Cairo University	Electronics and Communication Department			
	Academic Year:	2020	Semester:	2nd Semester
	Course Code:	ELC206	Course Title:	Signal Analysis
	Full Mark: 100			

Take-Home Research Assignment

Based on the current situation which forbids the conduct of final written examination, it was decided to adopt the alternative of Take-home research assignment. The details and procedure are explained in this document. You must read carefully and make sure that you are aware of every fine detail.

Assignment Description:

The assignment consists of two parts :
The 1st part is common for all students and is to be done on group basis according to rules below. It includes a group of assignments to be solved and simulated using Matlab.
The 2nd part is individual. Every student will receive Two problems. Student should answer the problems individually and prepare a Powerpoint presentation in addition to a Matlab simulation for each problem.

Plagiarism and copying from Internet or other students:

Students must behave ethically and avoid any plagiarism or copying from the Internet or other students. Students can get ideas from the Internet, or understand the problem (not the solution) from their colleagues. However, it is completely forbidden to copy parts of codes. Any detected plagiarism means failing the assignment.

Part 1 Matlab Assignments

Important considerations:

1- Only MATLAB or octave can be used to solve the problems.
2- Scripts only are accepted, don't write functions. We should be able to run the codes directly by loading your file and pressing run button in MATLAB.

3-Make sure that all files required to run the code are in the same folder (.wav files, .jpg files, ... etc) so that when we download the files we can easily run the codes. This is the responsibility of the students

4- It is VERY VERY VERY important that the codes are commented. Codes without comments will be penalized. Add comments that explains variables, algorithms, … etc

Group size:3

This parts includes the following assignments:

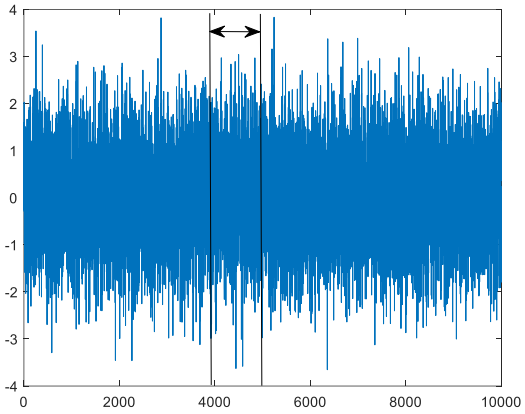
Problem 1: Detecting hidden periodic signal

In this assignment, a periodic signal is hidden inside a noise signal. The methodology that were used to hide the periodic signal is as follows:

1- Generate a random signal (white noise – read about it) with average power =1.
2- Generate a periodic signal (a sin wave) with period *N*, Length *L* (only few periods are generated) with amplitude *A*
3- The periodic signal is added to the random signal at location *S*, so it is added to the signal between samples S and S+L-1

It is required to determine the following about the different parameters of the periodic signal (its location, period, length, and amplitude)

Hints: think about the variance, correlation (related to convolution), the autocorrelation function (read about it and its properties for periodic and random signals), the frequency domain of the signal (short time Fourier Transform), spectrogram. Note that you will need to process different parts of the noise+signal to find the location of the signal as it doesn't exist in the whole signal. For example, for the figure below, the signal maybe between the two black lines. You can't observe it in the time domain, so you need to do some signal processing to extract it.



There are 10 files attached to the project. Choose only the file that is directed to you. To know which file should be used, add the IDs of the 3 students and take the modulo 10 of the result of the addition, and then add 1. For example, if students with IDs 110, 116, 405 are in the group, then add the three IDs (110+116+405=631. The modulo 10 of 631 is 1.The file that should be used is n2.mat

Problem 2: Simple speech recognition system

Speech recognition is one of the important applications of signal processing. In this problem, it is required to build a simple speech recognition system.

One of the students in the group is required to record the four words (move, stop, left, right) , each 10 times (total 40 times). Observe the waveforms of the different words and note that the time domain signal is different, even for the same word.

Recognition systems rely on extracting (features) of the signal. For example, one of the features can be the total energy of the word, the maximum value in the waveform, and any other feature. Choosing the most suitable set of features to solve a recognition problem is called feature engineering. In this problem, we would like you to think about features that can differentiate between the different words.

Students should choose some features that will be used to discriminate between the four words. Students are required to calculate the average value of the selected features for the 10 repetitions of the four words (this is the training phase).

