ECSE 512 – Digital Signal Processing
McGill University, Fall 2023
Term Project

Overview:

Working alone or in a team of two, students will be required to complete a term project on a selected topic or algorithm as described below. The aim of this activity is to foster students expand their knowledge and understanding of DSP and gain practical experience through the solution of an engineering problem. Realization of the project will involve the following steps:

- Reading related scientific/engineering literature.
- Developing and implementing DSP algorithm in Matlab (or equivalent).
- Testing and evaluating performance of algorithm.
- Writing a short technical report.

A detailed project description for this year, along with important related information on report format, deadlines, etc., is provided below.

Project description:

This project involves implementing and demonstrating the performance of a spectral noise subtraction algorithm for the enhancement of noisy speech, as originally proposed by S. F. Boll [1]. This method employs the short-term Fourier transform (STFT) to perform analysis-synthesis of the speech signal and apply noise suppression in the spectral domain. The basic STFT method for analysis-synthesis is explained in a paper by J. B. Allen [2]. You will find both references on the course web page under the Project folder.

You should first try to implement the STFT approach [1] without doing any spectral modification. Once you feel confident that the analysis/synthesis is working properly, you should add a basic spectral subtraction module based on the work in [2]. You should initially focus on what Boll calls bias removal, using preset values of the noise magnitude spectrum. If time permits, you may want to experiment with slightly more sophisticated techniques. Your algorithm should be implemented in a high-level language (Matlab or Python) and tested using noisy speech signals. To this end, you will need to select an adequate sampling frequency for audio applications and make certain design choices regarding the implementation of the spectral subtraction based on STFT, such as:

- Length of analysis window.
- Choice of analysis window.
- Desired level of noise cancellation.

You should use Microsoft WAV format for the representation of audio signals. These files can be accessed with the commands audioread, audiowrite, etc. in Matlab. For testing and demonstration purposes, you will need to create noisy speech files (i.e., clean speech plus noise). For this project, due to time limitation, you can record your own voice or grab some clean speech from a webcast or book-reader, and add some synthetic stationary noise (e.g., white or pink) at varying levels. If your algorithm is working properly, you should be able to remove some of the background noise without incurring too much distortion to the desired

speech. Ideally, the final processed speech samples must not have any clicks or undesirable noise. Again, if time permits, you may wish to experiment with more complex type of noise to see the limitations or your approach.

Report:

Your report should contain the following elements:

- A cover page with a short abstract.
- A table of content
- Section 1: An introduction providing (2 pages max):
  - A high-level overview of the project topic (motivation, problem statement, brief literature survey) along with some references.
  - Specific goals of the project and overview of the report's content.
- Section 2: Background theory on STFT, frame-based analysis-synthesis, and spectral subtraction, using equations and mathematical notations as needed (3-4 pages).
- Section 3: Description of your specific approach/algorithms and design choices, summary of algorithm and design trade-offs in choosing parameters (2-3 pages).
- Section 4: Results (waveform plots, spectrograms, audio files, etc.) and relevant discussions (3-4 pages).
- Section 5: Conclusion (.5 page max).
- List of references, presented professionally.
- Appendix containing all your code.

You should follow the guidelines below to ensure a professional and uniform presentation:

- Use 8.5 x 11 paper, single column (portrait) mode, with black print.
- Set top margin to 1.25 in and side/bottom margins to 1 in.
- Use Times New Roman, size 12 pt font, with 1.5 line spacing.
- Your report should include a cover page, 10-12 pages of descriptive text and figures, references, and listing of your software code with comments in appendix.
- Except for cover page, include page number at bottom.
- On cover page, indicate: project title; names and ID; brief abstract (5-6 lines), date, etc.
- Use a professional word processor, with equation editing and referencing capabilities.

Due date:

The report is due on **Monday, Dec. 5th, before 5h00pm**. This includes:

- 1 paper copy of your final printed report (you can leave under my door, MC756).
- 1 uploaded directory containing all relevant files: report file in pdf, software codes, etc.

Selected References:

[1] S. F. Boll, "Suppression of acoustic noise in speech using spectral subtraction," in IEEE Trans. on Acoustics, Speech and Signal Processing, vo. 27, no. 2, pp. 113-120, April 1979.
[2] J. B. Allen, "Short term spectral analysis, synthesis, and modification by discrete Fourier Transform," in IEEE Trans. on Acoustics, Speech and Signal Processing, vo. 25, no. 3, pp. 235-238, June 1977.

Grading scheme:

The final mark for the project will be obtained by summing marks obtained for the following components:

- Quality of presentation: 10
- Technical content: 10
- Results and discussions: 10

CEAB information:

The following engineering tools will be used in the realization of this project:

- Matlab software or equivalent (e.g., Python).
- STFT analysis-synthesis.
- Spectral modification and filtering in the frequency domain.
- Waveform plots, spectrograms.