CSC3160 - Fundamentals of Speech and Language Processing

Lecture 3: Basics of digital signal processing

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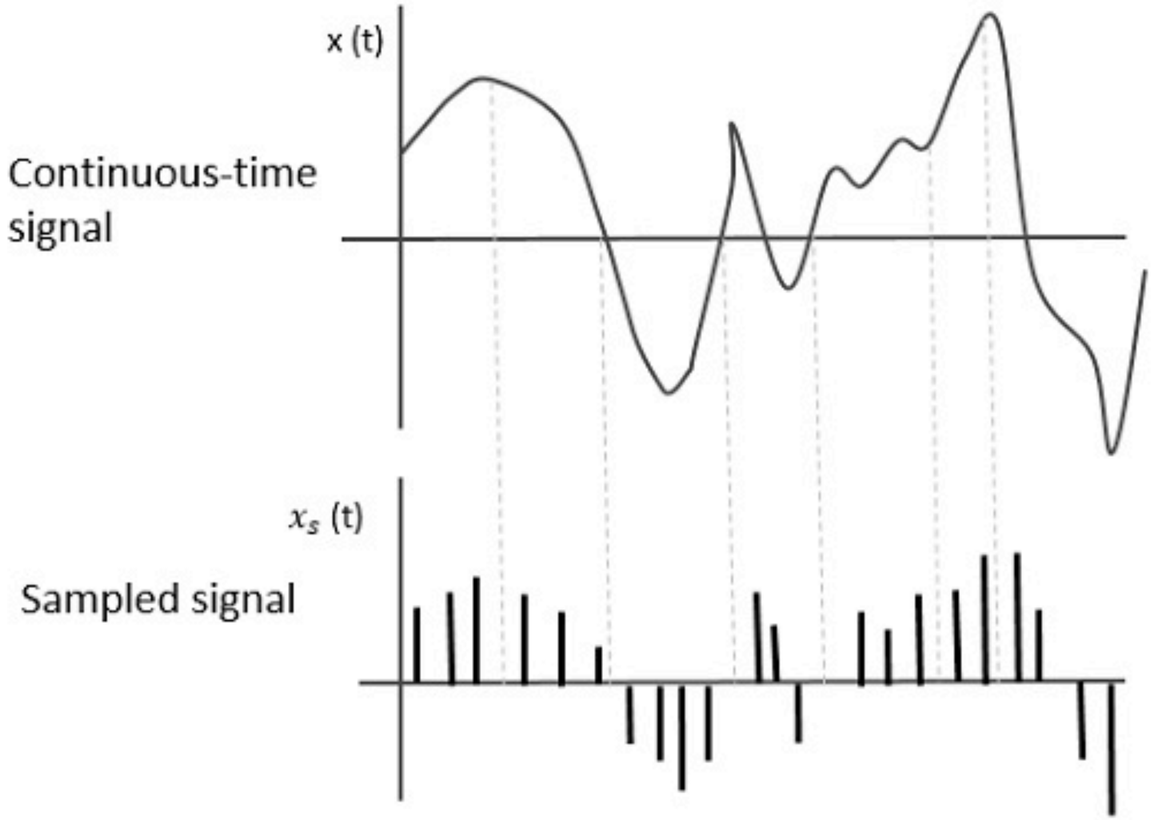
Agenda

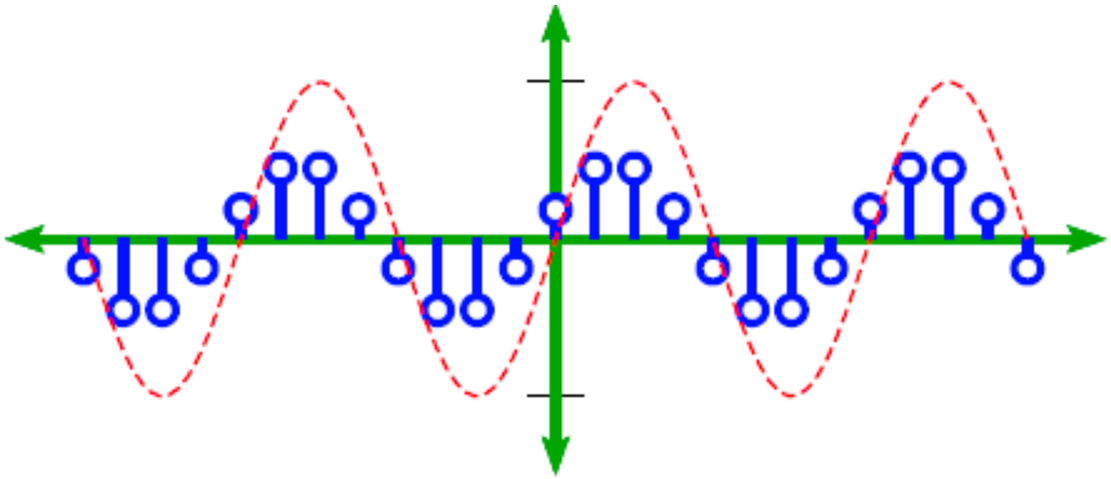
- Time domain vs frequency domain
- Basic of signal processing

