PS Signal Processing

Spectrogram

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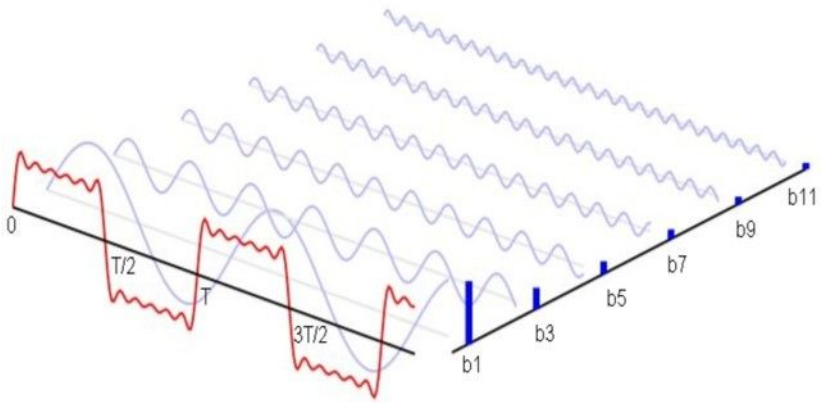
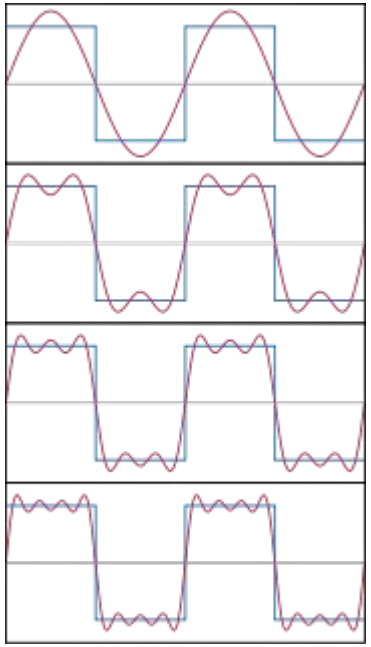
Time domain and Frequency domain

An audio signal is composed of many different individual signals with a unique frequency.

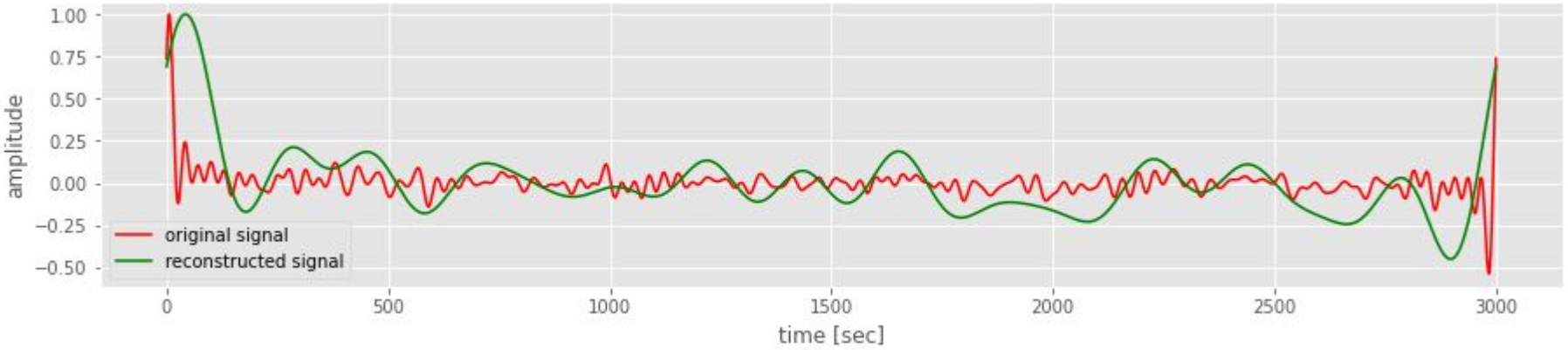
This is possible because a signal can be decomposed into a set of sine and cosine signals.

When we sum up these individual signals we can reconstruct the original one. This is called as **Fourier theorem**.



