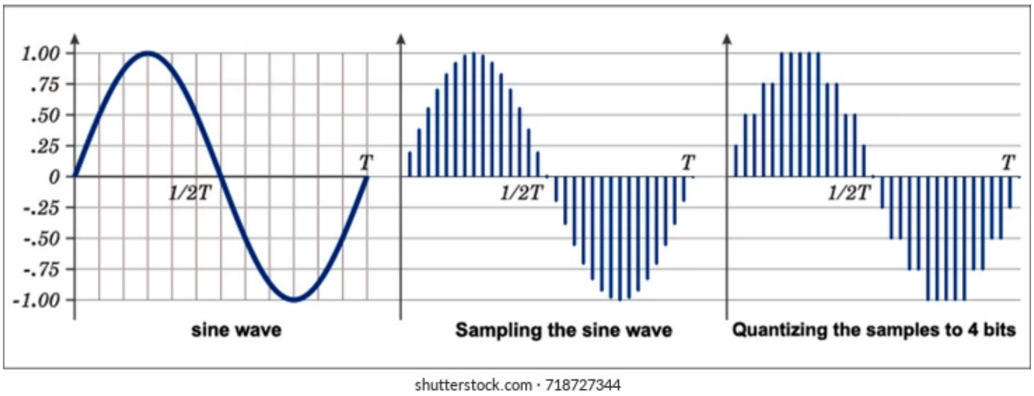
DFT

Sampling

- Discrete in Time

Quantization

- Discrete in Amplitude



source: shutterstock

Why continuous time signals to discrete time signals?

- Availability of cheap digital signal processors
- Easy computation
- Output of ADC is a digital signal

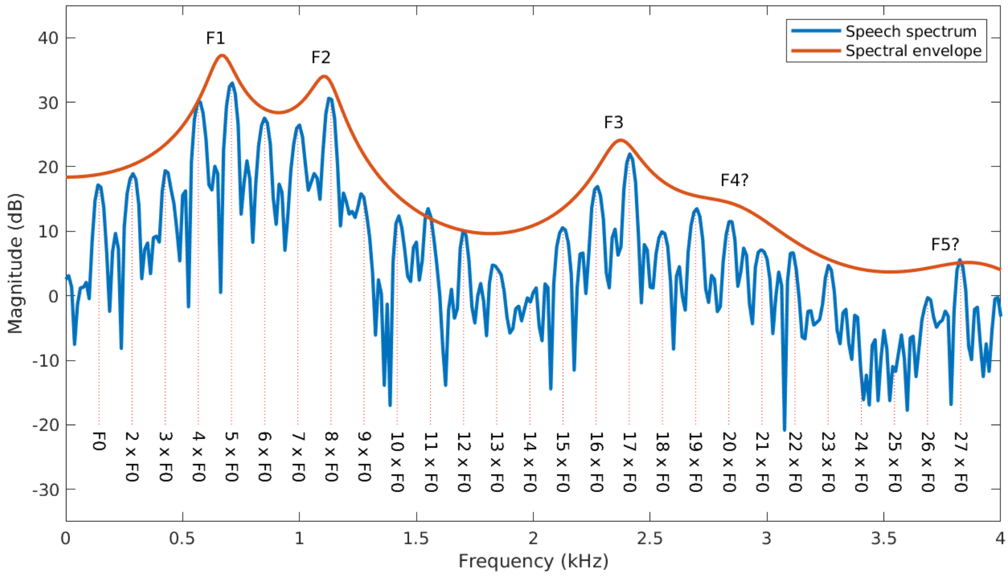
Analog (Continuous time) signal → Sampling → Quantization → Encoding → Digital (Discrete time) signal

Fourier Transform

- Converts a time domain signal to frequency domain signal.
- Input is a continuous time signal.
- For frequency domain analysis
  - Noise removal
  - Feature extraction
    - Which can further be used as data for your machine learning algorithms

What does a spectrum has to say?

An example of spectrum of speech signal:



Source: https://speechprocessingbook.aalto.fi/Representations/Fundamental_frequency_F0.html

- Two types
  - Magnitude spectrum
    - Change of magnitude with frequency
  - Phase spectrum
    - Change of phase with frequency

What is DTFT and DFT then?

Comparison:

S.No	DTFT	DFT
1.	Input is discrete in amplitude and time	Input is discrete in amplitude and time
2.	Applied to infinite length sequences	Applied to finite length sequences
3.	Continuous frequency spectrum	Discrete frequency spectrum
5.	Computationally expensive (infinite)	Computationally inexpensive
6.	Conventional mathematical formula used	Algorithms such as FFT is used.
7.	Depends on the length of the sequence	Complex Multiplications: N^2 Complex Additions: N(N-1) Finite calculations
8.	Operates on continuous frequency variable	Operates on discrete variable
9.	Formula (Given below)	Formula (Given below)