Sampling



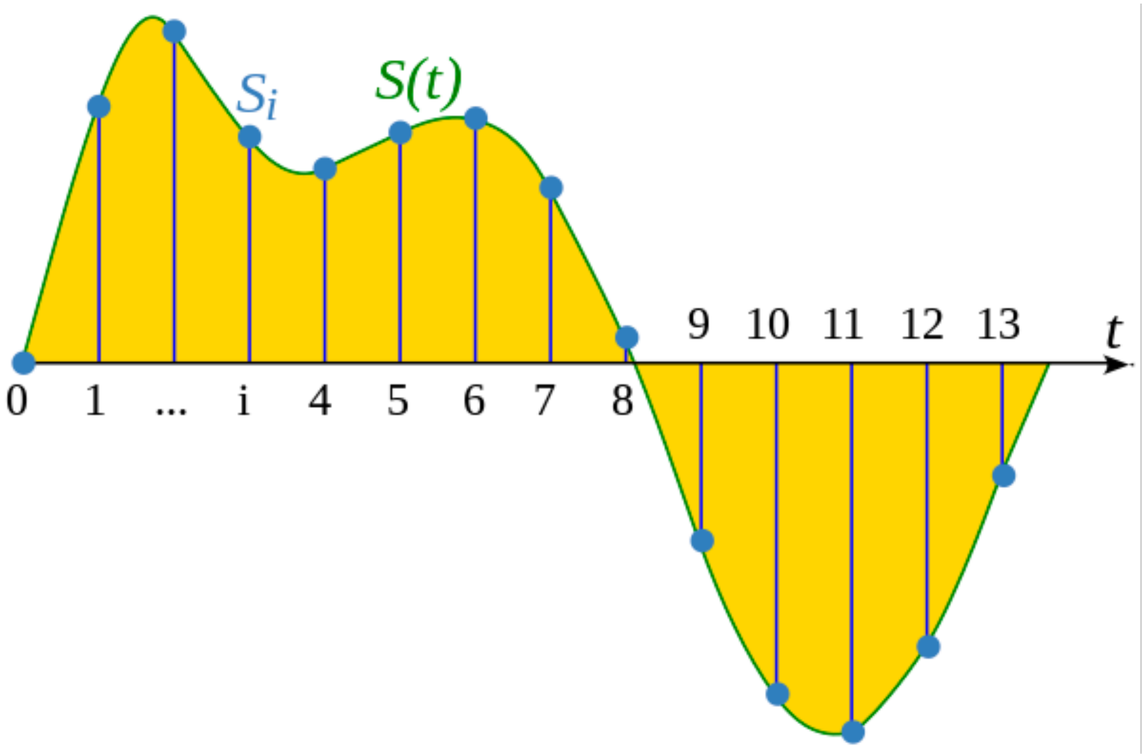
Sampling

- Sampling takes measurements of a continuous waveform at regular intervals and generates a sequence of measured values



Sampling rate

- Sampling rate = 1 / Sampling period

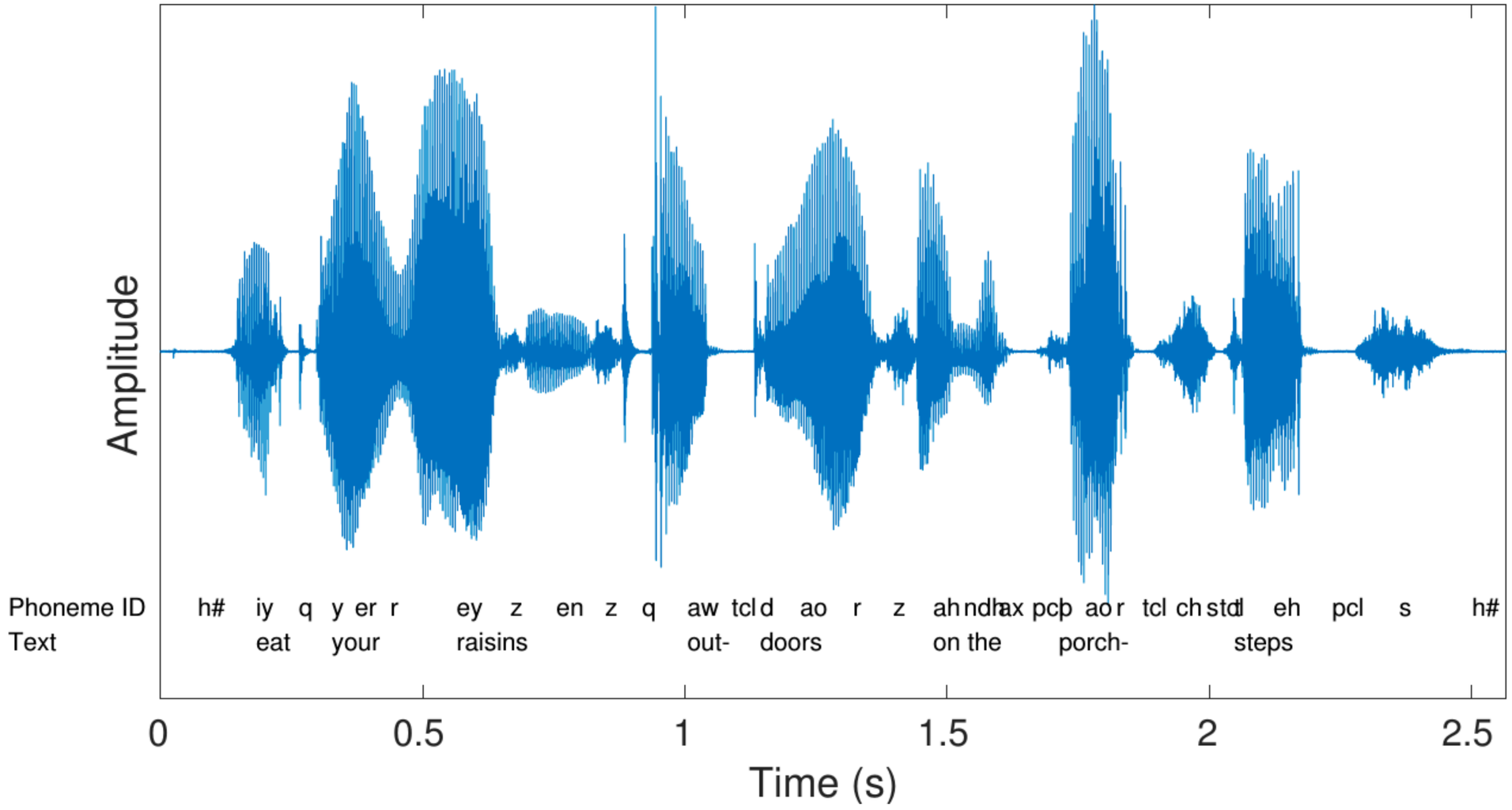


Comparison of different sampling rates

4k Hz	
8k Hz	
16k Hz	
22.05k Hz	
48k Hz	

https://colab.research.google.com/drive/1zPBwUfvEwUteiSLZSHXzMeleyC5rcN46?usp=sharing

Signal


Amplitude
Phoneme ID
Text
h# iy q y er r ey z en z q aw tcl d ao r z ah n dh ax pcl p ao r tcl ch stcl d eh pcl s h#
eat your raisins out- doors on the porch- steps
0
0.5
1
1.5
2
2.5
Time (s)

