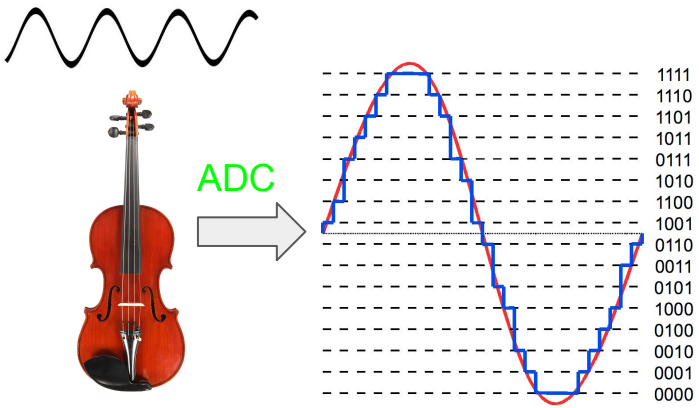
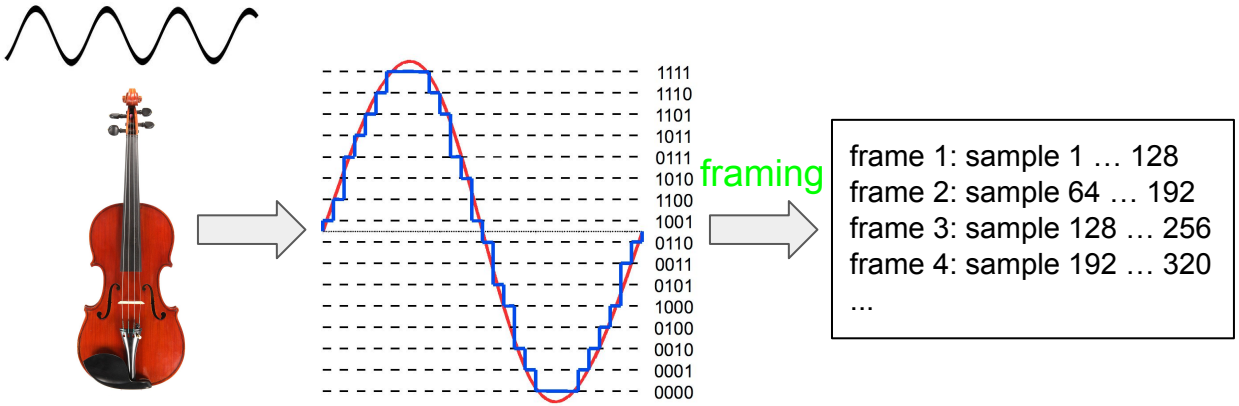
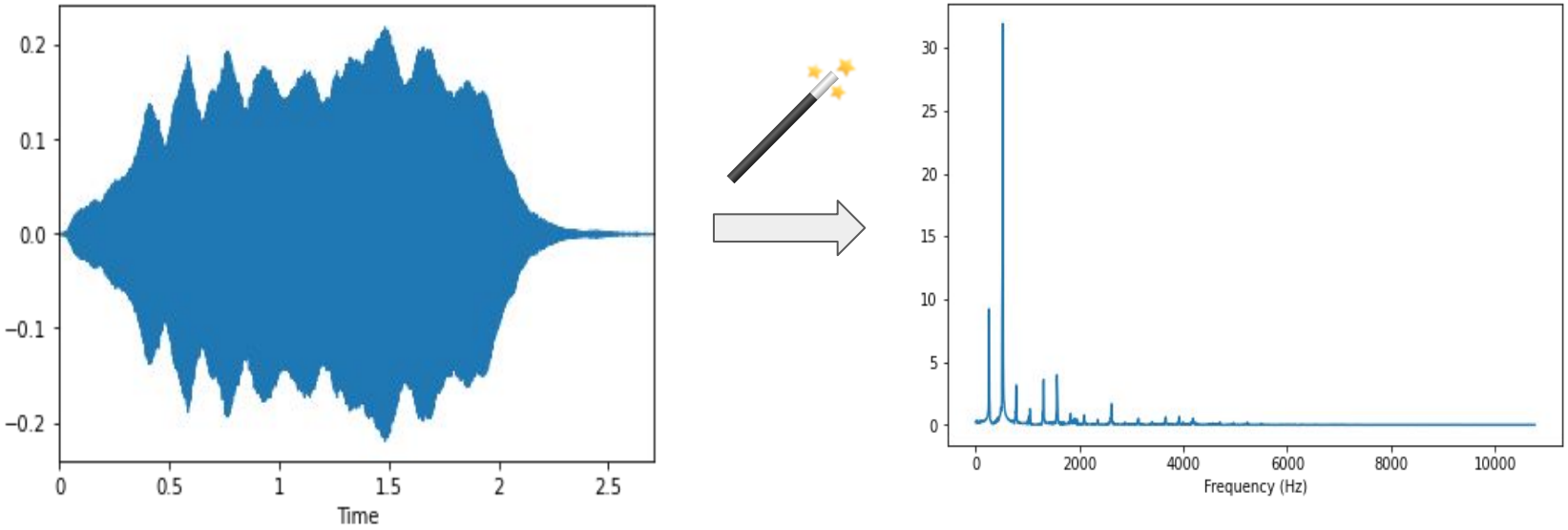


Frequency-domain feature pipeline



From time to frequency domain




I NEVER THOUGHT OF
SPECTRAL LEAKAGE
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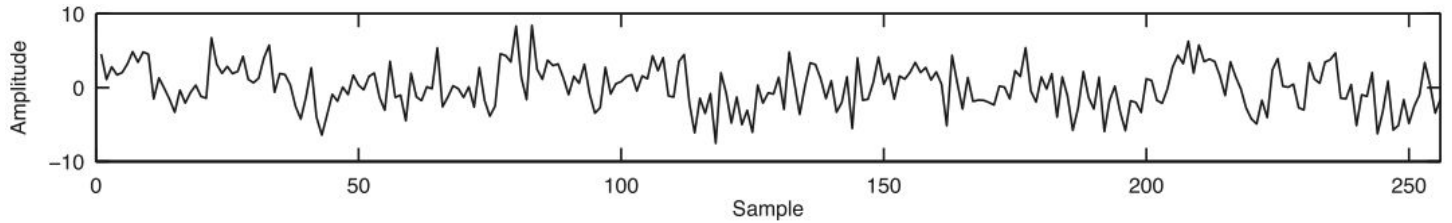
Spectral leakage

- Processed signal isn’t an integer number of periods

Spectral leakage

- Processed signal isn’t an integer number of periods
- Endpoints are discontinuous



Spectral leakage

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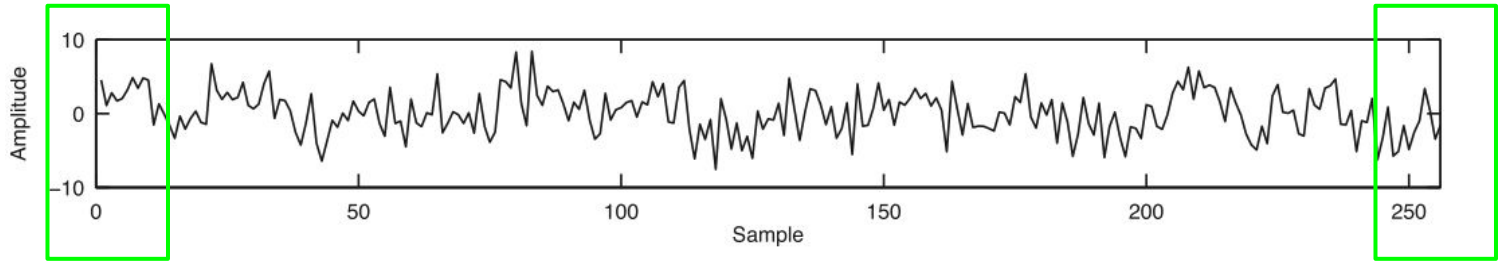
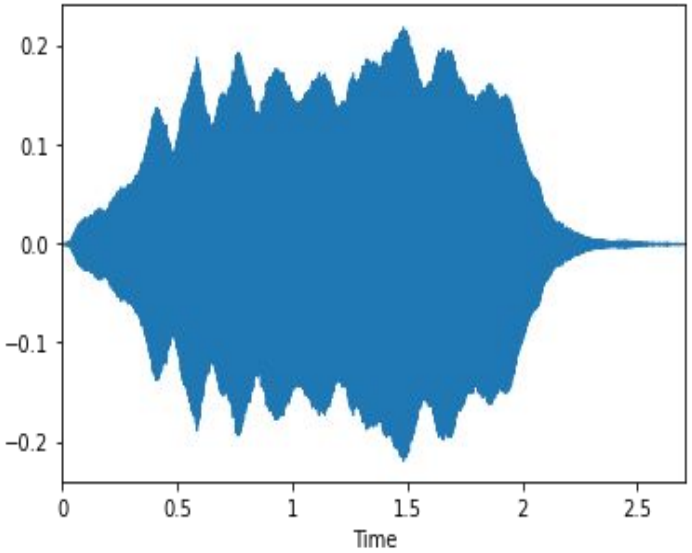
- Endpoints are discontinuous