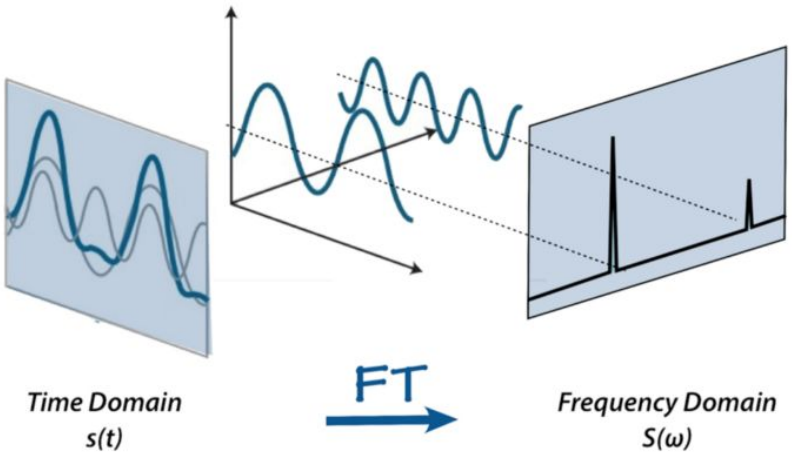


Time domain and Frequency domain



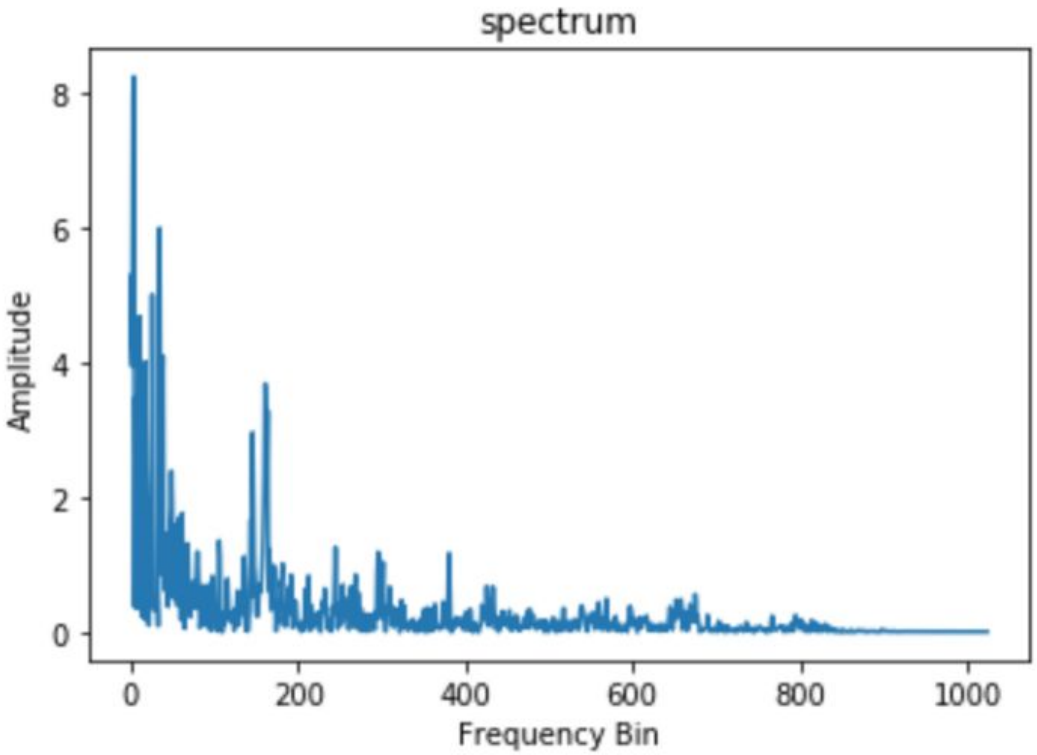
Time domain and Frequency domain

The **Fourier transform** is a math tool that allows us to decompose a signal into individual frequencies and its corresponding amplitudes. In other words, it is a mapping that allows us to go from the time domain to the frequency domain. The result is called the **spectrum** of the signal.



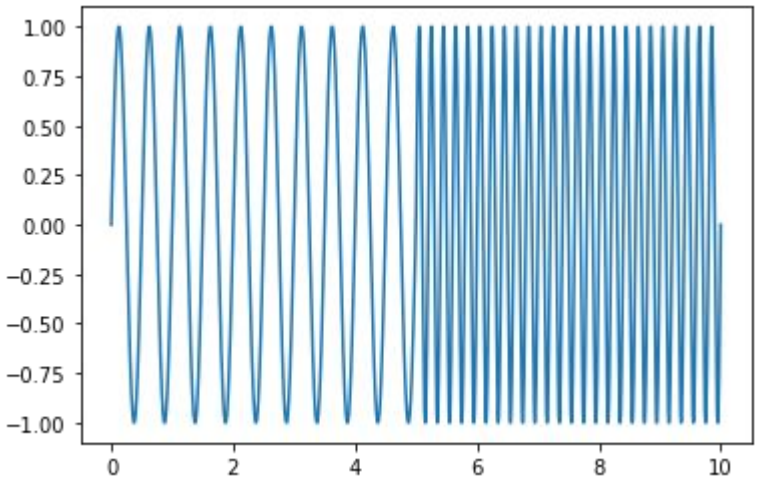
Time domain and Frequency domain

The **Fast Fourier Transform (FFT)** is an algorithm that allows calculating in an efficient way the Fourier transform.



