Open lab –Speech/Audio signal Processing using MATLAB

Lab Sheet 4

Spectrograms

Aim

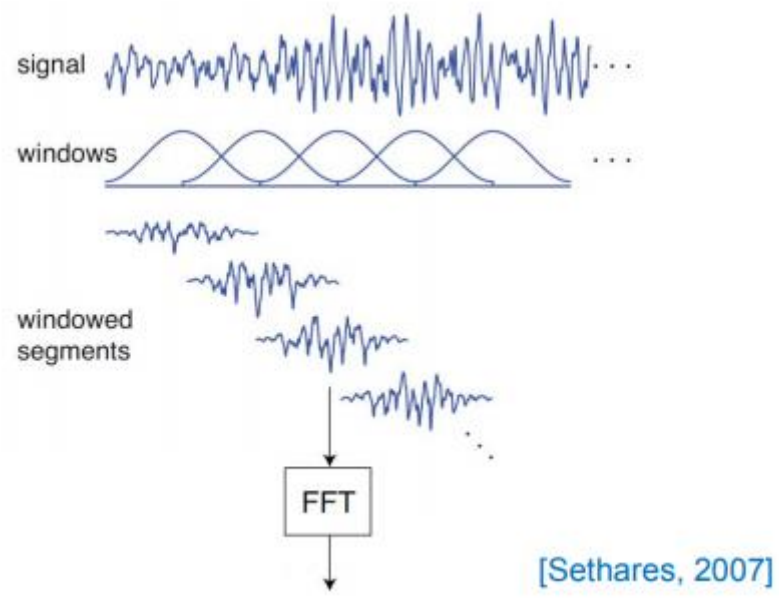
- To overcome the limitations of Fourier transform in case of non-stationary signals by using Short Time Fourier Transforms
- Familiarize spectrograms

Short Time Fourier Transform (STFT)

For signals that have frequency content that is changing over time, e.g., music, speech etc taking the DFT of the whole signal usually doesn't provide much insight. Rather than analyzing the frequency content of the whole signal, we can analyze the frequency content of smaller snapshots. Windowed F.T. or Short Time F.T. (STFT) involves segmenting the signal into narrow time intervals (i.e., narrow enough to be considered stationary) and then take the Fourier transform of each segment.

Steps:

– Define analysis window (e.g., 30ms narrowband, 5 ms wideband)
– Define the amount of overlap between windows (e.g., 50%)
– Define a windowing function (e.g., Hann, Gaussian)
– Generate windowed segments (multiply signal by windowing function)
– Apply the FFT to each windowed segment



Discrete-time Short-time Fourier transform

The Fourier transform of the windowed speech waveform is defined as

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

- where the sequence $f_n[m] = x[m]w[n-m]$ is a short-time section of the speech signal $x[m]$ at time n

Spectrograms

The spectrogram is a basic tool in audio spectral analysis and other applications. It has been used extensively in speech analysis. The spectrogram can be defined as an intensity plot (usually on a log scale, such as dB) of the Short-Time Fourier Transform (STFT) magnitude. Spectrograms are basically two-dimensional graphs -. Time and frequency parameters represents the axes. The amplitude (or energy or "loudness") of a particular frequency at a particular time is represented by the third dimension, color, with dark blues corresponding to low amplitudes and brighter colors up through red corresponding to progressively stronger (or louder) amplitudes.

Experiments

I. Download the speech file uploaded in AUMS and try to read the same using MATLAB. Find its sampling frequency and plot with a continuous time index. Try to playback the signal.
II. Plot the spectrogram of the signal.
III. Plot the spectrograms of the stationary and non-stationary signals given in labsheet 3. Comment on the spectrograms. What is your inference?