MSAN 628   Computational Statistics   Spring 2017

Class Time and Location:

- Section 1: W 11:05 - 12:55; F 10:00 - 12:00 Howard 529
- Section 2: W 3:15 - 5:05; F 2:30 - 4:30 Howard 529

Instructor: James D. Wilson   **Office:** 203B Harney Science Building   **Email:** `jdwilson4@usfca.edu`

Office Hours: Wednesdays 2:00 - 3:00, Fridays: 9:00 - 10:00 (in Howard on the 5th floor)

Grader: Me

Course Website: Canvas website

Textbooks: This course will include a survey of important statistical computational methods. As such, lectures will be drawn from many sources. No books are required, but some recommended books include

- *Bayesian Data Analysis, 3rd Ed.* by Gelman, Carlin, Stern, Dunson, Vehtari, and Rubin

- *Statistical Inference, 2nd Ed.* by Casella and Berger

- *Machine Learning: A Probabilistic Perspective* by Kevin Murphy

Course Overview: This course provides an in-depth look into advanced statistical computational techniques for estimation, imputation, simulation, and hypothesis testing. These skills are incredibly important for modern practitioners in data science and analytics. By the end of the semester, students will be comfortable with aspects of wrangling and modeling data using state-of-the-art techniques in estimation, hypothesis testing, and imputation. Students will implement all computational techniques using the R programming language, and will have familiarity with the following key aspects of statistical analysis:

- multivariate probability distributions and densities
- the likelihood paradigm for statistical inference and prediction
- introduction to Bayesian inference
- computational techniques for estimation, simulation, and approximation including Markov Chain Monte Carlo simulation via Gibbs and Metropolis-Hastings, numerical integration, importance sampling, and rejection sampling
- imputation models and techniques including the expectation-maximization algorithm and its extensions, variational inference, and expectation propogation
- graphical models including hidden Markov models and Bayesian networks
- multiple hypothesis testing techniques including Bonferroni correction and the Benjamini-Hochberg step-up procedure

Course Learning Outcomes: By the end of the course, students will be able to use the R programming language to

- proficiently wrangle and model data with missing values
- estimate point and maximum a posteriori estimators for Bayesian and frequentist predictive models
- approximate otherwise computationally intractable functions using numerical integration and resampling methods
- communicate results using R
- fit a wide array of predictive models using advanced computational techniques

What you should bring to Class:

A pencil or pen, paper, a computer, any notes that have been posted to Canvas, and a sunny disposition :)

Attendance: Attendance is required every day and will be recorded and worth 20% of your final grade. It is your responsibility to catch up on any lecture material, homework, or programming lesson that you miss due to an absence.

Topics Covered: We will cover the following topics in accordance with the schedule below.

Week	Topic	Description
1	**Multivariate Models**	review of multivariate probability distributions, Bayesian inference, multi-parameter models and interpretation, the multivariate normal, conditional expectation
2	**Point Estimation and Simulation**	maximum likelihood estimators, maximum a posteriori (MAP) estimators, Markov Chains, an overview of simulation
3	**Estimation via Bayesian Computation**	importance and rejection sampling, Metropolis algorithm, Metropolis-Hastings the Gibbs Sampler, numerical integration
4	**Models for Missing Data and E-M**	joint probability models for missing data at random and completely at random, expectation maximization algorithm and its extensions for multiple imputation
5	**Other Methods for Missing Data**	k-Nearest Neighbors, variational inference, expectation propogation, and multiple imputation
6	**Multiple Testing**	the multiple testing problem, Bonferroni adjustment, false discovery rate, Benjamini-Hochberg step-up procedure, hidden Markov models
7	**Bayes Nets**	models, dependence, and estimation

Assessment:

- **Attendance** (20%): Attendance will be recorded every class. You will lose 2% of this grade for every class that you miss, unless previously discussed.
- **Assignments** (50%): For each assignment, you will be required to upload a .pdf file to the Canvas site that contains clear demonstrations of R code, any analyses, and any visualization used to answer the questions on the assignment. Assignments will provide case studies that emphasize the methodology learned in class that week. These must be submitted before the deadline set on Canvas, else you will receive **10** points off every day that it is late.
- **Final Exam** (30%): The final exam is a cumulative exam that will assess the concepts learned throughout this course. This will be an in-class written exam given on the scheduled final exam date provided by the University of San Francisco final exam schedule.

Grading Procedure: At the end of the semester, your grade will be calculated according to the following rubric:

A	90 - 100
B	75 - 89
C	60 - 74
F	≤ 59

There will be no curve implemented in this course. Late assignments will not be accepted and will automatically receive a grade of 0.

