<u>Physics 5305 Final Project</u>

March 27, 2017

This final project is due at 11:15 am on April 26. Please submit the project report to Dr. Lou in class or leave the project in his mail box at the Physics Department.

Late project will not be accepted.

Basic Requirements for the Project

The final project can be any topic that you would like to simulate and analyze. It should include analysis, modeling, and simulation of data. Although a standard project will be outlined and recommended to you, you are actually free to choose any projects that are sufficiently significant to include the following components:

- Generation of basic random variates, demonstrate their randomness.

- Define the project system: The system of your project needs to be completely defined. Identify all system elements and their associated attributes, and the system image that completely defines the state of the system at any stage of the simulation.

- Model the system with a flow chart with sub-models or elements: The connections between sub-models and elements are established here. A flow-chart would normally be very useful to demonstrate these connections. Elements are checked to see if they are independent, loosely correlated to other elements, or highly correlated to other elements.

- Code the R.V. generators for the relevant stochastic processes using the random number generators available in ROOT.

- Build the criteria for a specific event to happen: Criteria for certain stochastic events will be established here. For example, when the distance between two adjacent vehicles in the same lane is less than their average length for two cars, a collision will occur. When a presidential candidate changes his political position on an important issue, voters having a stand on the same issue might change their voting decisions as well.

- Code the complete simulation package in your preferred programming language. C++ macros with the ROOT analysis package are recommended.

- Some comparative statistics analysis of the system being simulated in a adaptive fashion, and give some recommendations based on the analysis: Data obtained from the simulation must be analyzed to find out important statistics (such as largest annual change in prices, the mean number of days of down/up markets, the average return of your portfolio obtained in a simulation of many years as in the financial market simulation.) A comparative simulation should be performed in which you will need to change the behavior of certain elements to try to optimize a system. Based on this kind of simulation and analysis, make recommendations to a decision-making committee.

- A final report of no more than five pages long is expected. The report should contain a description of the project and the system definition, the formulation of the model, the element table containing all elements and their attributes. A flow-chart of your simulation package, a table of relevant statistics, a comparative study of the system, and conclusions including possible recommendations for improvement to the system.

Recommended Phys5305 Final Project

Simulation and Analysis of Electrons Originating from Two Sources

A hypothetical experiment detects electrons coming from two difference sources, A and B. These electrons have known characteristics –

electrons from source A:
polar angular ~$1+5\cos^2\phi$; uniform azimuthal angle λ; energy $shape \sim 50 + 20E (0 < E < 10)$

electrons from source B:
polar angular shape ~$1-2\cos^2\phi$; the azimuthal angular ~$\sin^2\lambda$; energy $shape \sim 30 + 2.2E^2 (0 < E < 10)$

An array of sensors measuring (ϕ, E, λ) are mounted spherically around the location of the sources. The sensors measure the angular positions and energy of an escaping electron, with a resolution matrix

$$M_{\phi E \lambda} = \begin{bmatrix} 4\times10^{-2} & 0.5 & 0 \\ 0.5 & 25 & 0 \\ 0 & 0 & 9\times10^{-4} \end{bmatrix}$$

where $0<\phi<\pi$, $0<\lambda<2\pi$;

Generate sufficient number of electrons in your simulation and determine the following:

(1) The distributions of variables (ϕ, E, λ) from A and B, respectively, as obtained from your Monte Carlo simulation.
(2) The mean values for (ϕ, E, λ), and the *rms* uncertainties of electrons from A and B, respectively.
(3) Assuming 1000 and 10000 electrons are produced from sources A and B, respectively, and that the detector acceptance is close to 100%. Develop a set of selection criteria to select electrons from A in order to measure its production rate with the best significance.
(4) What are factors limiting the precision of the measurement (3)? Are the precisions in the angles and the electron energy sufficient? (do you need a better detector to improve significantly the measurement?).
(5) Optional – Use the Monte Carlo simulated events to train a NN program to distinguish between the electrons from sources A and B. Provide graphics of the training/validation, and efficiency for A-electrons vs. rejection rate of B-electrons. Do (3) with NN for best measurement of the rate of A electrons. Fully justify your choice.