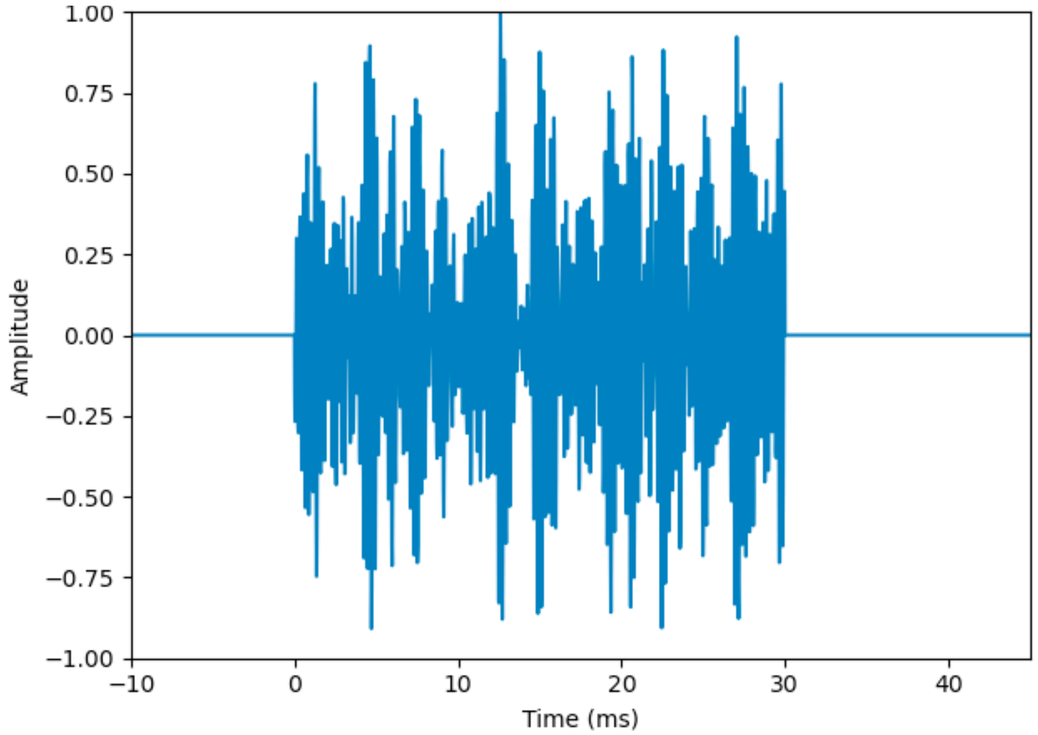
Windowing for analysis

- A signal of a sound/speech/music is a sequence of acoustic events/words/lyrics etc.
- The signal of a sound/speech/music is time-variant in character.
- To extract information from a signal, we must therefore split the signal into sufficiently short segments
- Extract segments which are short enough that the properties of the sound/speech/music signal does not have time change within that segment.

- Windowing is a classical method in signal processing and it refers to splitting the input signal into temporal segments

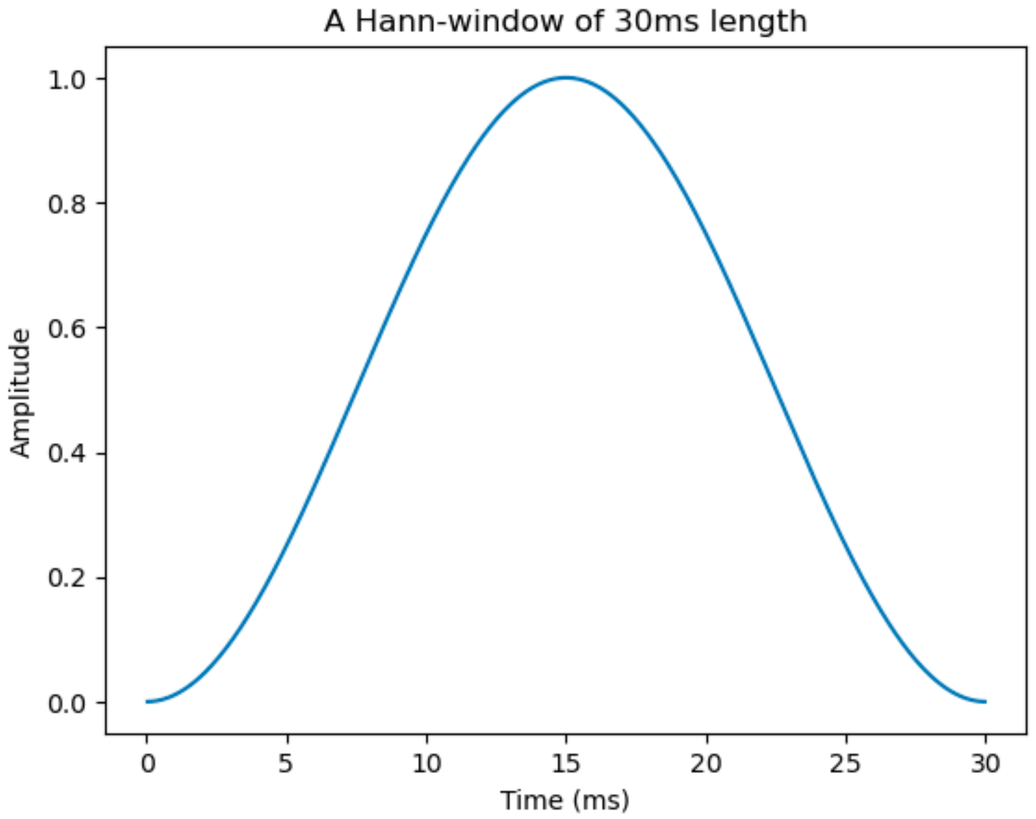
Windowing

- The straightforward windowing is to apply a rectangular window
- The borders of segments are then visible as discontinuities, which are incongruent with the real-world signal



Windowing for analysis

- Windowing functions are smooth functions which go to zero at the borders
- Hanning window as an example



