Communications and Information Engineering Program
Probability and Stochastic Processes (CIE 327)
Project 2 (Stochastic Processes)

ANALYSIS OF STOCHASTIC PROCESSES

It is required to create a GUI-based tool that allows a user to enter any stochastic process and results in the ensemble and the time statistics of such process. The GUI can be built using Matlab or any other software package.

GUI Description

The GUI should do the following:

1) Allow the user enter a random process in the form of the ensemble, i.e. all the sample functions, each defined by two vectors; time and amplitude. Note that the time vector can be common to all the sample functions.
   An example .m file of the ensemble is attached.
2) Allow the user to perform and display the following:
   - Plot M sample functions of the ensemble of the process, where M is entered by the user
   - Calculate and plot the ensemble mean of the process
   - Calculate and plot the statistical auto-correlation function between the i^{th} sample and the j^{th} sample of the process, where i and j are entered by the user
   - Calculate the time mean of the n^{th} sample function of the process, where n is entered by the user
   - Calculate the time auto-correlation function of the n^{th} sample function of the process, where n is entered by the user
   - Calculate and plot the power spectral density of the process
   - Calculate the total average power of the process

Testing your GUI

Test your GUI for the random processes $X(t)$ and $Y(t)$, where,

1) $X(t)$ is defined as in the attached sample file.
2) $Y(t)$ is defined as

$$Y(t) = \beta \sin(2\pi t), \quad \text{where } 0 \leq t \leq 2, \quad \beta \sim \mathcal{N}(0,1)$$

3) $Z(t)$ is defined as

$$Z(t) = X(t) \times Y(t)$$

4) $P(t)$ is a 10-bits Polar NRZ process,
   with $A = 5$ volts, $T_b = 2$ seconds, and initial time shift, $\alpha \sim \mathcal{U}(0, T_b)$
5) $M(t)$ is a 10-bits Manchester code process,
   with $A = 5$ volts, $T_b = 2$ seconds, and initial time shift, $\alpha \sim \mathcal{U}(0, T_b)$

Deliverable

Deliver the following:

1) An executable file for the GUI
2) All the source codes (**.m** files)
3) The outputs of the GUI for the test stochastic processes, 5 processes in total, as follows:
   - A plot of 3 random sample functions of the process, each plotted in a different subplot.
   - A plot of the ensemble mean
   - Comment on the previous plot
   - A 3D plot of the ACF between i^{th} sample and the j^{th} sample for every i and j.
     Hint: This is a 3D plot, where the horizontal axes are i and j, and the vertical axis in the value of the ACF
   - Comment on the previous plot
   - The value of the time average and the time ACF of a random sample function.
   - Is there a relation between the statistical mean and the time mean, for the test process? Comment
   - Is there a relation between the statistical ACF and the time ACF, for the test process? Comment
   - Plot the PSD of the process
   - A complete .pdf report documenting all the previous outputs, with proper titles, subtitles, labeling, captioning and **commenting**.
4) A video recording showing the running GUI and how it is used to generate the required plots.

GENERAL INSTRUCTIONS & GRADING CRITERIA

Instructions

1) This is an individual project.
2) Reports are not to be shared with others.
3) Any copied reports, either fully or partially, will receive 0 points. This applies to both the original and the copy.
4) Late submission will be penalized at the rate of 10% per day for a maximum of 5 days, after which no submissions will be considered.

Project Grading Criteria

Grading of each part will depend on:

- **50%:** Completeness and correctness of the **deliverable**.
- **10%:** Clarity of the **GUI design and ease of use**.
- **20%:** **Report** writing and organization.
- **20%:** Comprehensiveness and clarity of content in the **recorded video**.