Submission of the required project particulars is to be no later than:

23:59, Wednesday, May 21, 2025

Late Assignment Assessment Policy:

- As per UWA Assessment policy a penalty of 5% of the total mark allocated for this assessment item is deducted per day for the first 7 days (including weekends and public holidays) after which the assigned work is not accepted.

Assessment

- The **maximum mark** for this project (including report and required data) is **40**.
- This project activity is worth **20% of the final mark** for this unit

Introduction

Background: An undercover detective attempted to record an audio, $y(n)$, of a movie attended by one of the police suspects, unknowingly wearing a microphone bug. To the detective's dismay $y(n)$ cannot be heard at all from the recording, $x(n)$, that was obtained due to a noisy crowd and what seems to be some very noisy construction work. You have been tasked to help solve the detective's dilemma! To help with your solution you obtain two additional recordings of the construction noise, $v_1(n)$, and the noisy crowd, $v_2(n)$, happening at the same time of the recording. After listening to $x(n)$ you also notice a hum which you are told was due to a known problem with the recording equipment. You model the noisy recording, $x(n)$, as follows:

$$x(n) = y(n) + h_1(n) * v_1(n) + h_2(n) * v_2(n) + A\cos(\Omega n + \phi)$$

where:

- $y(n)$ is the desired audio that you want to extract
- $v_1(n)$ is the construction noise, and $v_2(n)$ is the crowd noise
- $h_1(n)$ and $h_2(n)$ are the unknown acoustic impulse response functions between the microphone bug worn by the suspect and the respective noises
- $A\cos(\Omega n + \phi)$ is the audible hum of unknown amplitude, frequency and phase.

Your Mission: (1) To generate an estimate of the clean signal audio, $\hat{y}(n)$, given the noisy recording, $x(n)$ (in file `NoisySignal.wav`), and recordings of the two noise sources, $v_1(n)$ and $v_2(n)$ (in files `NoiseRef1.wav` and `NoiseRef2.wav` respectively). What is the conversation about? and (2) Use nonparametric method(s) to produce the standard and modified periodograms of the noise $v_2(n)$ (in file `NoiseRef2.wav`). Discuss and explain the effects of different window functions on the periodograms. Implement Welch's method to improve the performance of the standard periodogram, and discuss how your group select the parameters of Welch's method to optimize the performance of the standard periodogram.

An Important Clue: Your investigations reveal that the acoustic environment at the convention was designed to provide RT60 reverberation times of no more than 50ms.

Teamwork

You are required to work as a team of 2-3 students.

- It is your responsibility to regularly communicate with the members of your team, participate team activities, e.g. meeting(s), and contribute to the team works over the entire period of project.
- If one team member doesn't participate group activities or doesn't respond team communications, the other team members shouldn't include this inactive student in the assignment coversheet. (Please contact Dr. Lin Zou (lin.zou@uwa.edu.au) at the earliest convenience if you have such member(s) in your team).

Setup and Preliminary Analysis

You will need to use the MATLAB environment for this assignment and can use workstations in either 1.51 or 2.71 in the EE building (but check if there are any scheduled labs from other units). Download the 'Group Project: Data and Scripts', extract the contents and read the README.txt file.

To familiarise yourself it is recommended you run the `Plot_Spectrogram.m` script to see what a spectrogram is (research this too), for both the noisy signal and also the noise reference signals. Notice the difference between the spectrogram of the noisy signal and the clean signal. Also play out the audio to hear what the noisy signal sounds like, can you make out what is being said at all? Compare the spectrogram of the noisy signal with that of the clean signal (`CleanSignal_Spectrogram.jpg`) so you can appreciate how noisy the signal is. Also play out the audio of the noise references to gauge what they sound like so you know what you have to deal with.

Some Solution Ideas

There is no one single design solution and indeed there is no guarantee as to how easy it will be to enhance the speech signal and by how much. What you learned and used in Lab 2 can certainly help. The periodogram estimation with nonparametric method(s) and Welch's method were also implemented and investigated in Lab 2.

These are just ideas which may or may not work for you:

- Can any form of low-pass, band-pass, or high-pass filtering be used?
- Can you use any of the noise reference signals and apply an NLMS or RLS adaptive filter?
- Or maybe you can derive the optimum MMSE FIR equations using least-squares estimation (LSE) analysis to estimate the autocorrelation and cross-correlation parameters?
- Can you improve the quality by using multi-pass filtering or smoothing (you have access to all the data)?
- What are the important measures of the performance of periodograms?
- How can Welch's method be used to reduce the variance of periodogram?

For the above feel free to reuse any of the m-files provided in Lab 2 for this project. Where possible use the available MATLAB filter functions as they will usually be more efficient. Consult http://au.mathworks.com/help/dsp/adaptive-filters.html for details. **NOTE: Please only use the MATLAB filter functionality which has been covered by your signals and systems and ELEC4404 (Signal Processing) units**. Remember you have full control, do whatever it takes to not just extract the conversation but so with the best quality, just as long as you can decipher the conversation or identify the music track.