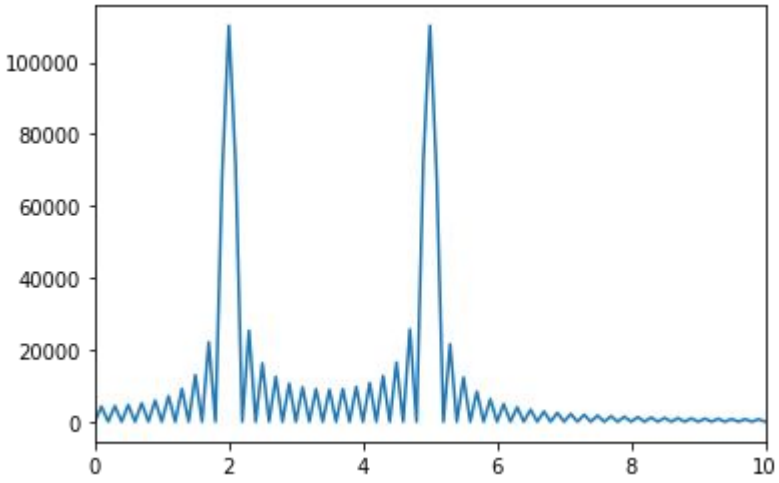
Time domain and Frequency domain

Signal in the time domain



FT

Signal in the Frequency domain



Drawbacks of Frequency domain

- The Fourier transform is a powerful tool that allows analyzing the frequencies involved in a signal
- What if the frequency varies with respect to the time?:
  - Music
  - Speech
- Those signals are known as non-periodic signals
- We need a way to calculate the spectrum of these “non-periodic signals”

Any idea?

Hint

The change rate of the phase or angle with respect to the time

$$f(t) = \frac{1}{2\pi}\frac{d\phi(t)}{dt}$$

A cos signal with a frequency that changes with respect to the time will be defined as

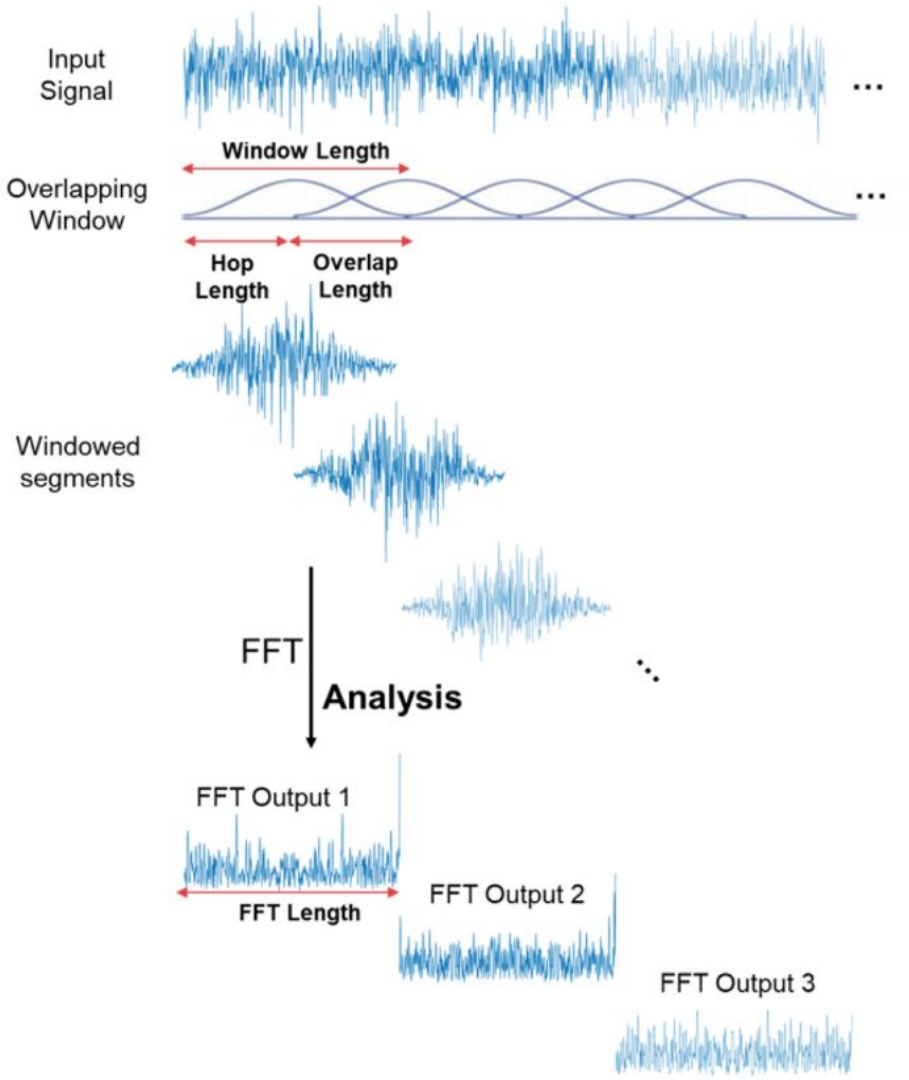
$$s(t) = Acos(\phi(t)) = Acos(2\pi \int_0^t f(\tau)d\tau + \phi(0))$$