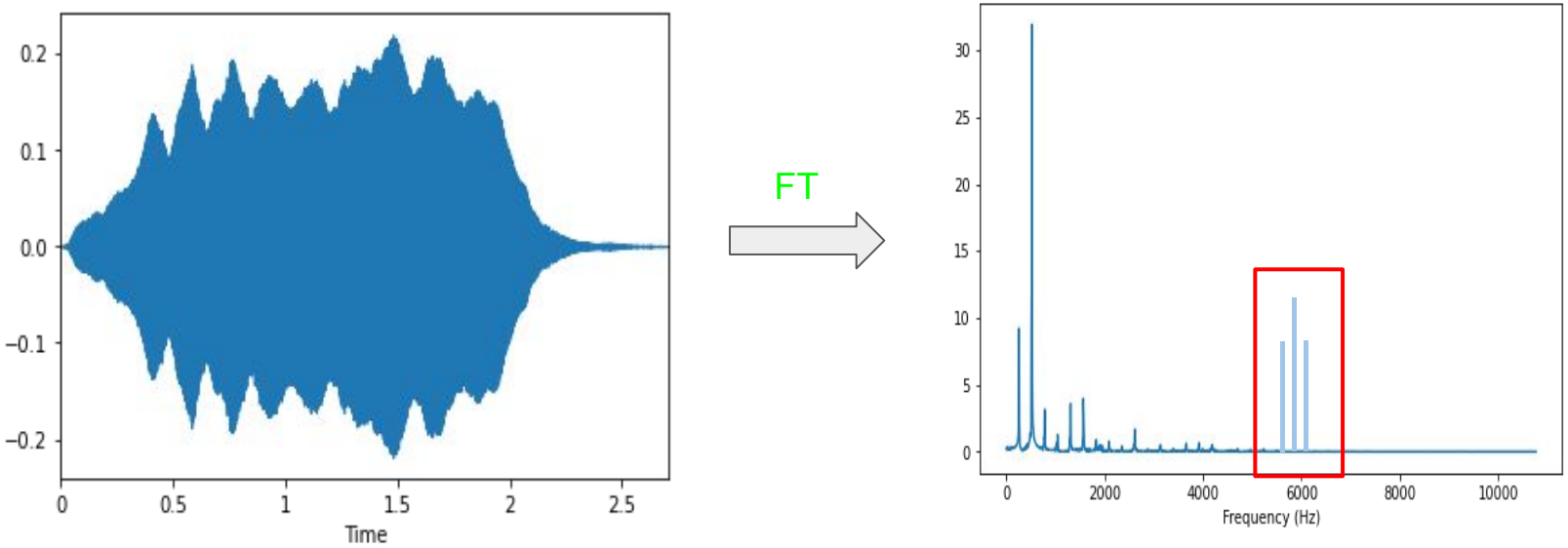
Spectral leakage

- Processed signal isn’t an integer number of periods
- Endpoints are discontinuous
- Discontinuities appear as high-frequency components not present in the original signal

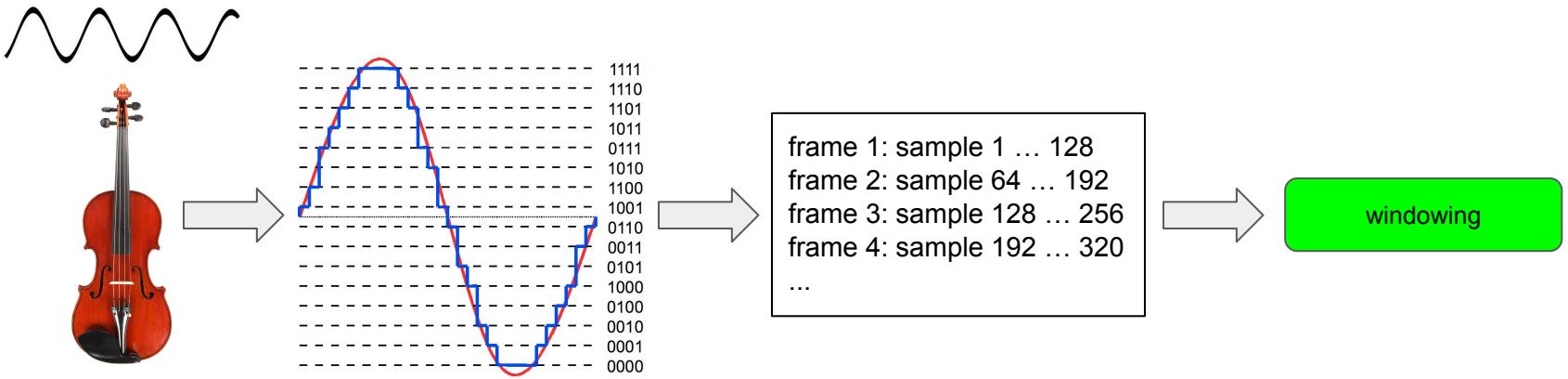
Spectral leakage



Spectral leakage



Frequency-domain feature pipeline



Windowing

- Apply windowing function to each frame

Windowing

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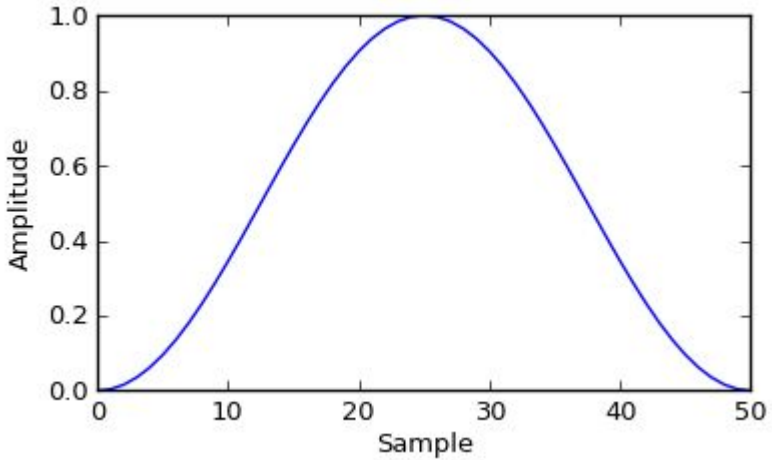
- Eliminates samples at both ends of a frame

Windowing

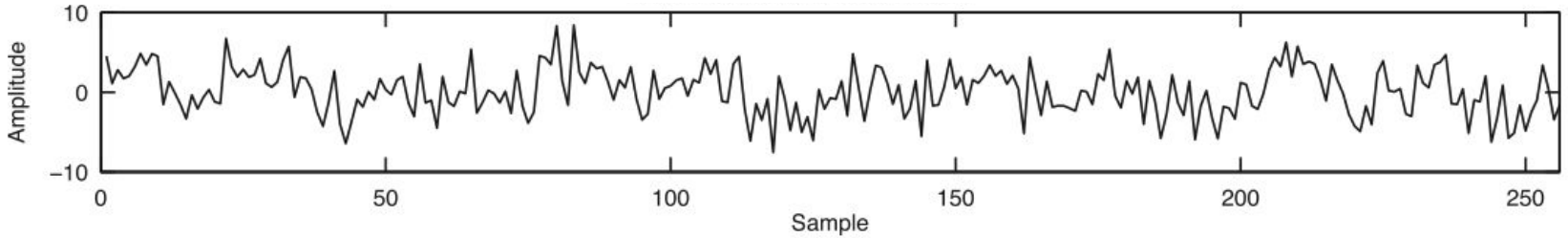
- Apply windowing function to each frame
- Eliminates samples at both ends of a frame
- Generates a periodic signal

Hann window

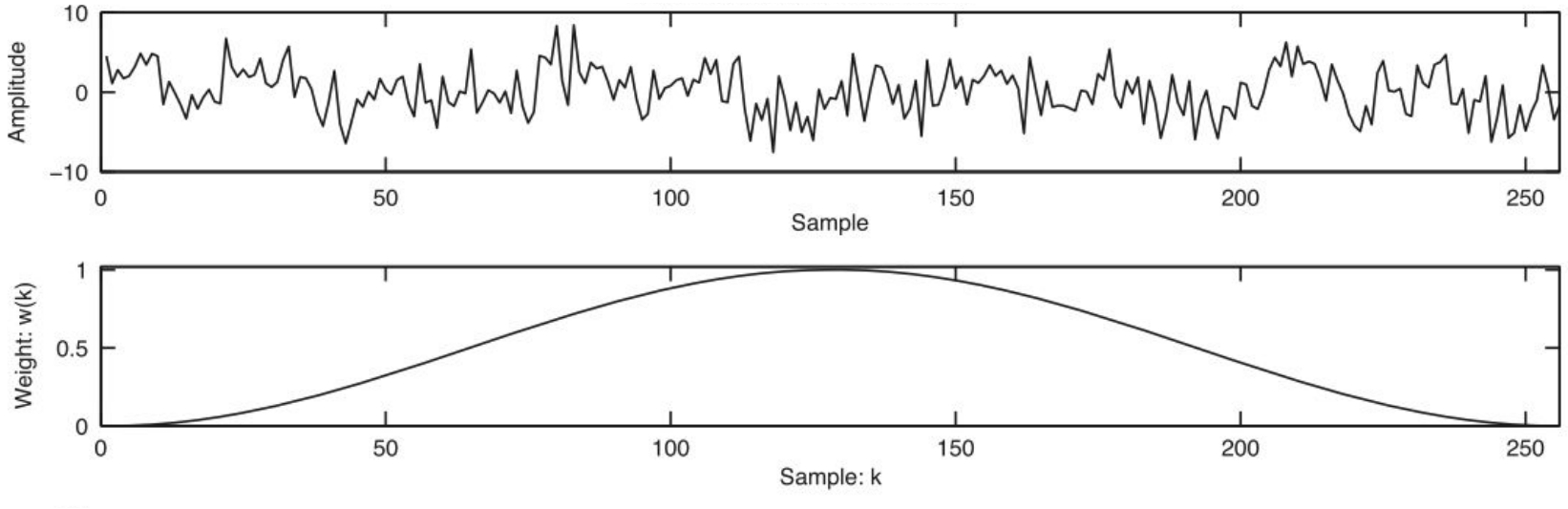
$$w(k) = 0.5 \cdot (1 - \cos(\frac{2\pi k}{K-1})), k = 1...K$$