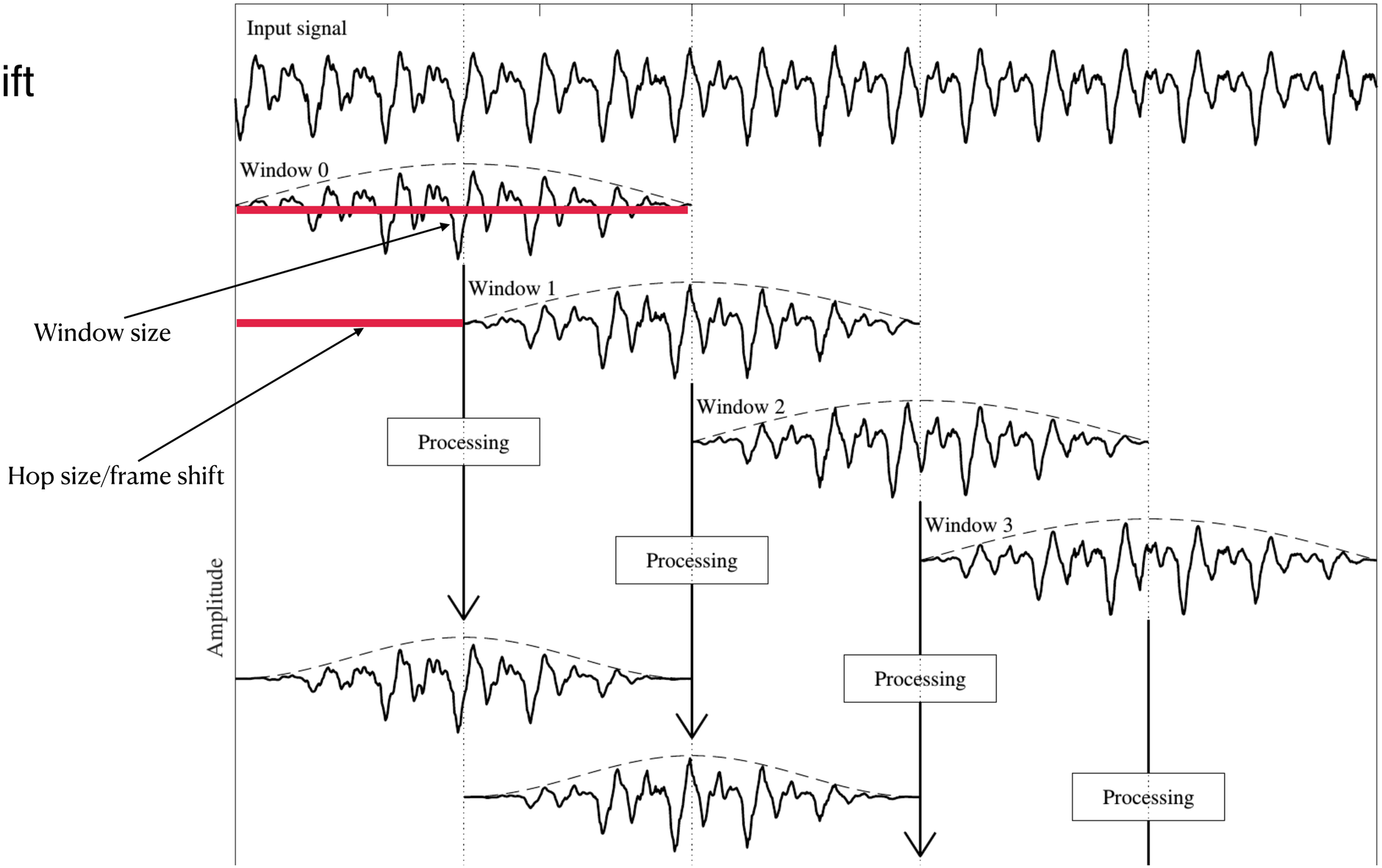
Windowing for analysis

- By multiplying the input signal with a window function, the windowing function also goes to zero at the border such that the discontinuity at the border becomes invisible. Windowing
- Windowing does change the signal

