ECE 3230 - Practicum I

Introduction to Continuous and Discrete Time Signals & Operations

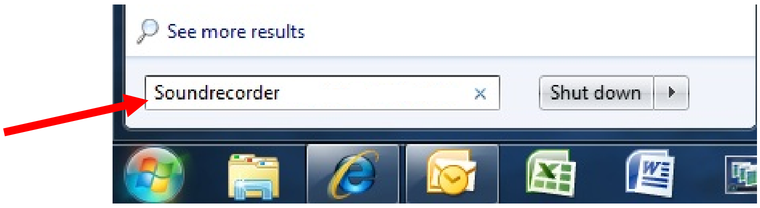
Reporting Requirements: Follow report instructions given in Syllabus.

Objective: i) To gain experience with continuous and discrete time signal representations in time and frequency domains; ii) To get familiar with operations performed on signals i.e. operations on the amplitude like amplification, addition, multiplication or operations on time axis like time reversal, scaling or shifting; iii) To learn general concepts and problems that require processing of signals; iv) To refresh Matlab knowledge.

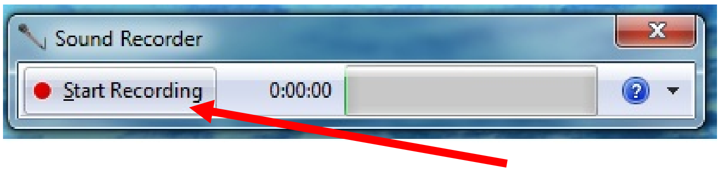
Background: Read Subsection 1.4 and 1.5 of Dr. Kevin Buckley's Notes posted on Blackboard.

In this Practicum, according to the procedures given below, you will work with speech signals, either the pre-recorded ones that you can download from the course website in Blackboard or the ones that you can record using Windows sound recorder.

Using the Windows Sound Recorder available on your laptop, you can create your own .wma audio file to be used in the related parts of the Practicum. The default audio file format from Sound Recorder in Windows is a .wma file. You can locate the sound recorder by typing "Soundrecorder in the "Search programs and files" box within the Start Button:



If you successfully accessed the Sound Recorder, you should see this on your Desktop:



You can then record your sounds by clicking the red 'Start Recording' button and when you are done you can stop by clicking the same button.

When you click 'Stop Recording', SoundRecorder automatically asks where you would like to save your sound file (outputfile.wma or whatever name you would like to save your recording). Note that the 'Save As' window indicates 'Save as Type: Windows Audio File" which is the ***desired*** .wma format. You ***must*** save your sound file in the ***same*** folder as you will be saving your MATLAB code for this practicum.

Procedures:

1. **Time and Frequency domain Representation of Signals**

a) You are given two sets (one female, one male) of recordings for the spoken words of "Villanova" and "University" in villanova1.wma (female), villanova2.wma (male), university1.wma (female) and university2.wma (male). Please download the files from the course website in Blackboard to the folder you will use for this Practicum where you save your Matlab code also. Make sure that Matlab command window is working under that same file directory also.

b) Read the audio file, villanova1.wma to the sound signal vector S in MATLAB using the command lines given below:

```
[S,Fs]=audioread('villanova1.wma');
```

The vector S in MATLAB contains all the information in the .wma file. (Notice that S is actually a two column vector, hence a matrix with two columns, since the recording is in stereo.) The variable ‘Fs’ is the sampling frequency in Hz used to sample the original continuous time speech signal to obtain the discrete time speech recording given to you. The sampling period, ‘Ts’, which is the time interval in seconds between each sample of the speech signal (each entry of the S vector) is then found as Ts=1/ Fs.

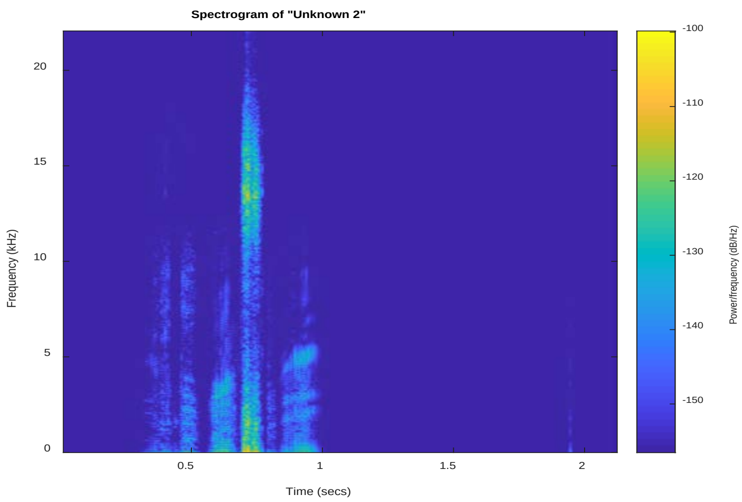
Plot the audio signal, S vs time, the spectrogram of the audio signal S, frequency vs time (spectrogram plot provides the frequency of oscillations in a signal at different time intervals), and listen to your recording in MATLAB for which you can use the command lines below:

```
Ts=1/Fs; %sampling period

N=length(S); %length of the audio signal, number of samples
Te = N*Ts; %final time
time=[Ts:Ts:Te]; % calculate the time axis (sec) of the wma file

% plot the wma file vs time
figure(1)
plot (time, S)
title('Speech Signal of "Villanova" ')
xlabel('time (sec)')
ylabel('Amplitude')

% plot spectrogram of the audio signal
figure(2)
spectrogram(S(:,1).^2,1024,1000,2048,Fs,'yaxis')
title('Spectrogram of "Villanova" ')

% Listen to the audio signal using soundsc command: amplitude autoscaled
soundsc(S,Fs)
```