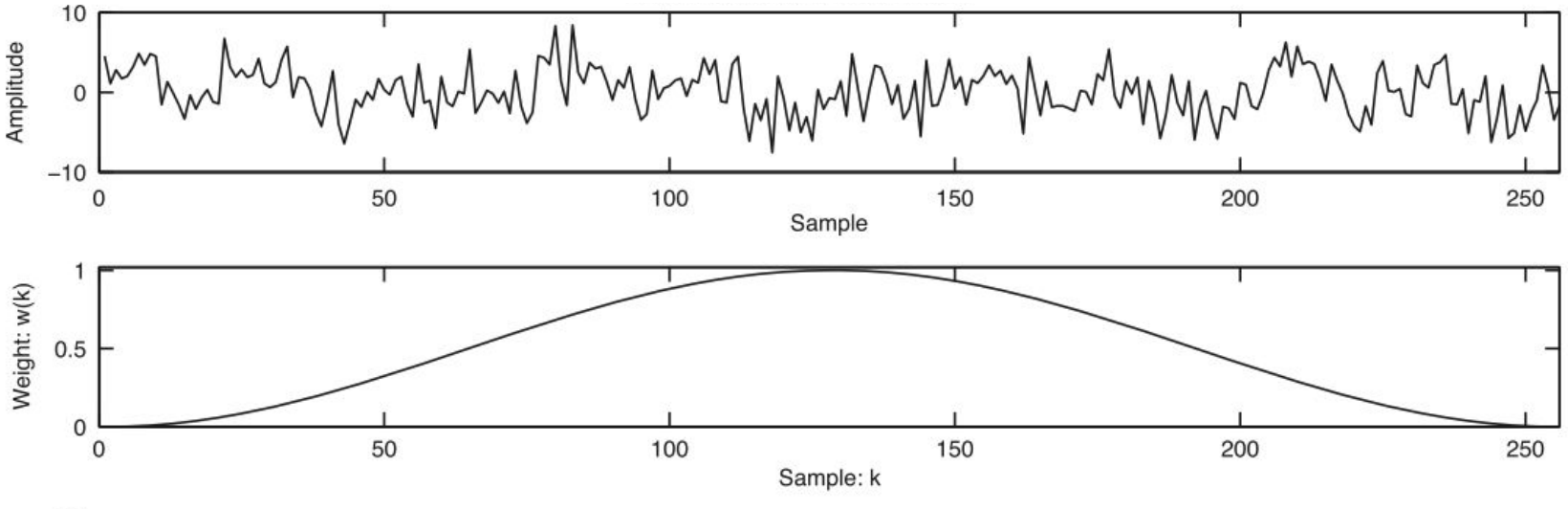
Windowing



Windowing

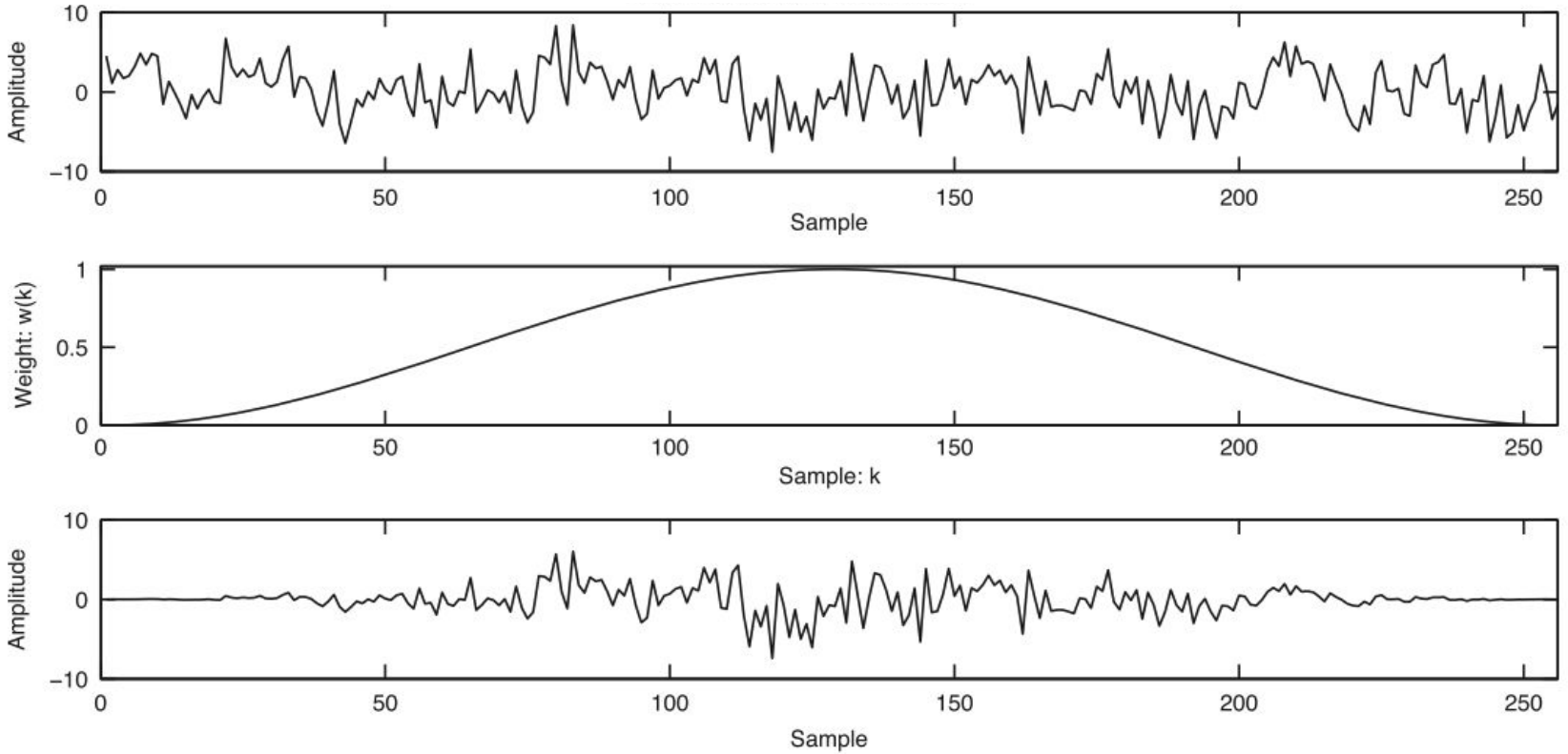

Amplitude
10
0
−10
0
50
100
150
200
250
Sample
Weight: w(k)
1
0.5
0
0
50
100
150
200
250
Sample: k

Windowing



$$s_w(k) = s(k) \cdot w(k), k = 1...K$$

Windowing


Amplitude
10
0
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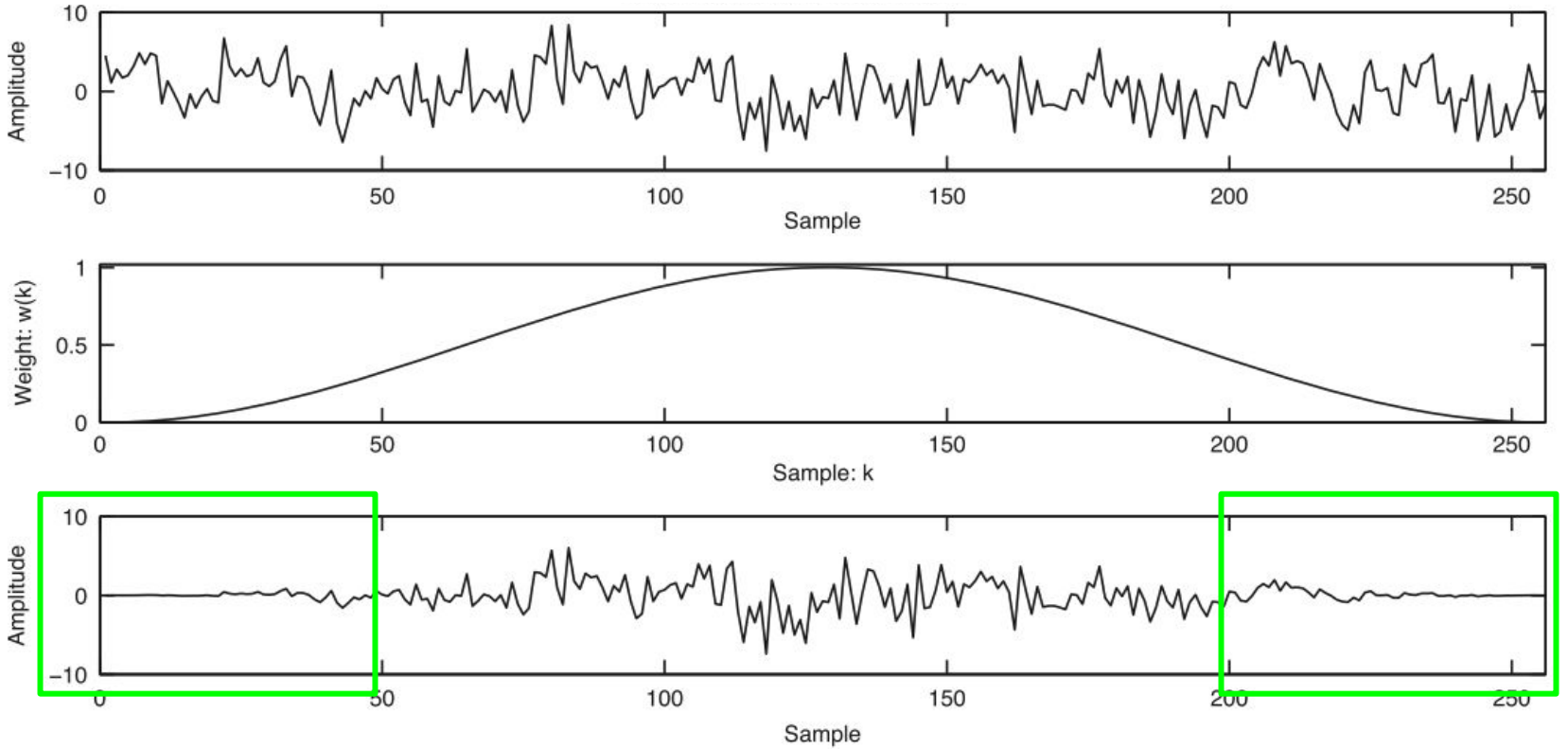
50
100
150
200
250
Sample
Weight: w(k)
1
0.5
0
0
50
100
150
200
250
Sample: k
Amplitude
10
0
−10
0
50
100
150
200
250
Sample

Windowing


Amplitude
10
0
−10
0
50
100
150
200
250
Sample
Weight: w(k)
1
0.5
0
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250
Sample

Houston we have another problem!