Live demo

Windowing: Framing

- Hop size/Frame shift
- Window size

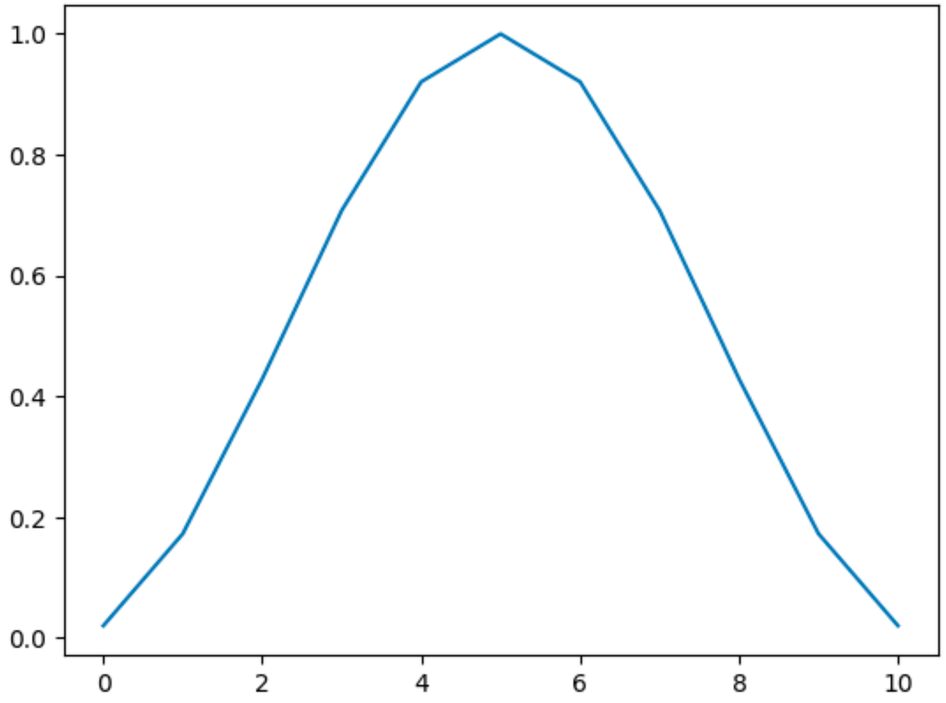


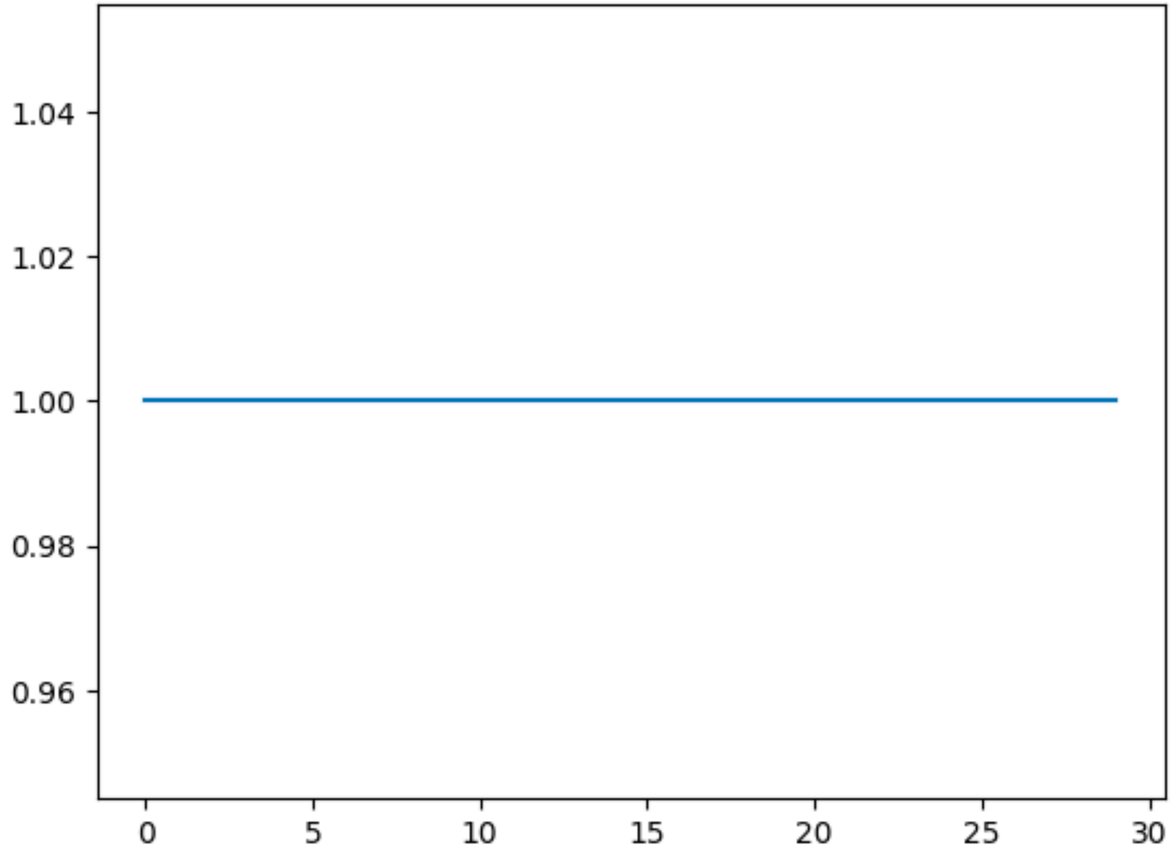
Convolution

- Convolution is a mathematical way of combining two signals to form a third signal.
- It is the single most important technique in Digital Signal Processing.
- Using the strategy of impulse decomposition, systems are described by a signal called the impulse response.

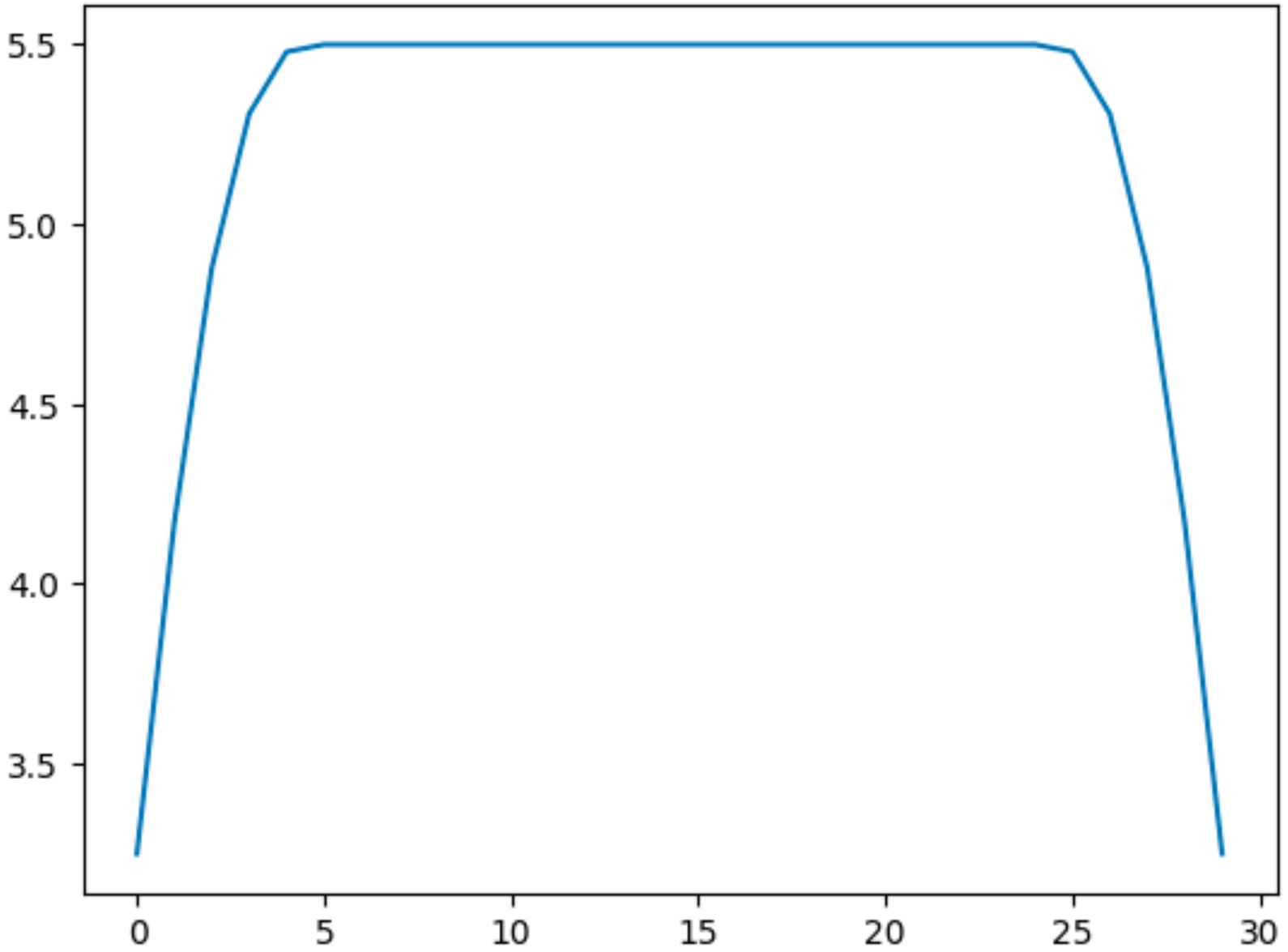
$$(f * g)[n] = \sum_{m=0}^{N-1} f[m]\, g[n-m]$$

