BMEn 8101: Homework Set #5 **Instructor: Professor Hubert Lim**

Due by 11:59PM on March 29, 2024

Three of the problems below will be selected for grading. Problem 7 will be graded for sure. Each graded problem will be worth 10 points, so total of 30 points.

Please submit your homework in digital form to **BMEN8101Lim@gmail.com**.

Problem 1: 10.12

Problem 2: 10.19
Explain what each method will do to the frequency resolution of the STFT of x[n] (i.e., $X_r[k]$)?

Problem 3: 10.22

Problem 4: 10.32 (a), (b), (c), (d)
Please explain how you determined your answer choices.

Problem 5:
Using Matlab, please plot the STFT magnitude (i.e., spectrogram) for the both the clean and noisy speech signals from HW#4 (SigNoise and SigOG). Try both the rectangular and Hamming windows with varying lengths, L, and explain how these different windows affect the spectrogram. By comparing the spectrograms for the clean versus noisy speech, do any particular parameters improve visualization of the speech components over the noise components? Make sure to use a small enough frame shift value, R, and sufficient zero padding (so increase DFT to N points) to improve visualization of the plots. Does zero padding improve visualization of the speech components from the noisy background? Provide sufficient plots to justify your answers.

Problem 6:
From Problem 5, please reconstruct your STFT signals back into the time domain. Show that you selected appropriate overlapping windows based on the mathematical constraint shown in class and that the reconstructed signal matches the original signal. Please zoom up on your signals in several locations to show they are similar. Also zoom in at the start and end of the reconstructed signal and describe any distortion that may be caused by a lack of sufficiently overlapping windows to satisfy the constraint. Please look at pages 7-11 in the **STFT Windowing Reconstruction** document on CANVAS for different rules/constraints for each type of window (i.e., how to select R, M, L and N for your windows).

Problem 7:
You need to denoise a time-varying noisy signal using STFT (download **"tvNoisySpeech.mat"** from CANVAS; it contains a noisy signal and the original signal as well as the sampling frequency (fs) for the signals). This will require submission of multiple figures and justifications of what you tried and how well they worked. You will also email your best denoised signal as sound wav files to the TA (**BMEN8101Lim@gmail.com**). Please name this name: **HW5_StudentName_STFT.wav**. Try different window types and lengths to help you improve the denoising of the signal. Because the type of noise is changing over time, you will need to make an algorithm to denoise the signal differently across different time segments. I would suggest that you first visualize the signal using STFT as you did in Problem 5 to determine the type of noise in each segment. Then run your algorithm to denoise the signal over time using STFT (e.g., making a bandstop filter that shifts its frequency range with each proceeding segment

or using spectral subtraction that eliminates different frequency components across segments). Remember to follow the STFT Flow Chart presented in class (e.g., windowing constraint, zeropadding, etc.).

NOTE: Please create your own matlab code to do Problems 5 to 7 above. You can use Matlab's spectrogram function and the ones provided on the CANVAS website to help you understand and implement your own STFT code.

A nice link for more info on various/numerous topics relating to DSP. The link goes directly to reconstructions with the STFT but you can navigate the site to view other topics.
https://ccrma.stanford.edu/~jos/sasp/Overlap_Add_OLA_STFT_Processing.html