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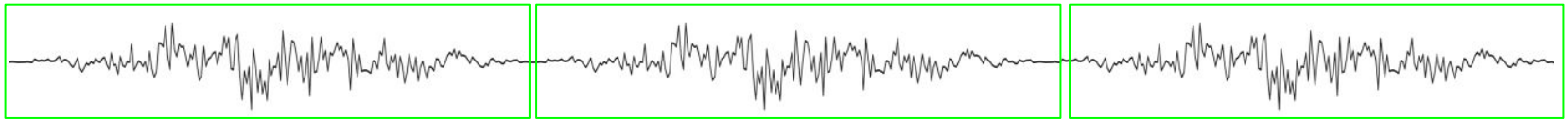

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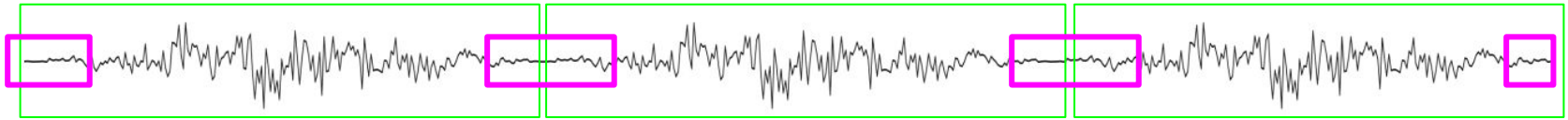
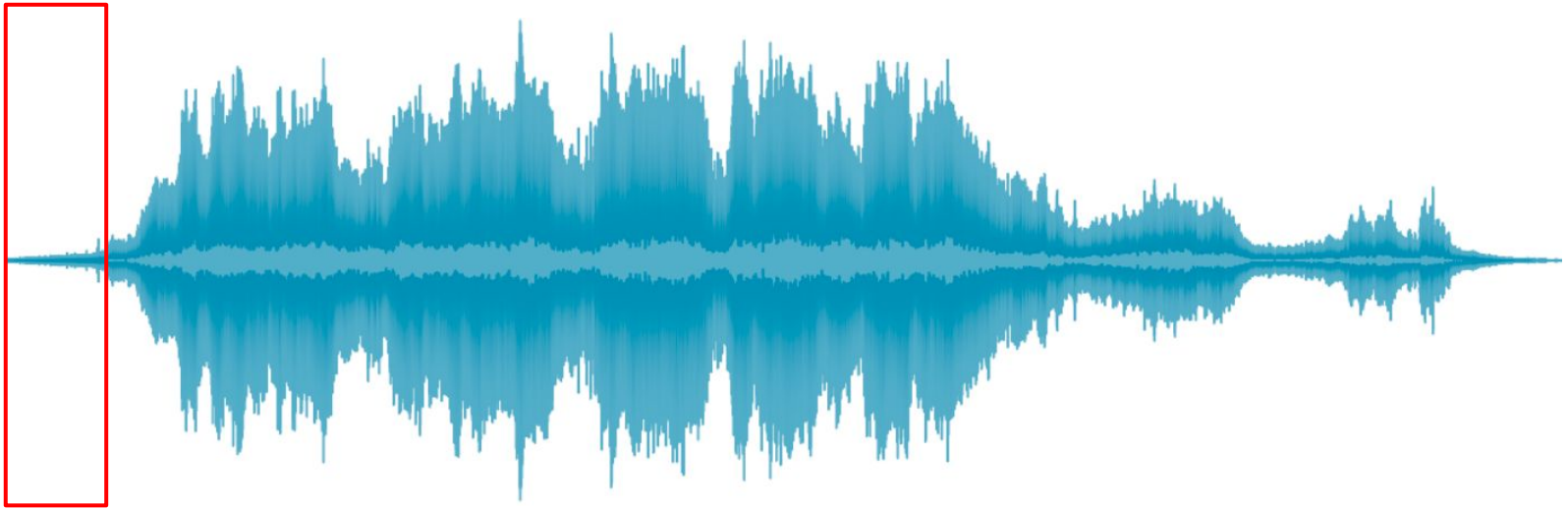


Non-overlapping frames



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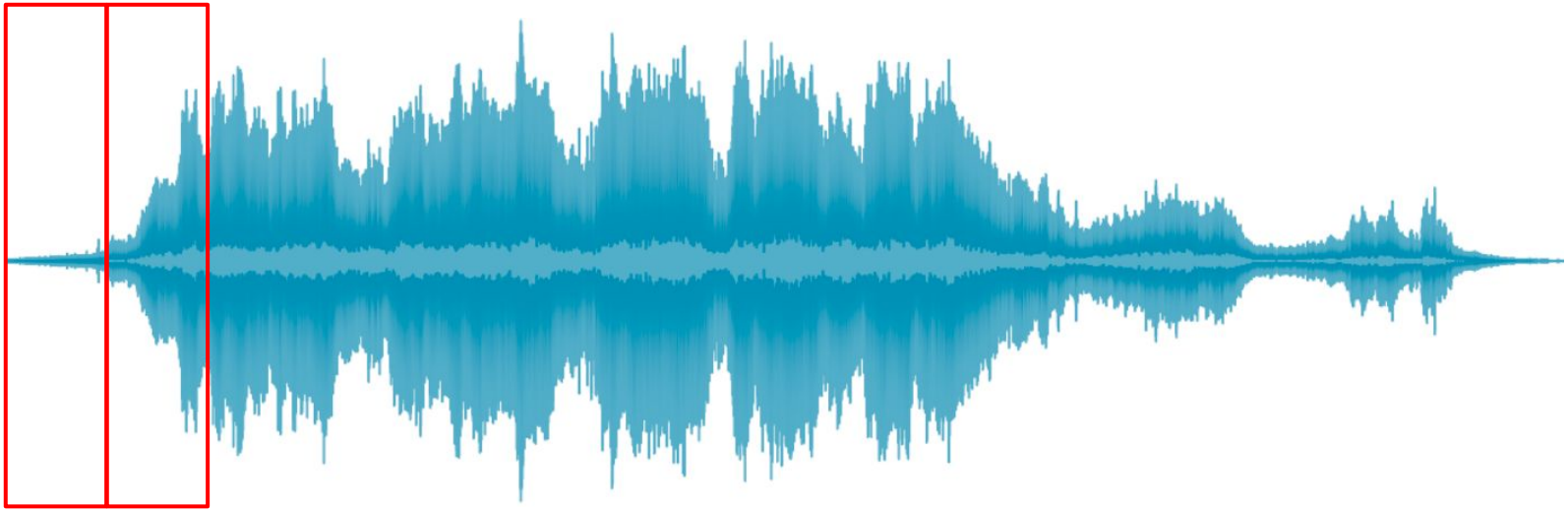

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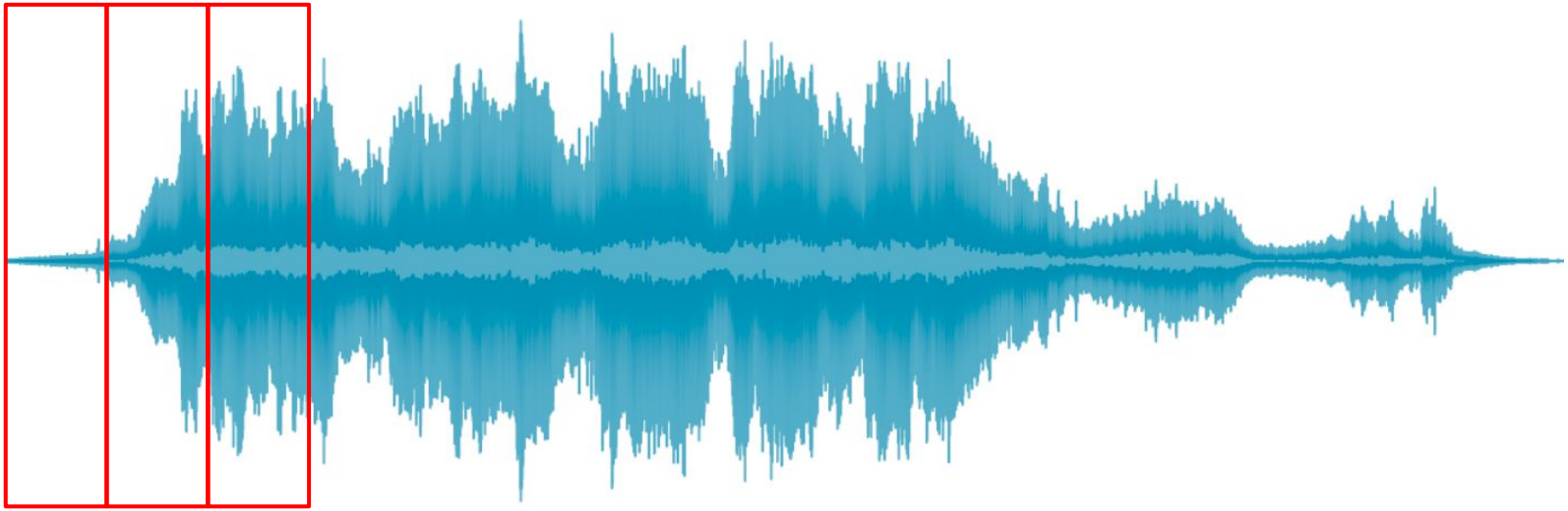
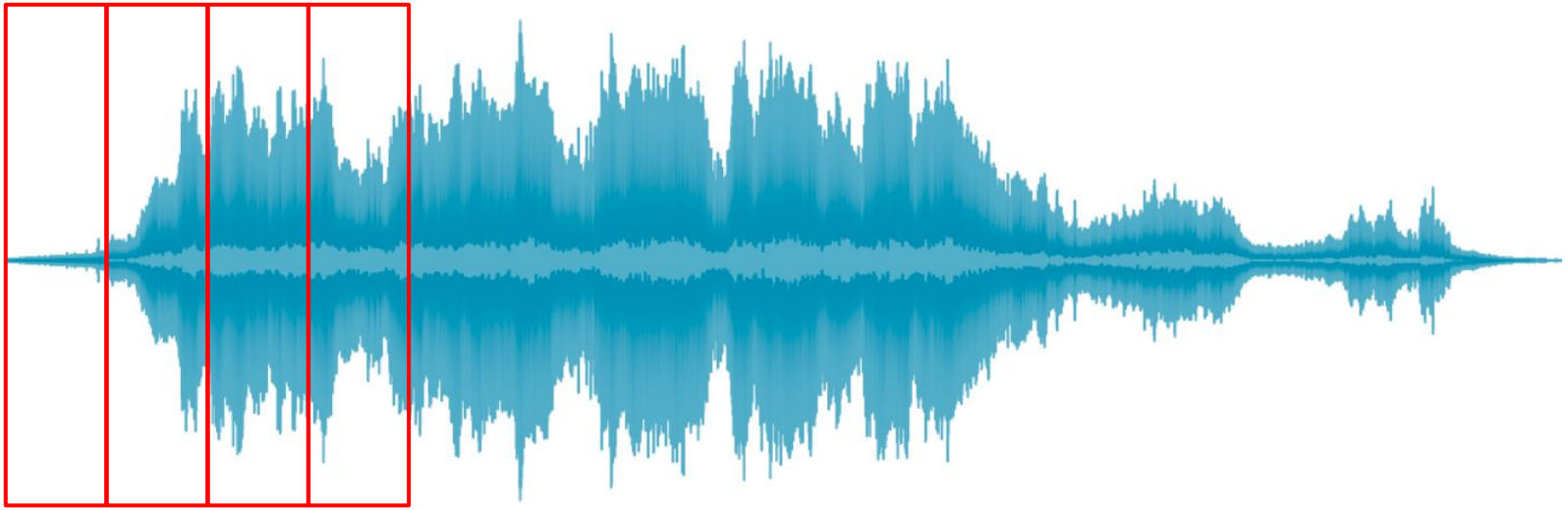
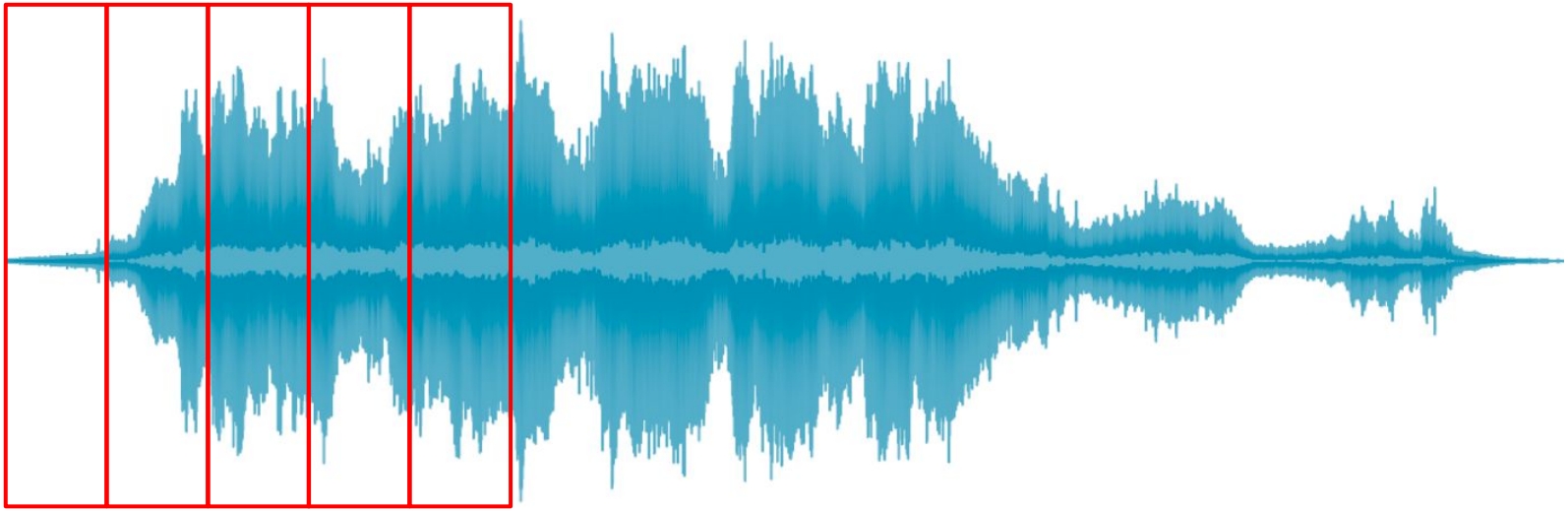