Convolution

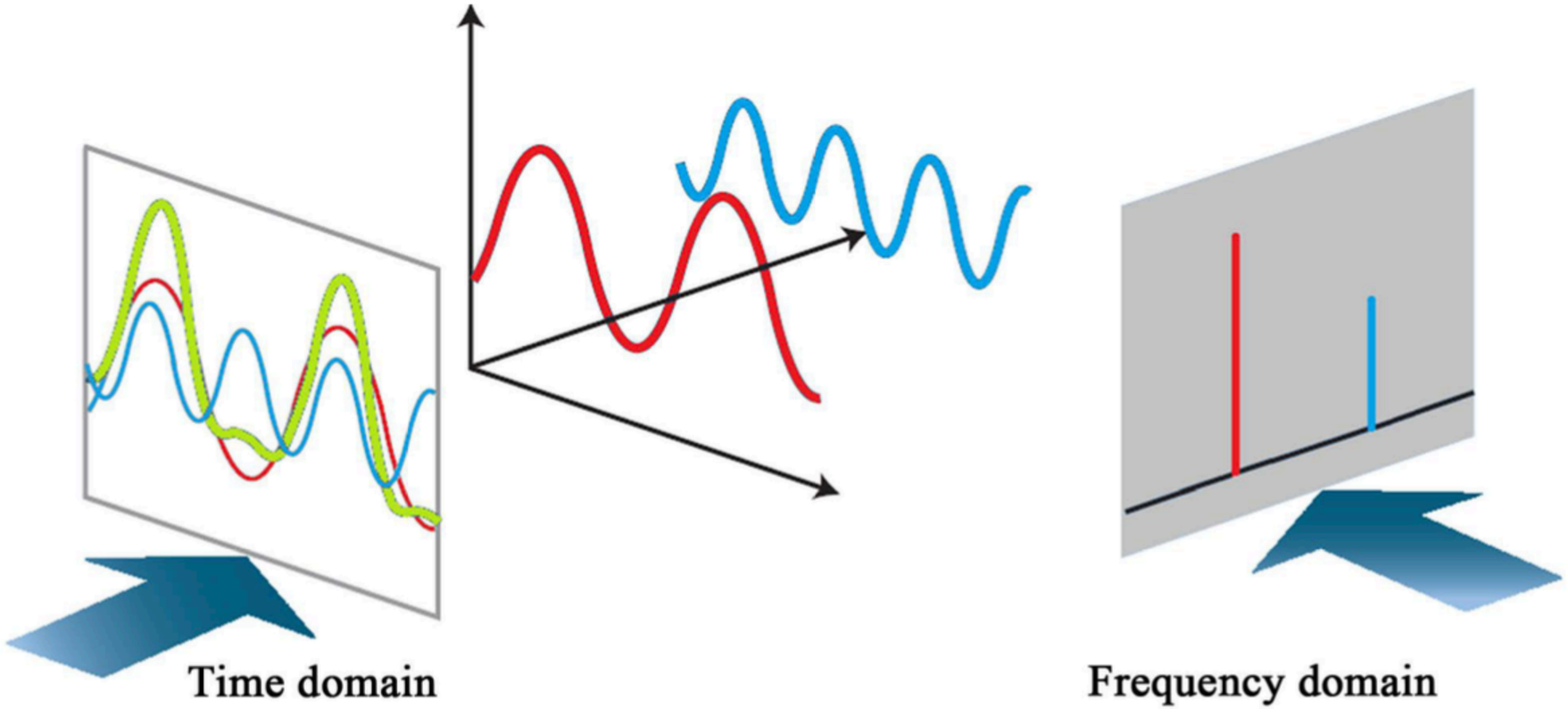




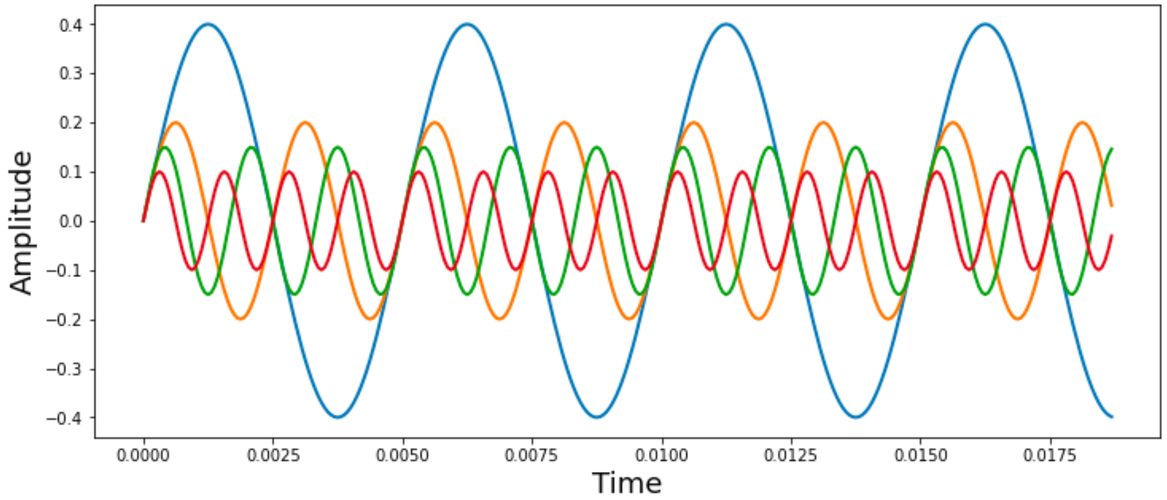
Convolution

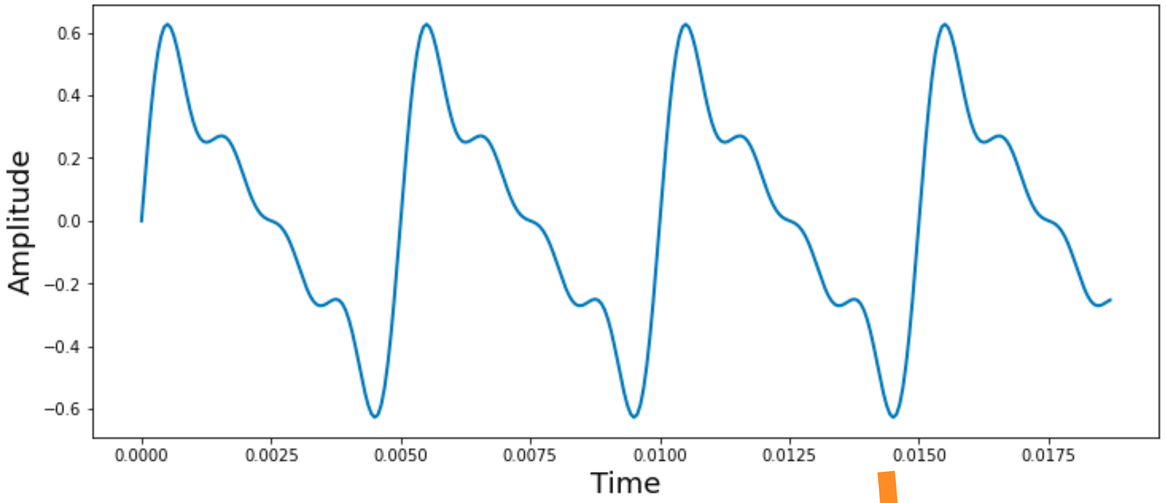


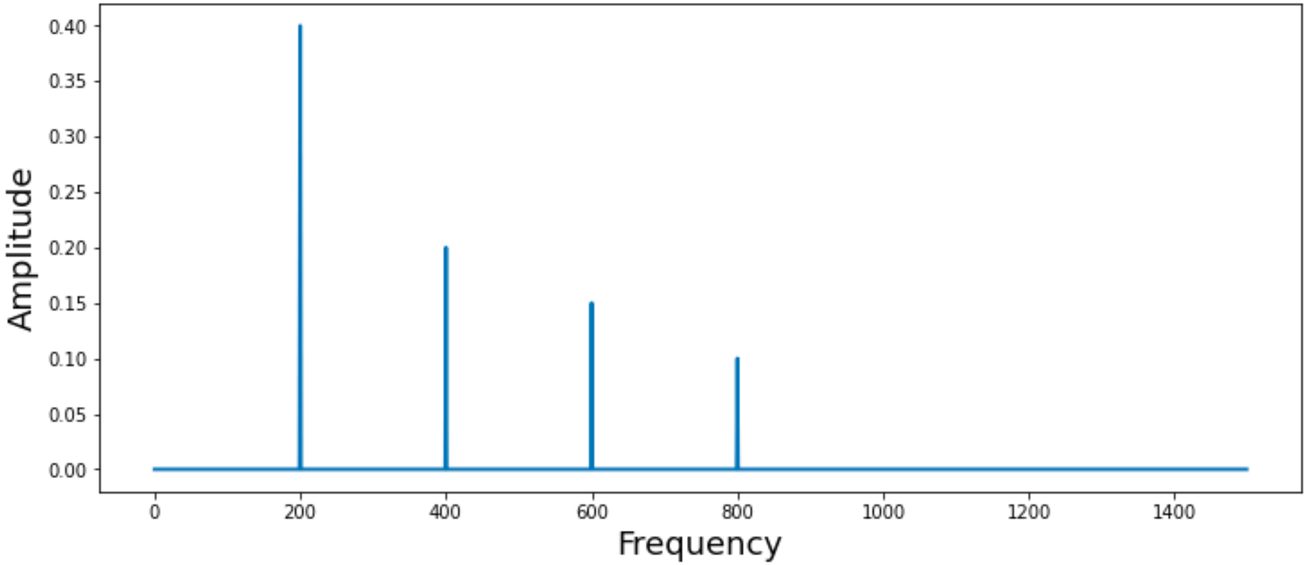
