Statistical Computing (Stat 771)

UW Madison, Fall 2018

Instructor: Vivak Patel (vivak.patel@wisc.edu)
Instructor's Office Hours: By arrangement.

Credits: 3. Each credit-hour is satisfied by 45 hours of learning activities.
Instruction: In-person meetings on Tuesdays and Thursdays from 9:30am to 10:45am in CS 1257

Course Prerequisites: I expect students to have a familiarity with linear algebra and multivariate calculus at the undergraduate level. I also will expect students to have an elementary understanding of probability (e.g., conditional expectations) and mathematical statistics at the undergraduate level.

Description and Goals: In this course, we will interpret "statistical computing" to mean those generic computational and algorithmic tools that are used to do statistics in practice. The goal of this course is to overview the theory and practice of important computational concepts and specific algorithms that have been essential to statistical practice.

By the end of this course, you should have mastered the theory and practical aspects of some numerical methods for solving:

1. Linear system and linear regression problems
2. Nonlinear systems and nonlinear optimization problems
3. Data assimilation, online filtering methods
4. Large data problems

Here is a more descriptive and ambitious list, which we may or may not get to depending on time.

- Statistics on a computer: Floating Point
- Least Squares Problems: QR + Large/Streaming Data Problems
- Data Compression: SVD + Random Projection
- Statistical Subroutines: Iterative Methods for Linear Systems, Random Methods for Linear System
- Generalized Estimating Equations: Nonlinear Equations
- Compressed Sensing + Lasso: First Order Optimization Methods, Stochastic Gradient Methods
- Nonlinear Least Squares, GLM, Quasi-Likelihood: Smooth Optimization Methods, Incremental Gauss Newton
- Data Assimilation I: Linear Ordinary Differential Equations, Nonlinear ODEs

- Data Assimilation II: Kalman Filter, Particle Filter, Parameter Estimation, Expectation-Maximization, Variational Methods, MCMC, SMC2
- Conditional Inference: Bootstrapping, Jackknife, Permutation Tests, Bag of Bootstraps

I anticipate that this will be a very demanding course, and I do not anticipate getting very kind feedback by the end of the course or during the course. However, I do believe that, when you are in the middle of your own research, you will look at this course (and me, I hope) very favorably.

Programming: The programming assignments should be done in Julia (v0.6.4 or later, https://julialang.org/), but other languages will be acceptable with approval from the instructor. However, you will use Jupyter (http://jupyter.org/) for your exams and final paper. Be sure that you can print to PDF (i.e., you will need to ensure that you have a function TeX system in place).

Grading: Exam I (20%, Thursday, October 18), Exam II (20%, Thursday, November 29), Presentation I (10%, October 23/25), Presentation II (10%, December 4/6), Final Paper (40%, Tuesday, December 4)

Homework: While problems assigned (during lectures) each week will have a suggested due date, these problems will be optional.

Study Groups: The instructor will assign students into study groups that should meet weekly (recommended). Each member of the study group should attempt the solutions on their own first (do not look up the solutions online, it will not help you), and then solutions should be discussed in the group. You will get the most out of your exercises this way. Moreover, the group should discuss final paper ideas and reach each others papers. Instructors will ask students in a study group for feedback on other their fellow study group members' papers.

Exams: Exams will have an in-class written component and a programming component.

Presentations: Students will be required to do two short presentations during the term. These presentations should present progress on the final paper.

Final Paper: The final paper should be the start of a research quality paper whose topic is completely open so long as there is some aspect of computing involved. The idea for the paper topic should come from the student or discussions with other faculty members whose interests overlap with the student's interests. Additionally, students will meet with the instructor at least twice (by appointment) to review the topic and progress of the paper before the final submission (see the dates below).

1. The first appointment should be scheduled around the end of September.
2. The second appointment should be scheduled around the end of October.

Failing to schedule and attend these appointments will be taken into consideration during the grading of the final paper.

Academic Integrity: By enrolling in this course, each student assumes the responsibilities of an active participant in UW-Madison's community of scholars in which everyone's academic work and behavior are held to the highest academic integrity standards. Academic misconduct compromises the integrity of the university. Cheating, fabrication, plagiarism, unauthorized collaboration, and helping others commit these acts are examples of academic misconduct, which can result in disciplinary action. This includes but is not limited to failure on the assignment/course, disciplinary probation, or suspension. Substantial or repeated cases of misconduct will be forwarded to the Office of Student Conduct & Community Standards for additional review. For more information, refer to studentconduct.wiscweb.wisc.edu/academic-integrity/.

Accommodations for students with disabilities: McBurney Disability Resource Center syllabus statement: "The University of Wisconsin-Madison supports the right of all enrolled students to a full and equal

educational opportunity. The Americans with Disabilities Act (ADA), Wisconsin State Statute (36.12), and UW-Madison policy (Faculty Document 1071) require that students with disabilities be reasonably accommodated in instruction and campus life. Reasonable accommodations for students with disabilities is a shared faculty and student responsibility. Students are expected to inform faculty [me] of their need for instructional accommodations by the end of the third week of the semester, or as soon as possible after a disability has been incurred or recognized. Faculty [I], will work either directly with the student [you] or in coordination with the McBurney Center to identify and provide reasonable instructional accommodations. Disability information, including instructional accommodations as part of a student's educational record, is confidential and protected under FERPA." http://mcburney.wisc.edu/facstaffother/faculty/syllabus.php

Diversity & Inclusion: Institutional statement on diversity: "Diversity is a source of strength, creativity, and innovation for UW-Madison. We value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals.

The University of Wisconsin-Madison fulfills its public mission by creating a welcoming and inclusive community for people from every background – people who as students, faculty, and staff serve Wisconsin and the world." https://diversity.wisc.edu/