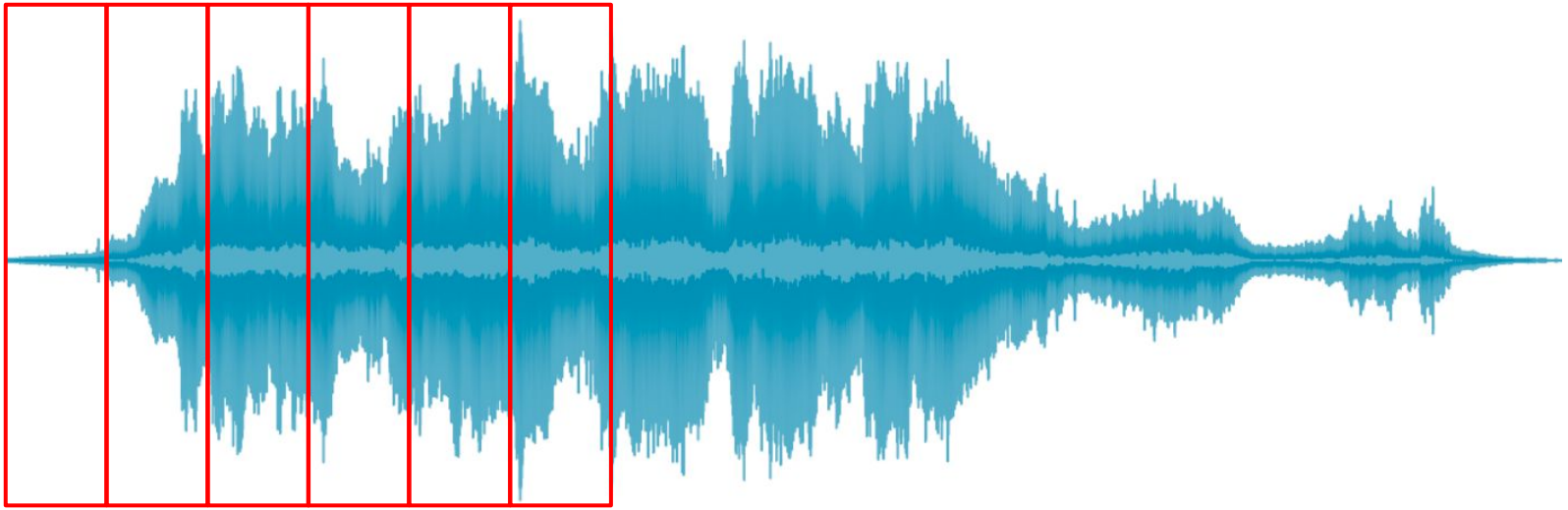
Non-overlapping frames



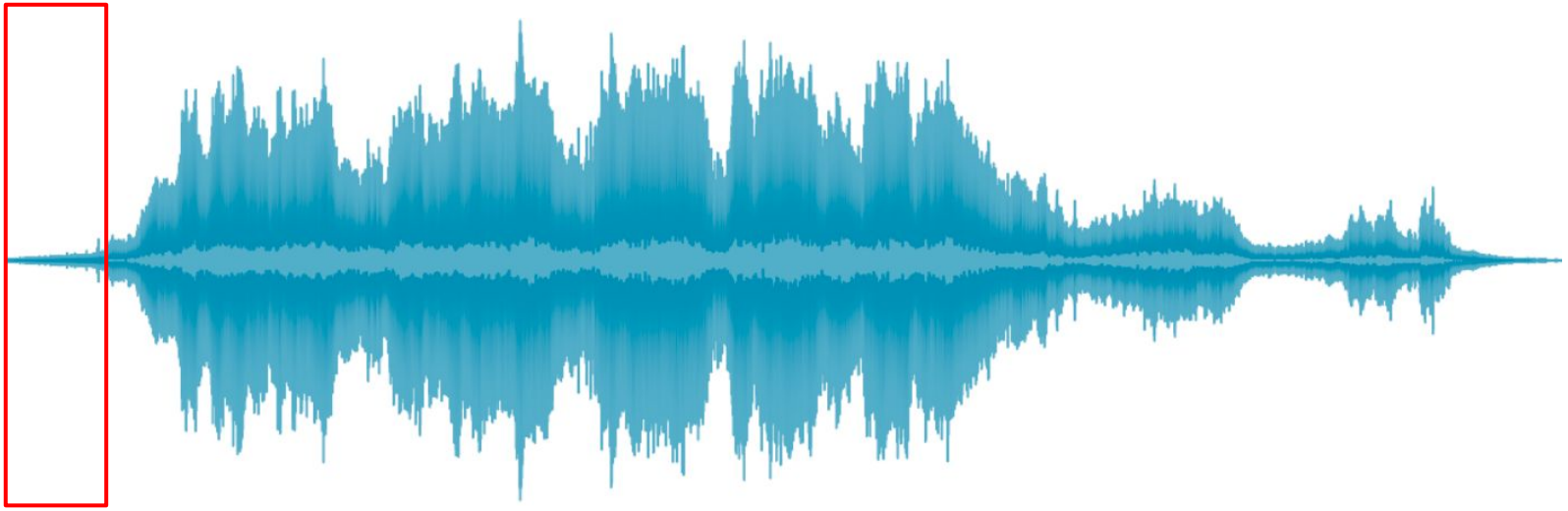
Non-overlapping frames



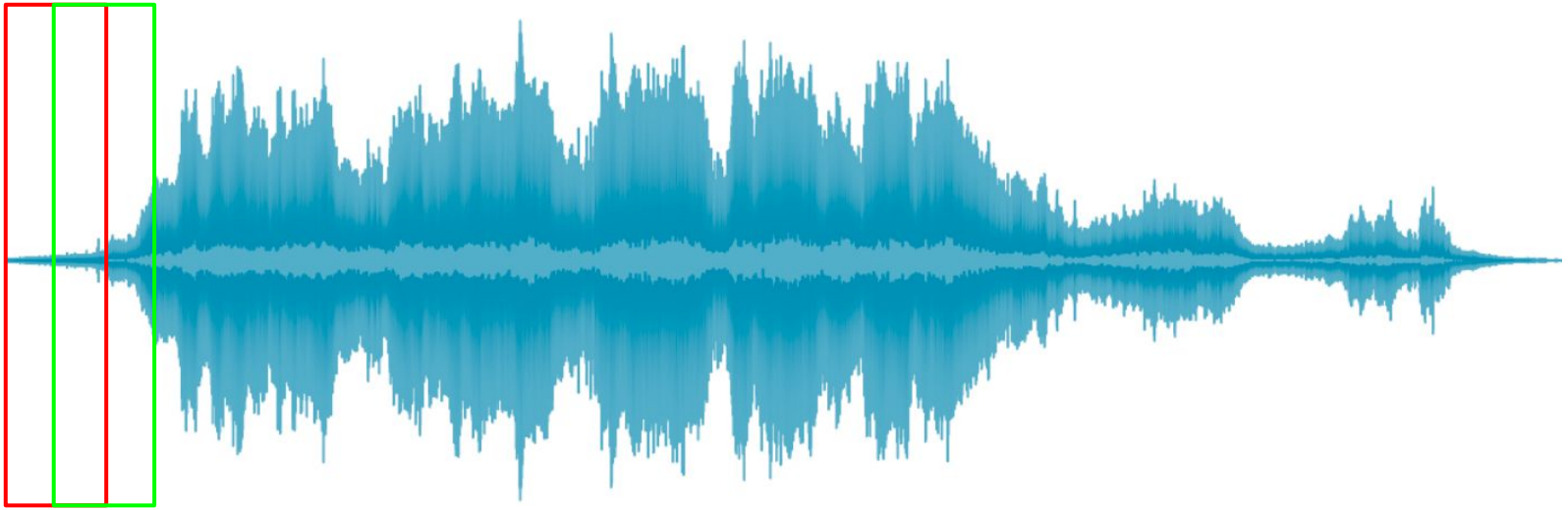
Non-overlapping frames



Overlapping frames



Overlapping frames



