STAT 4444/5444G – Applied Bayesian Statistics

Online Synchronous

Syllabus/Course Information

Instructor: Hamdy Fayez F. Mahmoud is a collegiate assistant professor in the Department of Statistics. Both his teaching and research concentrate on statistical methods and applied statistics.

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Class time and how do you contact me? I do love helping my students!

- **Class Zoom meetings:** MW 2:30-3:45PM- we need to create a sense of classroom online. *Never miss a class is recommended!*
- **By email:** I am always pleased to receive your personal emails with updates, questions or concerns or any problems that you may have.
- **Zoom office hours:** will be announced based on the survey results that I will send out
- If my office hours do not work for you, no problem, you can ask for one-to-one meeting and if you need to meet in person, you can ask for a **Mask-to-Mask** Meeting 😊

TA

- Han Chen Email: hc704@vt.edu

Course Modality

The modality of this course is online synchronous. Although we do not have a classroom, we do have scheduled class times. You are expected to attend all the classes and participate. The exams will be online during these scheduled class times.

Course Description

Classical statistics, encapsulating well-known methods such as point estimate, confidence intervals for population mean or proportion, t-tests, ANOVA, etc. are from the frequentist school of statistical thought. The basic idea of frequentist statistics is that the world is described by parameters that are fixed and unknown. Since these parameters are unknown, we do not know their exact values. Since they are fixed, however, we cannot discuss them in probabilistic terms. Probabilistic reasoning can only be applied to random variables - and parameters are not random, in the eyes of a frequentist. The Bayesian says, "Who cares?!"

It turns out that we can use probabilities not only to express the chance that something will occur, but we can also use them to express the extent to which we believe something, and all the math still works. The frequentist can only apply probabilities to the act of repeating an experiment, while the Bayesian can apply probabilities directly to their knowledge of the world.

Bayesian statistics are rippling through everything from physics to cancer research, ecology to psychology, law to politics, even sports analytics. Enthusiasts say they are allowing scientists to solve problems that would have been considered impossible just 20 years ago. It is proving especially useful in approaching complex problems, such as in the search for the crashed Air France Flight 447 in 2011.

This course is designed to introduce you to Bayesian methodology with emphasis on applied statistical problems: data displaying, prior distribution elicitation, posterior analysis, models for proportions, means and regression. Through hands-on experience with real data from a variety of applications, students will learn the basics of designing and carrying out Bayesian analyses, and interpreting and communicating the results. Students will learn to use software packages including OpenBUGS and R to fit Bayesian models.

Course Objectives

After completing this course, the student will be able to

- summarize the relative strengths of Bayesian and frequentist methods.
- derive the posterior distribution for one-parameter models with different types of priors.
- estimate the posterior mean and posterior proportion
- use Markov chain Monte Carlo (MCMC) methods to sample from a posterior.
- effectively summarize a posterior using tables and graphics.
- make inference about population parameters, including point estimation and credible intervals
- make prediction using Bayesian approach.
- build models for data
- apply Bayesian inferential techniques to extract evidence from data
- fit a regression model using Bayesian approach.

Textbook & Course Materials

- **Recommended Textbooks:**
  "Applied Bayesian Statistics: With R and OpenBUGS examples" by Mary Kathryn Cowles. 2013. Springer.
  "A First Course in Bayesian Statistical Methods" by Peter D. Hoff, 2009. Springer.
- **Canvas**: Announcements, lecture slides, grades, practice problems, etc., will be posted through canvas.
- **Computing:**
  1. This course will primarily use R, and it is freely available from https://www.r-project.org
  2. Download the user interface R-Studio, free from https://www.rstudio.com
  3. OpenBUGS, download it free from http://www.openbugs.net/w/Downloads

Grading

The final course grade will be based on four major grading components:

Homework	25 %	
Exam 1	20 %	Monday, March 1st, 2020
Exam 2	20 %	Monday, April 12th, 2020
Project	15 %	
Final Exam	20%	May 12, 2021 10:05AM – 12:05PM

Grading Scale

F < 59.5 < **D-** < 62.5 < **D** < 66.5 < **D+** < 69.5 < **C-** < 72.5 < **C** < 76.5 < **C+** < 79.5 < **B-** < 82.5 < **B** < 86.5 < **B+** < 89.5 < A- < 92.5 < **A**

Homework

Homework assignments will consist of written questions, data analysis on the computer, and written interpretation of computer output. Show your work when solving written homework problems. For computer problems, turn in printouts of your commands or programs and their output.

You are encouraged to study with others. However, if you do work with others on homework assignments, please write up your own assignment and make sure you completely understand all solutions that you submit.

Late homework will not be accepted except as required by university policy, i.e. because of "illness, mandatory religious obligations, or other unavoidable circumstances or University activities.

Exams

There will be two regular exams throughout the semester plus a final exam. The instructor will give you at least one week's notice prior to giving an exam. Students missing class on the day of an exam will only be given a make-up in the case of an excused absence; otherwise, the grade for the exam will be a zero. You cannot afford a zero on an exam!

Exams Make-up exams will be given only in case of a legitimate, documented excuse. If for some reason you are not able to take a particular exam at the scheduled time, you are required to inform me in advance. You should be aware that make-up exams are subject to be different and more difficult than the original exam.

Project

Students will work in groups of three to carry out projects involving application of Bayesian methods to problems of their own choosing.

Attendance

Attendance is expected at all classes. It is a vital part of the class and should be considered with the highest regard. Excessive absences will be interpreted as a lack of serious academic effort. You are solely responsible for missed handouts or announcements made during lecture. If you cannot attend a particular lecture, make sure that you stay informed regarding the information provided during that lecture.

Best Practices

You are expected to attend all classes, pay attention while in class, participate in class discussions, ask questions, act professionally, and do the required homework problems and quizzes when they are assigned. Forming a study group is highly recommended. Statistics is learned by actively participating. Paying attention in class and taking notes is not enough. You must work on the assigned homework problems, study the vocabulary, read the text, and study your class notes.

Students with Special Needs

Students requiring testing accommodations must work through the appropriate university offices. Any paperwork must be completed and validated prior to the first test. In addition, if you are a student with special needs or circumstances, or if you have emergency medical information to share with me, please make an appointment with me as soon as possible during my office hours or at a time that is convenient to your schedule and my schedule.

Honor Code: The Undergraduate Honor Code pledge that each member of the university community agrees to abide by states: "As a Hokie, I will conduct myself with honor and integrity at all times. I will not lie, cheat, or steal, nor will I accept the action of those who do." Any form of academic dishonesty, including cheating and plagiarism, may be reported to the office of student affairs. The Virginia Tech Honor Code will be strictly enforced in this course. All graded assignments must be composed of your own work. More information about the Honor Code can be found at www.honorsystem.vt.edu

Course policies are subject to change. It is the student's responsibility to check canvas for corrections or updates to the syllabus. Any changes will be posted in canvas.

I expect you to

- keep up with the material covered every week
- complete your homework and quizzes on time every week
- abide by the standards of academic honesty and student code of conduct
- seek help when you don't understand a topic
- aspire to enjoy learning about Bayesian statistics – yes you can, and I'll do my best to help!

Good luck and wish you a great semester!