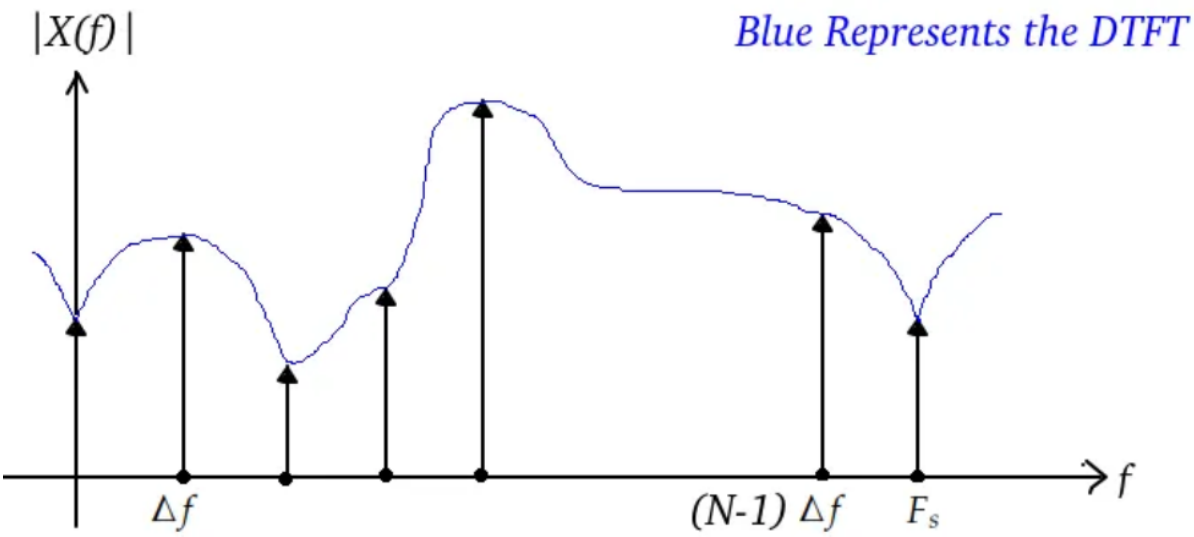
DTFT Formula:

$$X(e^{j\omega}) = \sum_{n=-\infty}^{\infty} x[n]e^{-j\omega n}$$

DFT Formula:

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{-j2\pi kn/N}$$

In short, DFT is the scaled sampled Fourier Transform of a Continuous Time Signal sampled above the Nyquist Frequency.



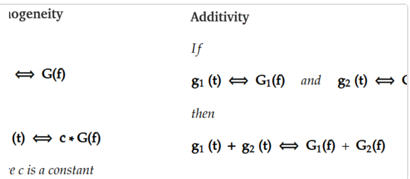
DTFT and DFT

Source: Medium

Check the following pages for more insights (go in the same order):

The Fourier Transform is a powerful mathematical tool used in feature engineering, particularly in…
1. Transformation to Frequency Domain: The Fourier Transform converts a signal from its original time or space domain into a representation…
https://medium.com/@evertongomede/the-fourier-transform-is-a-powerful-mathematical-tool-used-in-feature-engineering-particularly-in-c996c8220a83

Frequency Spectrum(Fourier Transform) of Continuous Time Signals
Spectral Analysis of signals play a vital role in the design of communication systems. Central to this is the mathematical tool called…
https://medium.com/@scinopio/frequency-spectrum-of-continuous-time-signals-ec9d9defa55c



Frequency Spectrum(Fourier Transform) of Discrete Time Signals

Modern Communication Systems use Digital Signals in contrast to analogue signals. The reasons are many, but one of them is the availability...

https://medium.com/@scinopio/frequency-spectrum-of-discrete-time-signals-30d8dd1af17d

$$G(f) = \int_{-\infty}^{+\infty} \left(\sum_{n=-\infty}^{+\infty} g[nT_s]\, \delta(t - nT_s) \right) e^{-j2\pi f t}\, dt$$

$$G(f) = \sum_{n=-\infty}^{+\infty} g[nT_s] \int_{-\infty}^{+\infty} \delta(t - nT_s) e^{-j2\pi f t}\, dt$$

Discrete Fourier Transform (DFT/FFT)

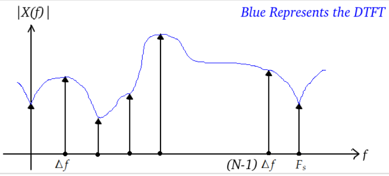
DFT is perhaps the most fundamental tool used in the Frequency analysis of Communication systems. It gives the sampled version of the...

https://medium.com/@scinopio/discrete-fourier-transform-6806be6456e3

Zero Padding, Frequency Resolution and Discrete Fourier Transform (DFT/FFT)

One of the common misconceptions about DFT is that zero-padding the signal can improve the Frequency Resolution. The aim of this article is...

https://medium.com/@scinopio/frequency-resolution-and-dft-ddaf95151cdc



Highly recommended to watch the following videos:

https://youtu.be/AWIONchKqhA?si=uZmTYWt5n5higj5R

https://youtu.be/d5Utdr8DagY?si=Hd4tJ0snolfFOO7B