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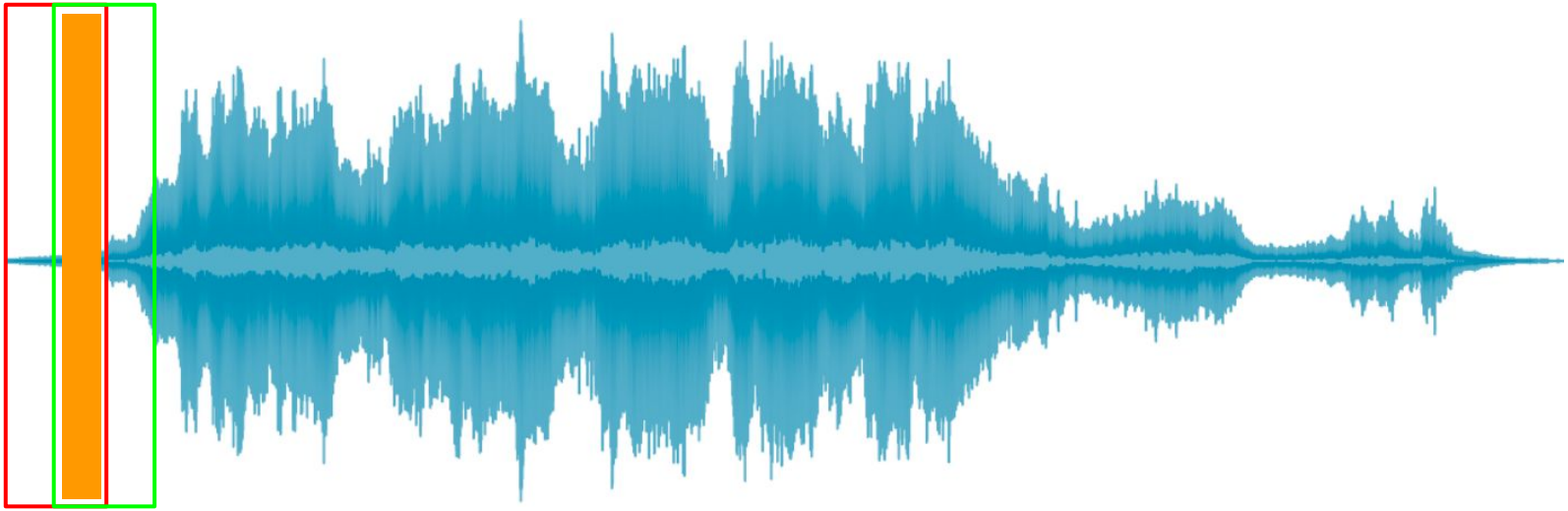
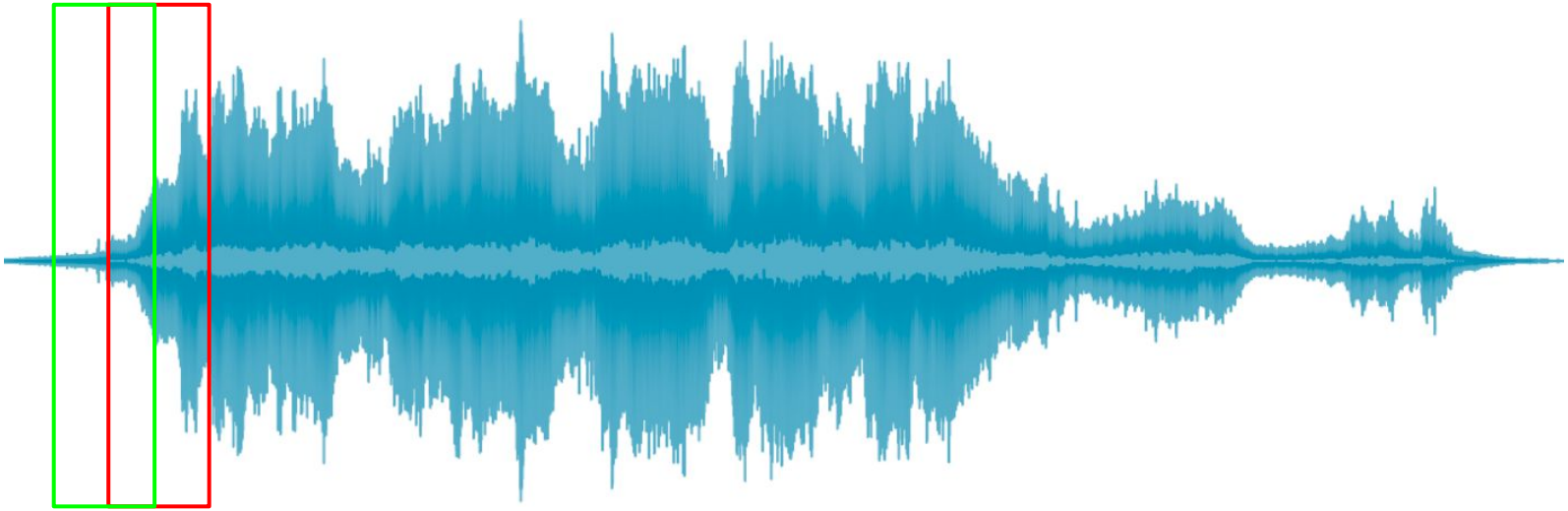


Overlapping frames



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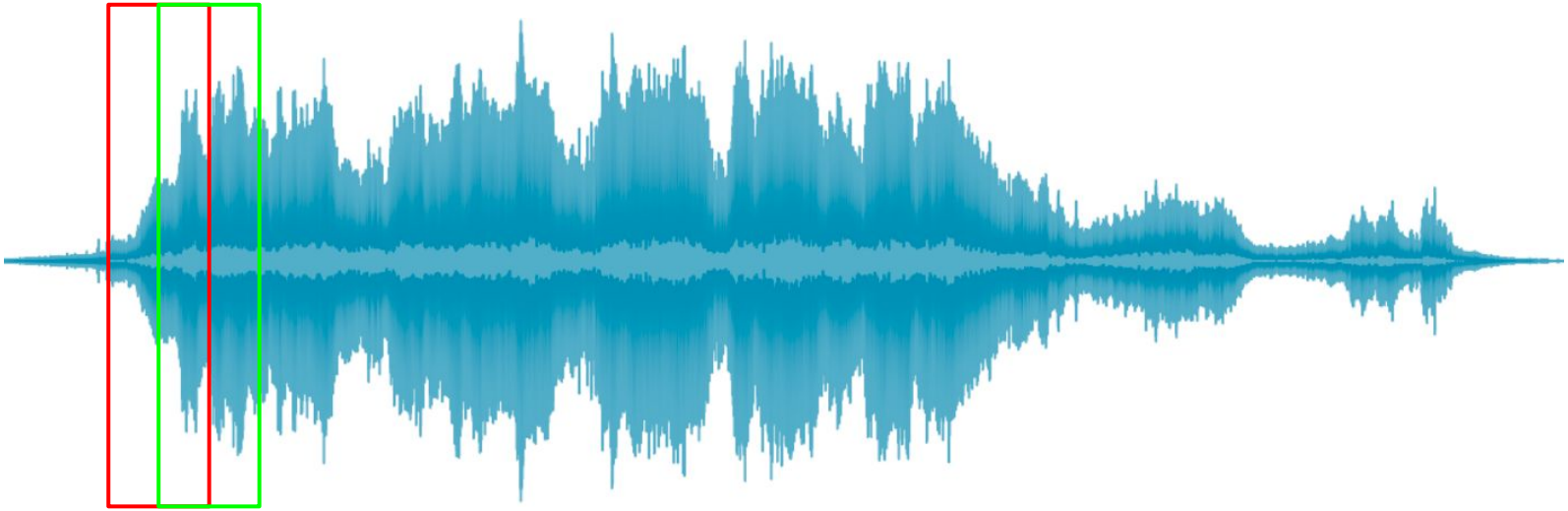
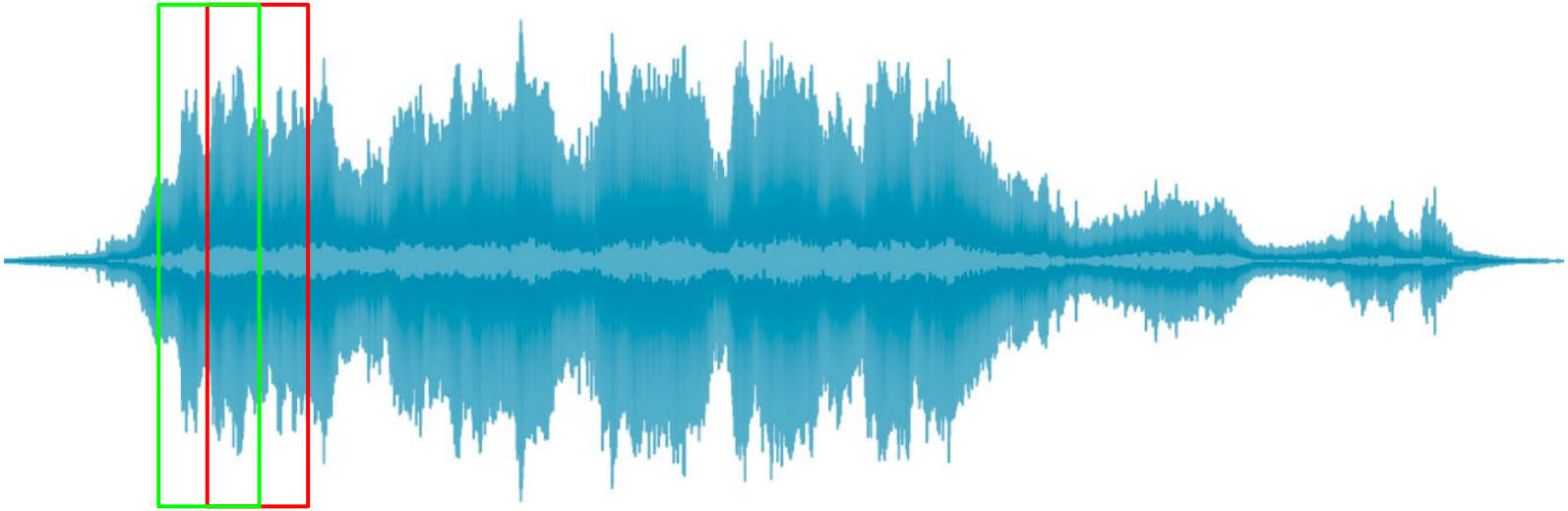