From time domain to frequency domain



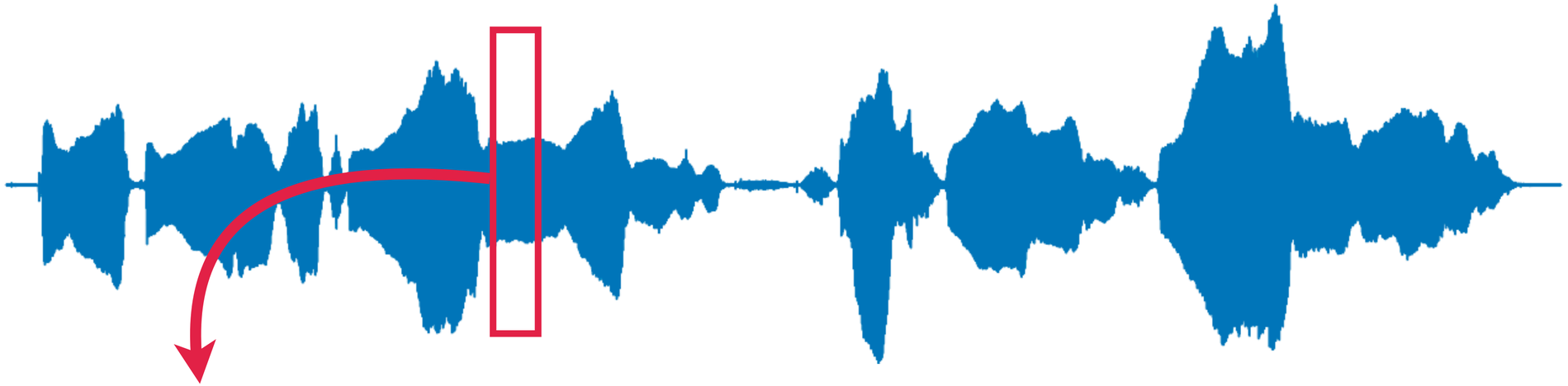
Frequency-domain representation

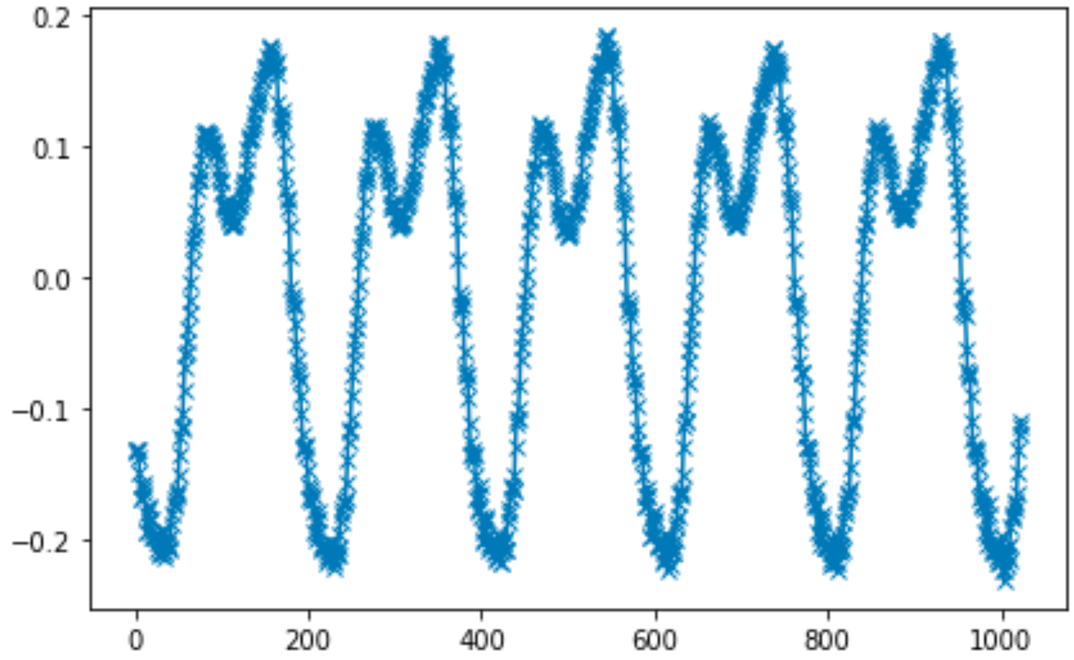


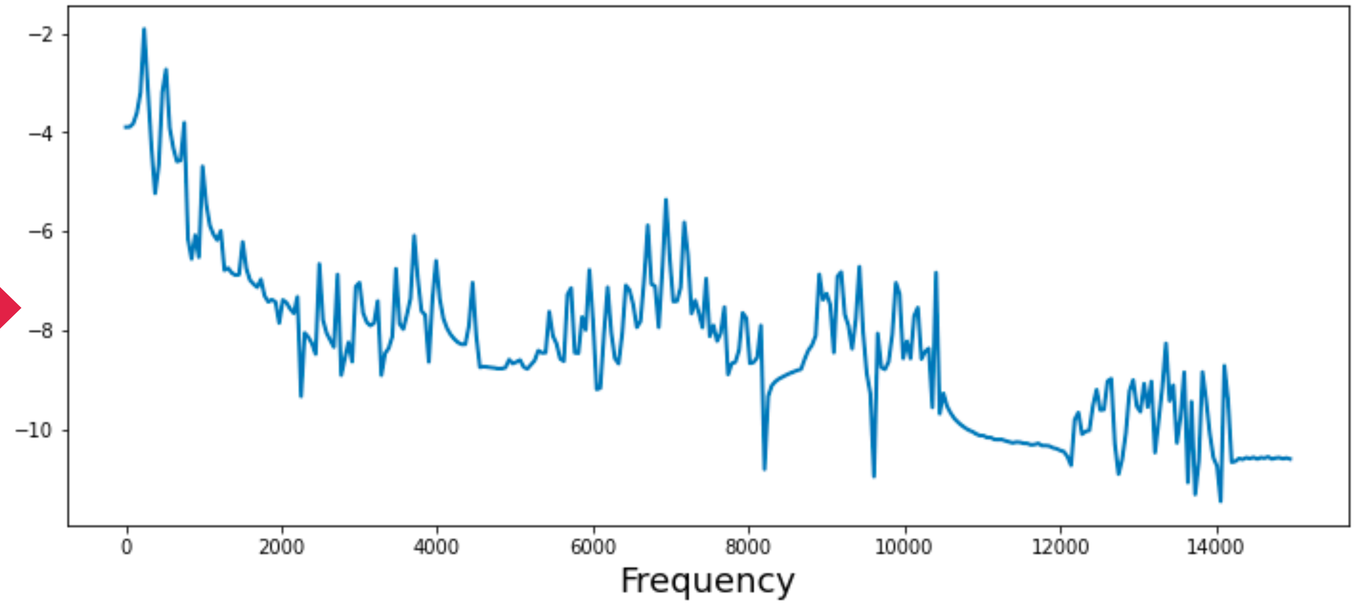