If “f” is constant, then

$$s(t) = Acos(2\pi t f + \phi)$$

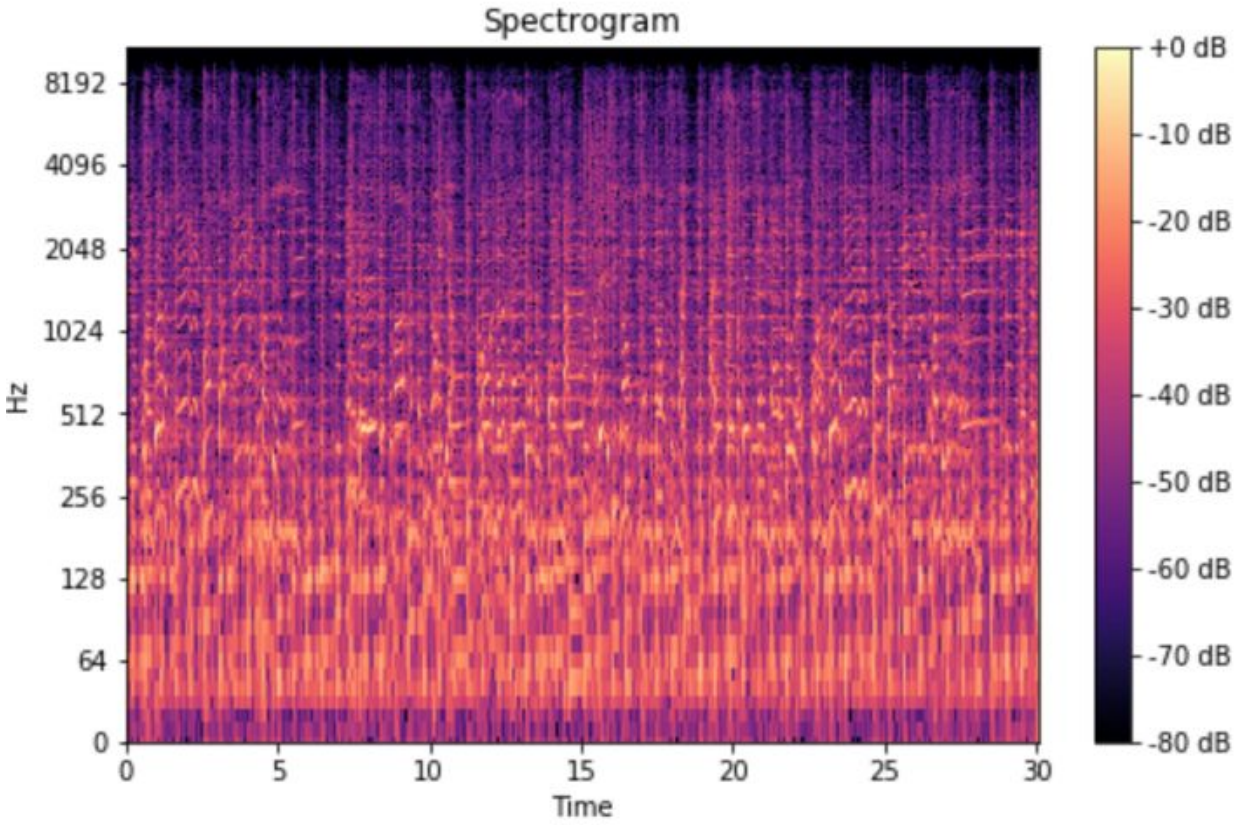
Spectrogram

- We could calculate the **FFT** in different segments of the signals
- This is called **Short-Time-Fourier-Transform**
- The FFT is calculated for each overlapped window.
- In this way, we get the called **Spectrogram**



Spectrogram

- We can think of a **spectrogram** as a set of stacked slices of **FFT**.
- This is a way to represent the amplitude of frequencies of a signal that vary over time
- The “Y” axis is represented in a logarithmic scale.
- The color represent the decibels (**DB**). We can think of this as a logarithmic scale of the amplitude.
- The logarithmic scale is because humans can only perceive a small range of frequencies and amplitudes.



Spectrogram

https://musiclab.chromeexperiments.com/spectrogram/