Overlapping frames



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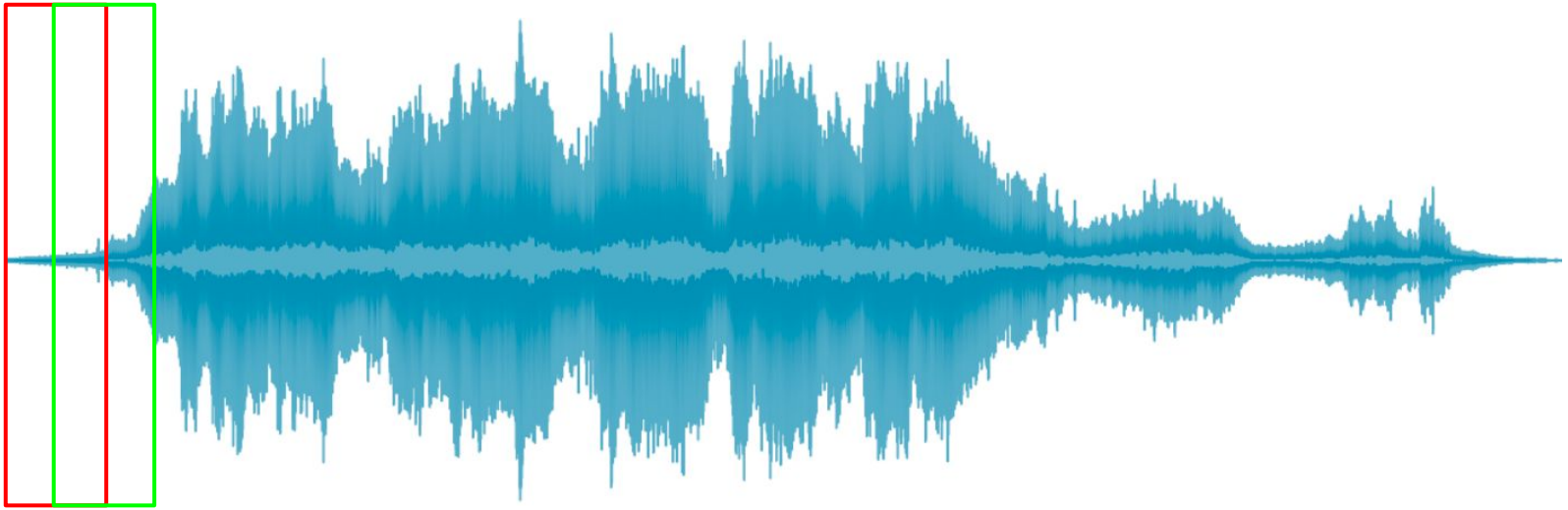

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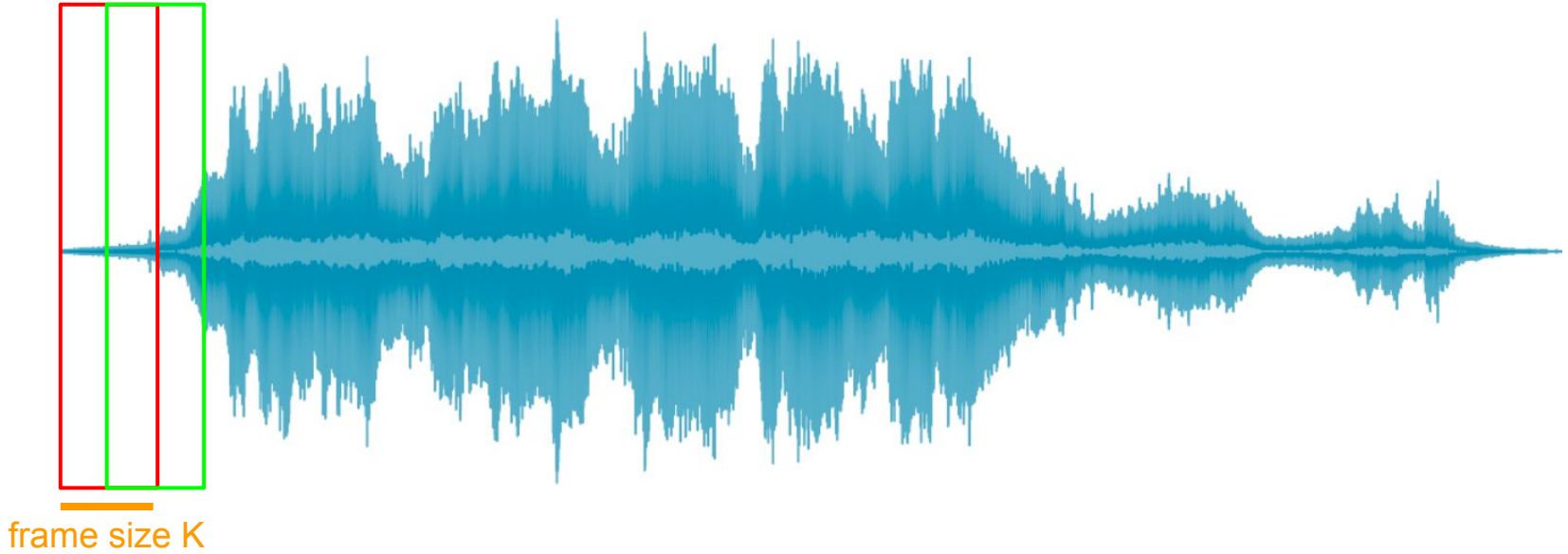
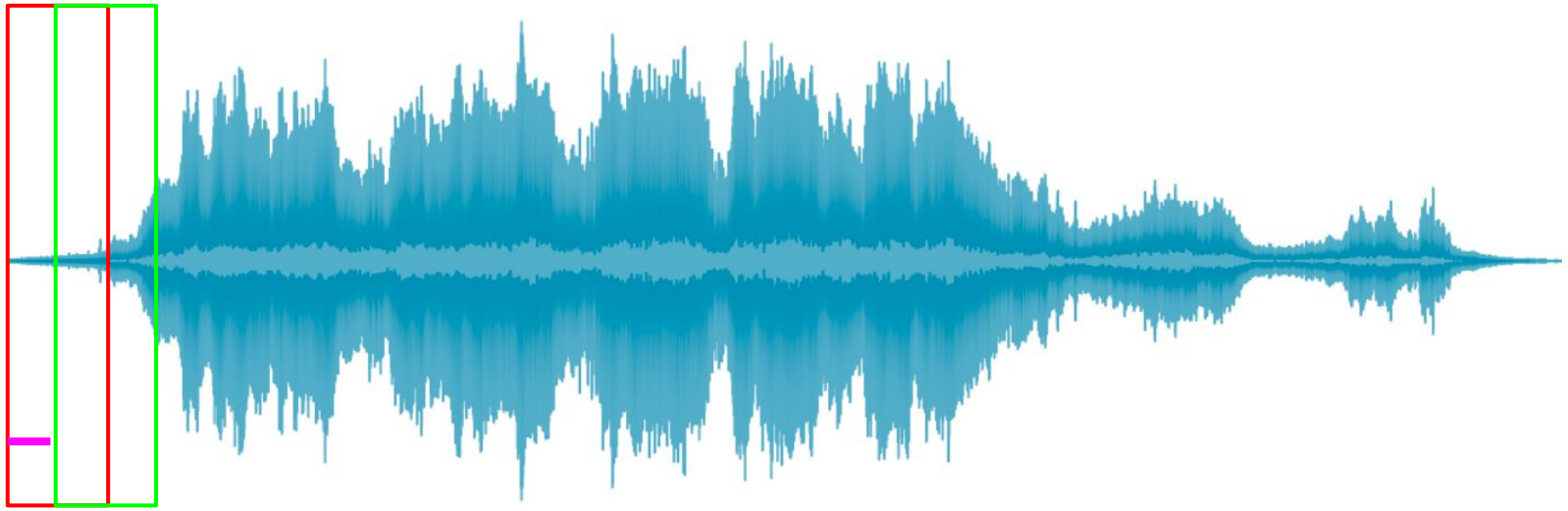
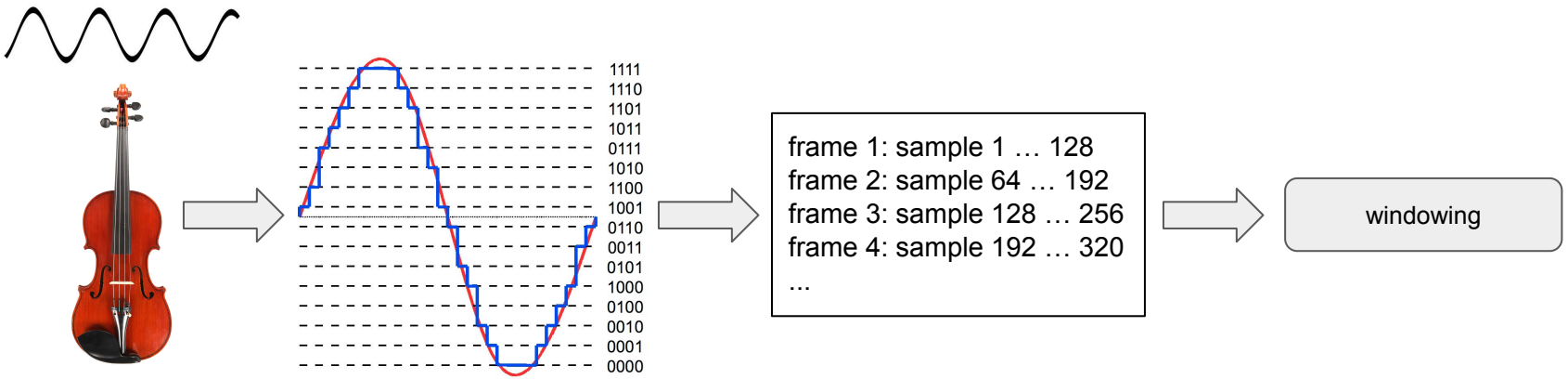


