

## ANALYSIS OF RANDOM VARIABLES AND RANDOM PROCESSES

It is required to create a GUI-based tool that allows a user to:

- 1) Enter the values of random variable values and results in the statistics of such variable.
- 2) 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) Section 1: Random Variables

- Allow the user enter a random variable in the form of its sample space.  
**An example .m file of the sample space is attached.**
- Display the mean, the variance and the third moment of the random variable
- Plot the MGF  $M(t)$  vs  $0 < t < 2$
- Plot the first and the second derivatives of  $M(t)$ , and calculate their values at  $t = 0$

#### 2) Section 2: Random Processes

- 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.**
- 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
  - 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 following:

- 1) The RV in the sample file.
- 2)  $X$  is a RV, where  $X \sim \mathcal{U}(-3, 5)$ .
- 3)  $Y$  is a RV, where  $Y \sim \mathcal{N}(-8, 4)$ .
- 4) The RP in the sample file.
- 5)  $Z(t)$  is a RP, where  $Z(t) = \cos(4\pi t + \theta)$ , where  $0 \leq t \leq 2$ ,  $\theta \sim \mathcal{U}(0, \pi)$ .
- 6)  $W(t)$  is a RP, where  $W(t) = A \cos(4\pi t)$ , where  $0 \leq t \leq 2$ ,  $A \sim \mathcal{N}(-5, 5)$ .

### ***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 random variables.
- 4) The outputs of the GUI for the test random processes, as follows:
  - A plot of 3 random sample functions of the process, each plotted in a different subplot.
  - A plot of the ensemble mean, and comment on the resulting 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 is 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
- 5) A complete .pdf report documenting all the previous outputs, with proper titles, subtitles, labeling, captioning and **commenting**.
- 6) 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 a team project, for teams of 2 ~ 3 students.
- 2) All team members are accountable for all the parts of the project.
- 3) Reports are not to be shared with others.
- 4) Any copied reports, either fully or partially, will receive 0 points. This applies to both the original and the copy.
- 5) 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**.