



New Mexico State University
Klipsch School of Electrical Engineering

EE589 - Digital Speech Processing
Spring 2008 - Exam #2

Name: _____

“The attached solution is due entirely to my own, individual efforts. I have not discussed this exam with any other student nor have I consulted with anyone other than (possibly) the instructor of this course in creating these solutions.”

Signature: _____ Date: _____

Prob. 1	/	25 points
Prob. 2	/	25 points
Prob. 3	/	25 points
Prob. 4	/	25 points
Total	/	100 points

Overview

The goal of this exam/project is to explore several speech signal enhancement and modification algorithms. You are free to use any and all resources available to you to prepare solutions to this exam. These resources include textbooks, class notes, computers, MATLAB, and the instructor of this course. These resources do *not* include using codes obtained from the Internet.

Required Files

All required files, including the NOISEX-92 noise corpus, for this exam can be found under the Related Links page of the EE589 web site.

Important Dates and Items to be Submitted

Your printed solution (answers, plots, and codes) to this exam is due on or before **5:00pm Friday, May 9, 2008**. In addition, all codes necessary to generate your solution should be submitted as an email to pdeleon@nmsu.edu with an exam2.zip file attached.

Lab Hours, Office Hours, and Appointments

During the period of May 5 – 9, Prof. De Leon will be available from 8:00am – 5:00pm with the exception of May 8 and several times during the week due to meetings. Students are encouraged to discuss the problems with Prof. De Leon and also free to call or email.

Prob. 1

In this problem we will develop a short code to perform a time-scale modification of a speech signal. To begin, code the `olaistft.m` tool.

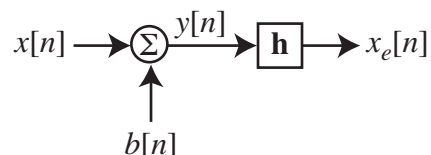
- (a) Using `Digits.wav`, plot the signal (use `plotcsig2`) and the spectrogram.

- (b) Time-scale the signal by a factor of 2 by repeating each frame of the STFT from (a). Synthesize the time-scale expanded signal from the modified STFT using the overlap-add method. Plot the synthesized signal and its spectrogram.

- (c) Listen to the modified signal. The articulation rate should be S-L-O-W (with little distortion) while maintaining the pitch. Comment on the plots in (a) and (b).

Prob. 2

In this problem we will develop a code to perform eigenfiltering of a noisy speech signal. The system model is shown below where $x[n]$ is the clean speech signal from `Name.wav`; $b[n]$ is the noise signal from `white.wav`; $y[n]$ is the noisy speech signal; \mathbf{h} is the eigenfilter; and $x_e[n]$ is the enhanced speech signal.



(a) Use the `welch2.m` tool to plot the estimated power spectrum of the clean speech signal, $S_x(f)$ as a function of f (Hz). Use the `add_noise.m` tool to create $y[n]$ with a 0 dB SNR and plot the estimated power spectrum of the noisy speech signal $S_y(f)$ as a function of f (Hz).

(b) Plot the unbiased correlation sequence of $x[n]$, $r_x[m]$ for $0 \leq m \leq 15$.

(c) Use $r_x[m]$ to build the Toeplitz matrix, \mathbf{R}_x (16×16) and plot the elements of the eigenvector, ν_{\max} corresponding to the maximum eigenvalue λ_{\max} of \mathbf{R}_x ; use MATLAB's `eig` and `toeplitz` functions. If necessary, scale the elements of ν_{\max} so that $\|\nu_{\max}\|^2 = \nu_{\max}^T \nu_{\max} = 1$. The eigenfilter $\mathbf{h} = \nu_{\max}$.

(d) Plot the magnitude response (in dB) of the eigenfilter as a function of f (Hz). Compare the magnitude response to $S_x(f)$ and comment on why this filter would improve the SNR.

(e) Eigenfilter the noisy speech signal and plot the estimated power spectrum of the enhanced speech signal, $S_{x_e}(f)$. Comment.

(f) On a single figure, plot the PESQ scores of noisy and enhanced speech signal as function of SNR in dB for $-5 \leq \text{SNR} \leq 40$ in steps of 5 dB. Comment.

Prob. 3

In this problem we will develop a short code to perform noise reduction of a speech signal using the oversubtraction version of spectral subtraction (Berouti). Code the `overspecsub.m` tool (see attached) and use the `add_noise.m` tool to initially create $y[n]$ with a 10 dB SNR. Use `Digits.wav` for the clean speech signal and `pink.wav` for noise signal.

- (a) Plot the spectrograms of the clean and noisy speech signal.

- (b) Write a code that computes the STFT of the noisy speech signal, calls `overspecsub.m`, and calls `lseistft.m` to produce an enhanced speech signal. Plot the spectrogram of the enhanced speech signal and compare to the spectrograms in (a).

- (c) On a single figure, plot the PESQ scores of noisy and enhanced speech signal as function of SNR in dB for $-5 \leq \text{SNR} \leq 40$ in steps of 5 dB. Comment.

Prob. 4

In this problem we will develop a short code to perform noise reduction of a speech signal using the Wiener filter. Code the `wiener.m` tool (see attached) and use the `add_noise.m` tool to initially create $y[n]$ with a 10 dB SNR. Use `Name.wav` for the clean speech signal and `factory.wav` for noise signal.

- (a) Plot the spectrograms of the clean and noisy speech signal.

- (b) Write a code that computes the STFT of the noisy speech signal, calls `wiener.m`, and calls `lseistft.m` to produce an enhanced speech signal. Plot the spectrogram of the enhanced speech signal and compare to the spectrograms in (a).

- (c) On a single figure, plot the PESQ scores of noisy and enhanced speech signal as function of SNR in dB for $-5 \leq \text{SNR} \leq 40$ in steps of 5 dB. Comment.