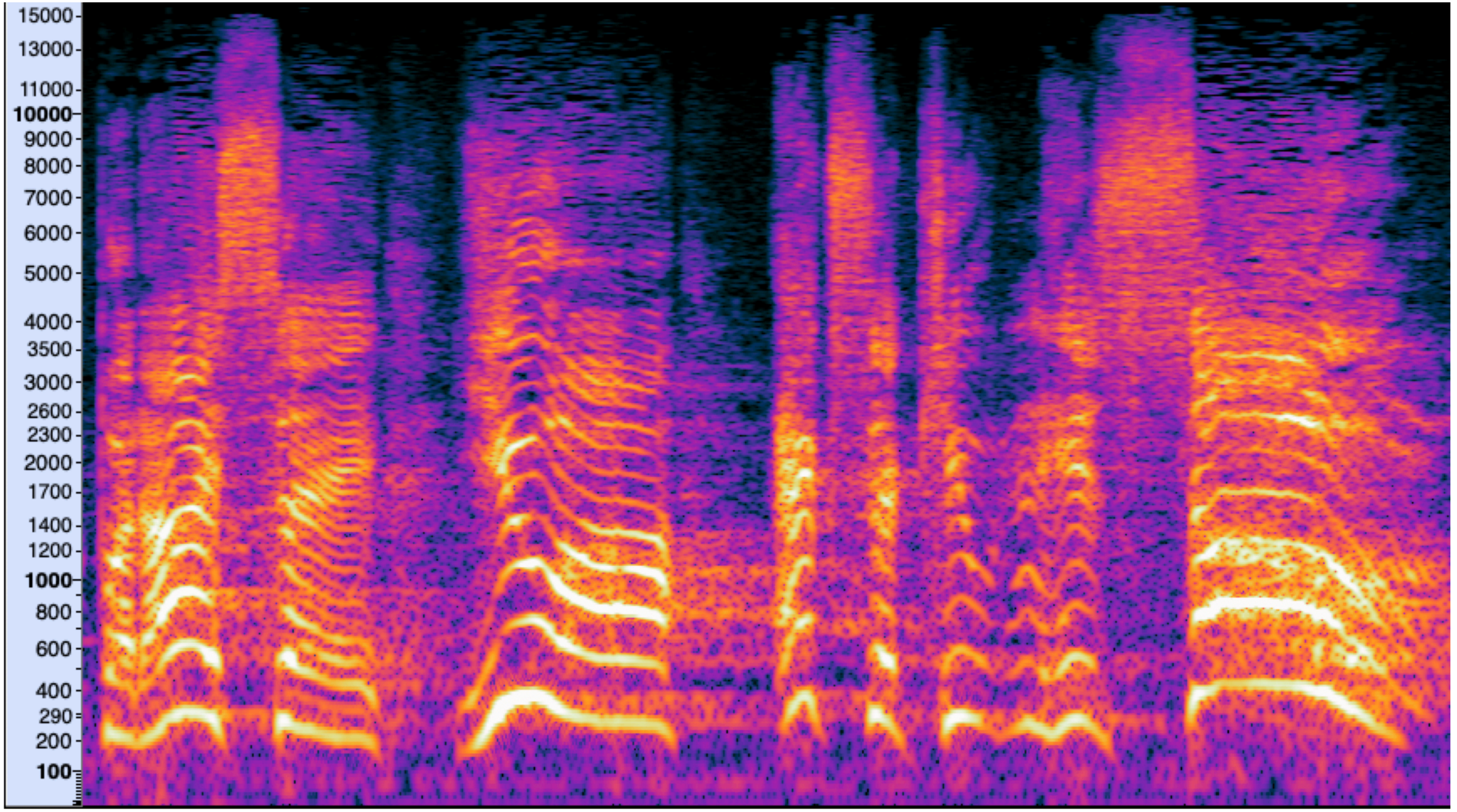
Frequency analysis







Frequency analysis



Summary

- Review of sampling and sampling rate
- Windowing and framing
- Convolution
- Time frequency representation