Peer Assessment and FeedbackFruits

All students are expected to fully participate in this project and to contribute to the teamwork. A mandatory peer assessment is to be carried out on FeedbackFruits platform to evaluate group members' contributions. FeedbackFruits is an online tool designed to aid the development of team-skills and

enhance the team experience. FeedbackFruits has been developed with the purpose to improve learning from team assessment tasks and make the assessments fairer for students. It is used to help students to understand the properties of quality work. By operating from a set framework of criteria, a full understanding of the attributes of your own and others work can be achieved. The peer assessment result is used to moderate each member's individual project mark (see ASSESSMENT section for more details). More detailed information about FeedbackFruits will be provided on LMS. For specific information on how we will be deploying FeedbackFruits in this unit please refer to the unit LMS Announcements and *Group Project Assessment, Instructions and Submissions*.

Submission Requirements

WHAT EACH TEAM NEEDS TO SUBMIT

- A properly completed Assignment Cover Sheet completed as a GROUP ASSIGNMENT (electronically or PDF scan hardcopy).
- **A**: (32 marks): A professionally presented (i.e not hand written!) group report (15 to 25 standard formatted pages, i.e., A4 size paper, 11- or 12-point font size, single line spacing, 2cm margins, etc.) is to be submitted by the team.

  For the mission (1) the report should include the following sections:
  - Introduction (Aims and Objectives)
  - Design Methodology (include justification/rationale for your choice, block diagram/configuration clearly showing all input/output data used (not MATLAB code!), also all configuration parameters, and how the values were chosen/determined)
  - Experimental Evaluations (Evaluate/assess the filter performance and quality of the enhanced signal using measures presented in tables, figures and graphs. Include multiple runs of your solution as you perhaps explore different parameter settings to show the evolution of your design thinking, troubleshooting, and improvements to the final solution. Determining the order of and number of filtering stages and discussing the trade-offs)
  - Success of your Solution
  - Conclusions and Limitations (Summary of what you have achieved and/or discussion of issues you had, or limitations you came across).

  For the mission (2) the report should include the following sections:
  - Introduction (Aims and Objectives)
  - Design Methodology (include justification/rationale for your methods, configuration clearly showing all details of the periodograms, window functions, and Welch's method (not MATLAB code!), also all configuration parameters, and how the values were chosen/determined)
  - Experimental Evaluations (Evaluate/assess the performance and quality of the periodograms using measures presented in tables, figures and graphs. Include multiple runs of your solution as you perhaps explore different parameter settings to show the evolution of performance, troubleshooting, and improvements to the final solution)
  - Discussion of the results
  - Conclusions and Limitations (Summary of what you have achieved and/or discussion of issues you had, or limitations you came across).

- **B**: (8 marks) A zip archive file with the following:
  - A README.txt describing the contents and how to use the scripts. This should also include the student IDs and Surnames of the team members so your zip file can be associated with report.
  - A MATLAB script (include any supporting scripts and input data files) of your final solution which can be executed to produce the enhanced audio file, which should be named

`EnhancedSignal.wav`. This zip file will be extracted and the MATLAB script executed to verify your solution using the standard MATLAB environment in UWA. Include any ancillary MATLAB files you used to evaluate performance.

- The enhanced speech waveform (*.wav) file. This will be checked against the output of your MATLAB script.

The zip file is only used to verify your design evaluations and check the clarity of your code, it should NOT be used to work out what you did; that should be fully described in the report under Design Methodology. **NOTE**: 1. Your MATLAB script will be verified using the same version of MATLAB used for Lab 1 and Lab 2. 2. All MATLAB scripts must be fully commented and be self-explanatory. 3. Do NOT attach the full MATLAB scripts in your group report.

SUBMISSION PROCEDURE

The team submission should be prepared as follows,

- **Group Report** (a single.pdf file including both assignment cover sheet and report)
- **Zip archive file** (incl. MATLAB scripts & ancillary files and README.txt). Use your group name to rename the zip file (e.g. "Project Group XX.zip")

Please adhere to the above format to ensure an effective and efficient marking of your team report. If in doubt contact Dr. Lin Zou (lin.zou@uwa.edu.au) no later than the day before the due date.

Submit the team report and zip file on LMS before the due time. You are allowed to submit **multiple versions** (maximum 3) on LMS, but only the final attempt is to be marked. If your team submits the final version report after the due time, the final version report will be assessed as a late submission.

NOTE 1: You do NOT need to submit the hardcopy of your team report.

NOTE 2: Your group report submission will be **scanned and checked for plagiarism** in LMS system, which uses algorithms to make decisions about potential plagiarism based on word frequency, sentence structure, and other linguistic characteristics that are specific to English. **Plagiarism will not be tolerated. The use of AI tools is strictly prohibited in any form.**

Assessment

The assessment of your group project will consist of: 16% (32 marks) for the report and 4% (8 marks) for the zip file sources. You will be severely penalised for both if the two are not consistent (e.g. report is vague and indicates success but your MATLAB script file doesn't work or doesn't produce what was expected), conversely there will be minimal reduction in marks on the report where there is consistency and evidence of the engineering process at work (e.g. MATLAB script file doesn't work but report explains and documents the issues you had, troubleshooting you undertook, etc.). According to the quality of your group project, a group mark is to be given to your group. The individual member's final project mark will be calculated using the formula: **Individual member's mark = (Group mark) x (FeedbackFruits peer assessment score)**