Students are then required to record the same four words 5 times again (total 20 times) and then calculate the features for those 20 words, compare them with the average

features from the training phase, and choose the nearest. Calculate the efficiency of your system.

Repeat the testing but with the rest of the students in the group, record your observations about the efficiency of the system in this case.

Hints: think about features in both time domain, frequency domain, localized features. Read about MFCCs and try using them. Read about speech recognition using MFCC

Problem 3: Developing a generic RTTTL composer

In this assignment, it is required to listen to the tones with different frequencies and how they can be used to generate music segments. Long time ago, Nokia invented RTTTL

https://en.wikipedia.org/wiki/Ring_Tone_Transfer_Language

It is required to develop a generic RTTTL composer. The input to the composer should be any RTTTL note, and the output is a wav file corresponding to the note

Here are some sample notes that you can test with

http://www.fodor.sk/Spectrum/rttl.htm

Problem 4: Data Hiding

It is required to develop a program to hide waveforms inside other waveforms using AM modulation, and then find these waveforms. Specifically, it is required to do the following:

1- Record 2 wav files by 2 different students in the group. Make sure they all have the same number of samples. The students should be other than the student that recorded his voice in Problem#2

2- Choose one of them to be the “main signal”, and the other is the hidden signal

3- Pass the hidden message by a low pass filter. Its maximum frequency is Pi/8

4- Multiplied it by 0.01*cos(2*pi*n/4)

5- The main signal is filtered to have a maximum frequency Pi/4

6- Add the hidden signal to the main signal

7- Listen the result of the addition, make sure you can only listen to the main signal

8- Develop an algorithm to extract the hidden signal. Note that you can assume what happened to the signal to be hidden

Problem 5: Motion blurring

Motion blurring is an effect that happens due to taking a picture for a fast moving object with a slow shutter speed

https://digital-photography-school.com/how-to-capture-motion-blur-in-photography/

https://en.wikipedia.org/wiki/Motion_blur

In this problem, it is required to have an image of the 3 students participating in the project, and write a generic function to do motion blurring in different directions and different intensities. Use only the 2D convolution function in MATLAB. Don't use other ready functions.

Part 2 Individual Assignment

Every student will receive 2 (two) problems related to the material taught in the course throughout the semester before and during the lockdown.
The assignment consists of two parts:

1) Solve analytically for the requirements in the problems. Hence, prepare a PowerPoint presentation including all the details of the solutions and the final answers.
2) Write a Matlab program to solve the problem and get all requirements. Compare the results of (1) and (2). Provide acceptable explanation for any differences between the analytic solution and the Matlab results.

Grading Policy

- 70% of the grade will be assigned to part 1.
    - 40% : Correctness of MATLAB codes and results
    - 30% : The presentation of the results and the analysis in the report

- 30% of grade will be assigned to part 2:
    - 10% : Powerpoint presentation quality, detailed steps and clarity of solution.
    - 20%: Matlab Code correctness and results.

Deliverables

Part 1:

It is required to submit both the codes and a report about the assignment solutions.

1. For the report, you should explain the logic, and add the output plots or images of your codes. For example, in problem 1, you should explain how did you find the message, why this works, ... etc. The filename of the report should be Analysis_report_ID1_ID2_ID3.docx, and Analysis_report_ID1_ID2_ID3.pdf. An editable version (doc, docx) AND a pdf version must be submitted.
2. The file name of each problem should be as follows:
   Problem1: P1_ID1_ID2_ID3.m
   Problem2 : P2_ID1_ID2_ID3.m
   .... etc
3. All the files that were used to solve the problems and their outputs (.wav files, .jpg files, ..etc)
4. One zip file that includes all previous files

Important note for part 1: ALL students in the group should upload the required documents and .m files to their Google classroom accounts. In the comments of the submission, write the names and IDs of ALL group members. ONLY One of the students should write in the comments (POINT OF CONTACT) and the two other students should write (PARTICPANTS)

Part 2:

1. MATLAB codes for assigned problems (each in a separate file).
2. One powerpoint file including solution of assigned problems.

Schedule of events

Date	Action
May ,7th ,2020	Announcement of the Take-home research assignment details (this document) on Google Classroom.

May,11th ,2020	Receiving final distribution of students on groups (3 students in each group) on Goggle Classroom.
From May 10th to June 2nd	Submission of part 1 Goggle Classroom..
May 30th	The 2 problems of the part-2 will be announced individually to each student on Google Classroom page.
June 2nd	Deadline of submission for part 2 on Google Classroom.