Important Dates:

- Wednesday, March 23rd - First day of class!
- Monday, April 10th - Last day to withdraw
- Friday, April 14th - Easter Holiday (**no class**)
- Wednesday, May 10th - Last day of class!
- Final Exam: this will be scheduled according to university standards and will be held in class. Scheduling information is available at `https://myusf.usfca.edu/onestop/registration/class-schedule-final-exams`.

Academic Integrity

As a Jesuit institution committed to cura personalis - the care and education of the whole person - USF has an obligation to embody and foster the values of honesty and integrity. USF upholds the standards of honesty and integrity from all members of the academic community. All students are expected to know and adhere to the University's Honor Code. You can find the full text of the code online at `www.usfca.edu/academic_integrity`. The policy covers:

- Plagiarism: intentionally or unintentionally representing the words or ideas of another person as your own; failure to properly cite references; manufacturing references.
- Working with another person when independent work is required.
- Submission of the same paper in more than one course without the specific permission of each instructor.
- Submitting a paper written by another person or obtained from the internet.
- The penalties for violation of the policy may include a failing grade on the assignment, a failing grade in the course, and/or a referral to the Academic Integrity Committee.

Students with Disabilities

If you are a student with a disability or disabling condition, or if you think you may have a disability, please contact USF Student Disability Services (SDS) at 415 422-2613 within the first week of class, or immediately upon onset of disability, to speak with a disability specialist. If you are determined eligible for reasonable accommodations, please meet with your disability specialist so they can arrange to have your accommodation letter sent to me, and we will discuss your needs for this course. For more information, please visit: http://www.usfca.edu/sds or call (415) 422-2613.

Behavioral Expectations

All students are expected to behave in accordance with the Student Conduct Code and other University policies (see http://www.usfca.edu/fogcutter/). Open discussion and disagreement is encouraged when done respectfully and in the spirit of academic discourse. There are also a variety of behaviors that, while not against a specific University policy, may create disruption in this course. Students whose behavior is disruptive or who fail to comply with the instructor may be dismissed from the class for the remainder of the class period and may need to meet with the instructor or Dean prior to returning to the next class period. If necessary, referrals may also be made to the Student Conduct process for violations of the Student Conduct Code.

Learning & Writing Center

The Learning & Writing Center provides assistance to all USF students in pursuit of academic success. Peer tutors provide regular review and practice of course materials in the subjects of Math, Science, Business, Economics, Nursing and Languages. `https://tutortrac.usfca.edu`. Students may also take advantage of writing support provided by Rhetoric and Language Department instructors and academic study skills support provided by Learning Center professional staff. For more information about these services contact the Learning & Writing Center at (415) 422-6713, email: `lwc@usfca.edu` or stop by our office in Cowell 215. Information can also be found on our website at `www.usfca.edu/lwc`.

Counseling and Psychological Services

Our diverse staff offers brief individual, couple, and group counseling to student members of our community. CAPS services are confidential and free of charge. Call 415-422-6352 for an initial consultation appointment. Having a crisis at 3 AM? We are still here for you. Telephone consultation through CAPS After Hours is available between the hours of 5:00 PM to 8:30 AM; call the above number and press 2.

Confidentiality, Mandatory Reporting, and Sexual Assault

As an instructor, one of my responsibilities is to help create a safe learning environment on our campus. I also have a mandatory reporting responsibility related to my role as a faculty member. I am required to share information regarding sexual misconduct or information about a crime that may have occurred on USFs campus with the University. Here are other resources:

- To report any sexual misconduct, students may visit Anna Bartkowski (UC 5th floor) or see many other options by visiting our website: `www.usfca.edu/student_life/safer`.
- Students may speak to someone confidentially, or report a sexual assault confidentially by contacting Counseling and Psychological Services at 415-422-6352.
- To find out more about reporting a sexual assault at USF, visit USF's Callisto website at: `www.usfca.callistocampus.org`.
- For an off-campus resource, contact San Francisco Women Against Rape (SFWAR) (415) 647-7273 (`www.sfwar.org`).

Student Accounts - Last day to withdraw with tuition reversal

Students who wish to have the tuition charges reversed on their student account should withdraw from the course(s) by the end of the business day on the last day to withdraw with tuition credit (census date) for the applicable course(s) in which the student is enrolled. Please note that the last day to withdraw with tuition credit may vary by course. The last day to withdraw with tuition credit (census date) listed in the Academic Calendar is applicable only to courses which meet for the standard 15-week semester. To find what the last day to withdraw with tuition credit is for a specific course, please visit the Online Class Schedule at `www.usfca.edu/schedules`.