PHSX 815 - Computational Methods in Physical Sciences: Project 3 Spring 2023

Project 3 Dates

- **Project 3 Due Date: April 10, 2023**
- Peer Review Input Materials due April 3, 2023
- Peer Review Responses due April 6, 2023

Project 3 Details

The third project this semester will be to develop some code, in either C++ or Python, to simulate a simple experiment, similar to Projects 1 and 2. The difference in this project is that now, your model must be dependent on some parameter (this can be a probability, mean, parameter of a prior distribution, etc.) that you will try to estimate using simulated data from your experiment (as opposed to testing discrete values of the parameter against each other in hypothesis testing).

Students must write a function (of the parameter(s) of interest) that is proportional to the likelihood of that function, given some data:

$$\text{function}(\alpha) = \mathcal{L}(\alpha|X) \ , \tag{1}$$

where α is the parameter of interest and X represents data from a simulated experiment. The "measurement" of α from data X then corresponds to finding the value of α that maximizes $\mathcal{L}(\alpha|X)$ (the data is "fixed" in an experiment).

In the project, students should be able to simulate experiments with different values of the parameter(s) α and study how well that parameter can be estimated from that data (ex. like the Neyman construction used in homework #8). Students should try to estimate a confidence interval (i.e. error bars) on the parameter from these measurements, and can study how that uncertainty changes with, for example, the number of measurements in an experiment or other factors.

Specifically, the submitted project (due **April 10, 2023**) should include the following components:

- **Code [25% of grade]:** Students must create code to simulate their experiment, and code to analyze the simulated output. These must be at least two separate programs. The code must be able to store simulated results in a persistent data format (like a text file, JSON format, or other) and read and analyze inputs in this format. The code must be posted in a GitHub repository (which should be called `PHSX815_Project3` and should be properly documented. This includes method and executable descriptions documented in the code, along with a `README.md` file included in the repository explaining its contents and use. The `README.md` should provide instructions as to how to use the code.

- **Writeup [15% of grade]:** Students must document their project in a short paper, typeset using LaTeX. The paper should describe the experiment that is being simulated (with some interpretation beyond "sampling from X probability distribution", be creative!) and what question(s) is being answered with the code. The paper should include relevant figures and tables (must include at least one figure created by the student). Students will be graded on the clarity of the text, figures, tables, and the formatting of the document.

- **Algorithm analysis [20% of grade]:** Each project paper should include a discussion of the code developed for the project. This need not include documentation for the specific executables, libraries, functions, etc. in the code (this should be documented in the code itself) but rather a conceptual discussion of the algorithms and strategies used in the code. What probability distributions were used? How were samples drawn from them? What algorithms are used? Why were they chosen? How are they relevant to the problem you are trying to solve? The paper should also include any relevant citations.

- **Output interpretation [20%of grade]:** The code for each project is expected to produce the simulated output of an experiment, with whatever parameter/model/hypothesis variations students have chosen. In the paper, students should include a discussion and analysis of the programs output, including relevant figures and numbers. This should include trying to answer at least one well-defined question, such as: How accurately can a parameter of interest (probability, rate, etc.) be inferred? How well can we distinguish between different values? How many trials would be required to measure a parameter to a particular precision?

- **Peer review [20% of grade]:** Each project has a peer review requirement, where students must both submit material for peer review (due Monday, April 3, 2023) and submit responses to material that they have reviewed (due Thursday, April 6, 2023). Students can use the class periods between those dates to work on their peer review response. See below for more details. Unlike other project elements, late submissions for the peer review portion will not be accepted for credit.

Projects should be submitted through Canvas by 11:59 pm on Monday, April 10, 2023. Late project submissions will be accepted with a grade deduction of up to 25% in all components, adjusted by how late the submission is. Late project submissions will be accepted up to May 14th.

Peer Review Details

The peer review requirement has two components:

- **Peer Review Input (due Apr. 3)**: Students must submit to Blackboard some material for another student (to be chosen by Prof. Rogan) to review related to Project 3. This can be some code under development, or some draft elements of a project paper. Students should also indicate what sort of review and feedback they might find useful. Failure to submit some material on time (and thus preventing another student from being able to review it on time) will result in a significant point reduction from the Peer Review portion of students' Project 2 grade.
- **Peer Review Response (due Apr. 6)**: Students will receive the peer review input material (via email) from another student on April 4, 2021 (before lecture that day). Students should provide feedback to their assigned peer review input in the form of a short document (less than a page is sufficient, more is fine too). This feedback should take into account any guidance provided in the input. For example, for a review of a portion of code reviewers should try to run the code, check whether it is clearly documented, and provide tips and suggestions as appropriate. For a review of a portion of text, students should read that text and provide feedback and suggestions as to whether it is understandable, readable, and formatted in a clear manner. Students are welcome to contact each other outside of class during the review process to discuss projects. All student interactions, whether in- or outside-of class, should be conducted with mutual respect and empathy according to the class rules described in the syllabus.

The success of the peer review process depends on students both thoughtfully providing materials as input for review and providing sincere, and timely feedback as a reviewer. Please take a 'Golden Rule' approach, i.e. try to provide the type of input you would hope to receive as a reviewer and do your best to give feedback of the type that you would find useful in the preparation of your own project.