

EE 321: Digital Signal Processing

Python Assignment: Set - P01

You are tasked with processing a noisy audio signal to improve its quality. The signal contains both low-frequency noise and high-frequency noise. You need to perform the following tasks using DSP techniques with Python:

1. Load the noisy audio signal from the file “noisy_audio.wav” into a numpy array. Design a low-pass FIR filter with a cutoff frequency of 2 kHz to remove high-frequency noise from the signal. Choose an appropriate filter order of your choice. Plot the magnitude and phase response of the designed filter. Apply the designed filter to the noisy audio signal. Plot the original noisy signal and the filtered signal in the same graph to compare their frequency content. (Do not use any DSP Python libraries for filter design. Build your own filter function.)
2. Compute and plot the spectrogram of the filtered signal obtained in Part 1. Identify and mark the frequency bands containing the remaining noise in the spectrogram. Suggest a suitable filter type (e.g., band-stop or notch filter) to remove the remaining noise components based on your analysis.
3. Implement the filter you suggested in Part 2 to remove the remaining noise components from the filtered signal. Plot the magnitude and phase response of the designed filter. Also, plot the original noisy signal, the filtered signal from Part 1, and the final cleaned signal with the remaining noise removed. Calculate and display the signal-to-noise ratio (SNR) of the cleaned signal compared to the original noisy signal. (Do not use any DSP Python libraries for filter design. Build your own filter function.)

Submission Guidelines:

- Read all the questions carefully. If you have any doubts, discuss with the corresponding TA.
- Write all the codes in a single IPYTHON Notebook only (Jupyter Notebook or Google Colab). Submit the IPYTHON Notebook (.ipynb format) containing all your codes, plots, comments, and explanations for each task. You can create separate sections and subsections within the notebook for different parts of the questions.
- Do not use any DSP Python libraries. Build your own functions from scratch.
- Prepare a detailed assignment report explaining all the questions asked, different steps, derivations and calculations, algorithms, and generated outputs and attach all the necessary plots. Submit the report in PDF format only.