Overlapping frames



hop length

Frequency-domain feature pipeline



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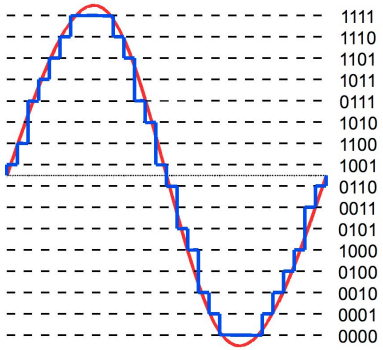
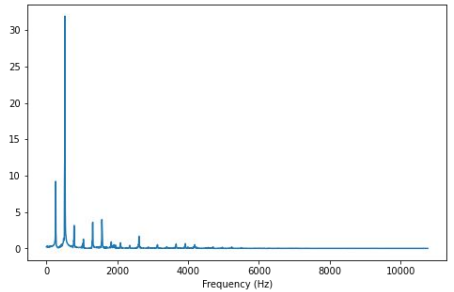


frame 1: sample 1 … 128
frame 2: sample 64 … 192
frame 3: sample 128 … 256
frame 4: sample 192 … 320
...

windowing

FT



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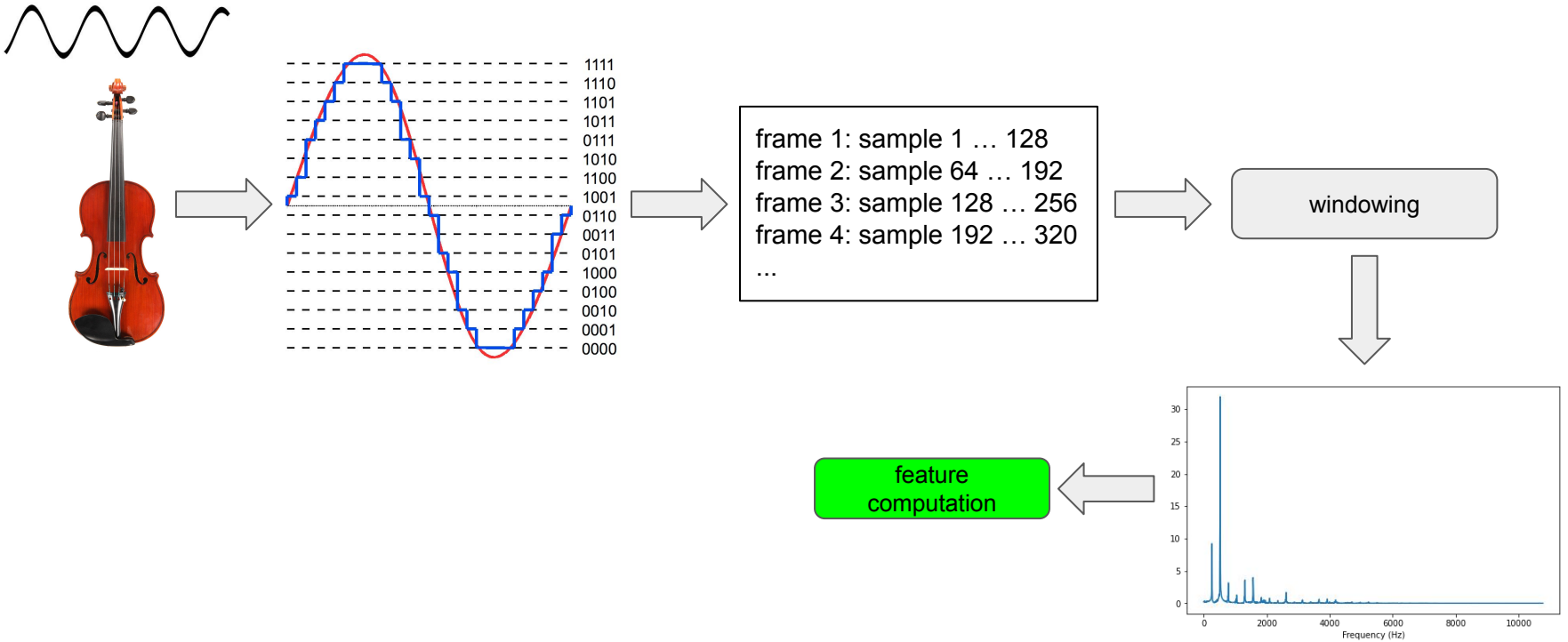

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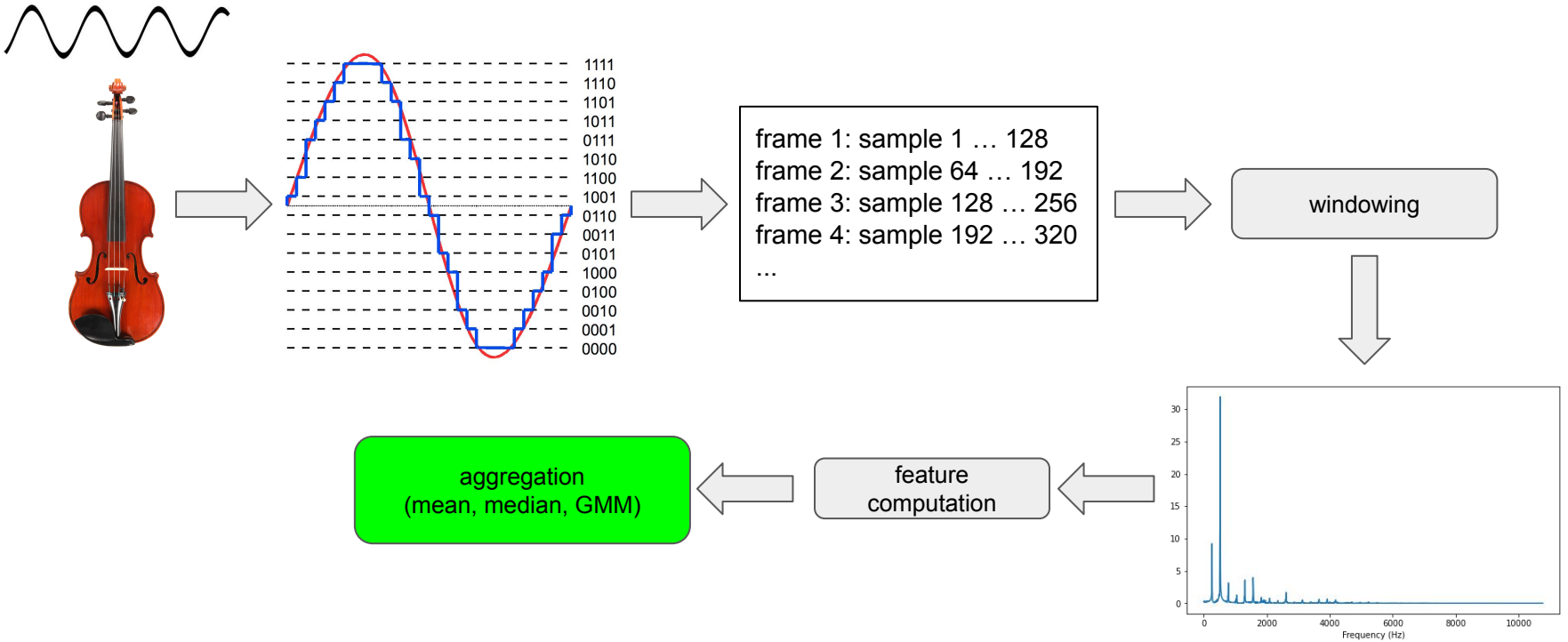

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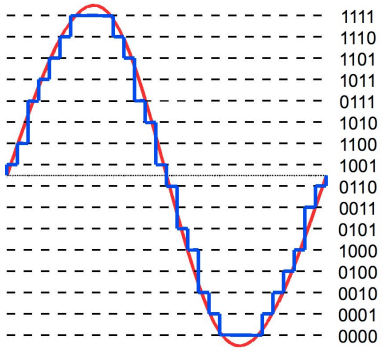

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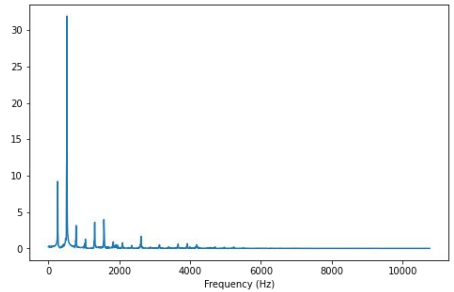
windowing



feature computation

aggregation (mean, median, GMM)

feature value/vector/matrix

What’s up next?

- Time-domain features