c) Repeat part (b) for the remaining audio file for word “Villanova” (villanova2.wma) and the two sets of recordings for word “University” (university1.wma and university2.wma). What do you observe in time domain signals of different words, where do the high and low amplitude of the signals exist (vowels or consonants) in these speech signals? In the spectrogram plots, what do you observe, what is the time and frequency contents of the word “Villanova”, and the word “University”, are they distinguishable, how does the frequency content change for each syllable, which one gives the highest frequency content? Note that in the following weeks you will learn more about frequency domain representations of time domain signals when you cover Fourier transformation technique.

d) Repeat part (b) for your own recordings of the word “Villanova” (villanova_self.wma) and for word “University” (university_self.wma). To record your audio files while saying the words please refer to the instructions given in the background section. How do your recordings in time domain (time series signal plot) and in time and frequency domain (spectrogram plot) compare with the given sets of audio files for the corresponding words? Are there any time or frequency content differences or similarities?

e) If you are given the spectrogram plot of an unknown word as below where it is known that it belongs to one of the word categories of either “Villanova” or “University”, with the given time-frequency information as you have studied in previous parts, can you identify which word category this plot corresponds to? Provide your reasoning in your selection. Can you think of a field of application in signal processing area for this type of operation?



2. **Operations on Time and Amplitude Content of Signals**

a) Listen to the audio recording of yourself for the word “Villanova” using 2Fs and Fs/2 in the **soundsc** command. Listen to your signal for original Fs but when you use flipud(S) in soundsc command. (You can type ‘help flipud’ in MATLAB command window to learn what this command does.) What kind of time domain operations do these commands do on the signal (time reversal, time scaling (stretching or compression) or time shifting)?

b) Listen to your original signal using **sound**(S,Fs) and also using **sound**(S/5,Fs). Note that here you have to use sound command instead of soundsc to be able to hear the difference. What kind of operation on the amplitude does this do on the signal (amplitude scaling, summation, multiplication, derivative or integration)?

c) Use the recording of yourself for the word “Villanova”. Generate a new signal, W (actually a matrix of N x 2) the same length as your audio signal S (length N in its rows) having zeros for the first part of the word “Villa” and ones for the region corresponding to the second part of the word “Nova”. Here you can generate a column vector W of ones of length the same as the size of the original signal S using the Matlab command “ones” (if you do not know the command type “help ones” in Matlab command window) and then equate the first entries of the matrix corresponding to the part up to the end of “Villa” to zero. You can do these operations with the commands given below:

```
W=ones(size(S));
W(1:???,:)=0; %fill in the length ??? according to your recording
```

Multiply this new signal W, point by point with the signal S to generate the new signal WS=W.*S (in MATLAB point by point multiplication is performed with the command “.*”). Plot the signal WS vs. time. Listen to WS using soundsc command. What kind of operation does this multiplication with W do to your audio signal S?

d) You will perform amplitude scaling and signal addition, and investigate the effect of noise on signals in this part. Use your original sound recording for the word “University”. Generate a new signal E, which is the same size as your original recording S and of type as white Gaussian noise. Add this noise E to the original signal S at different weights to generate a noisy signal Sn. You can use the following commands to perform these operations:

```
E=randn(size(S));
Sn=S+???*E; %fill in the weight??? for a small and a high value
```

Plot the signal Sn vs. time and the spectrogram plot of Sn for a small and a high weight value, what do you observe for different weight values in the time-frequency content of the signal? Listen to Sn for small and high weight values. How does adding E affect the sound of S? Where can such noisy signals occur in real life and can you suggest a method that engineers in signal processing field use to eliminate such noise?

Practicum I: Introduction to Continuous and Discrete Time Signals & Operations
Instructor/TA Sign Off Sheet, & Report Form

Student's Name: ……………………………………….

For this Practicum, attach all plots requiring sign off below.

1. Procedure 1(b,c): Plots and sounds of the given audio signals ……….…………………………….
Comment on the questions.

2. Procedure 1(d): Plots and sounds of audio signals from self……….…………………………….
Comment on the questions.

3. Procedure 1(e): Comment on the questions.

4. Procedure 2(a,b): Sounds of signals after given operations……….…………………………….
Comment on the questions.

5. Procedure 2(c,d): Plots of signals after given operations……….……………………………
Comment on the questions.