



PubH 7460-001

Advanced Statistical Computing

Fall 2016

| | |
|------------------------|--|
| Credits: | 3 |
| Meeting Days: | Tuesdays and Thursdays |
| Meeting Time: | 8:15 – 9:30am |
| Meeting Place: | Jackson Hall 2-137 |
| Instructor: | Dr. Mark Fiecas |
| Office Address: | Mayo A454-4 |
| Office Phone: | 612-624-2636 |
| Fax: | 612-626-0660 |
| E-mail: | mfiecas@umn.edu |
| Office Hours: | Tuesdays and Thursdays, 9:45 – 11:00am |

I. Course Description

When analyzing data, one may have to choose between using a standard statistical model that may be relatively simple to use but fail to capture intricate details in the phenomenon of interest, or use more complex models that may require the use of sophisticated numerical methods. Thus, it is useful to have experience with simulation-based methods for, e.g., statistical inference or numerical optimization. In the first part of the course, we will discuss Monte Carlo methods, which will include an introduction to Bayesian statistics, concluding with a discussion on Markov Chain Monte Carlo (MCMC) methodologies. In the second part of the course, we will discuss other computer-intensive methods, including deterministic optimization procedures, the EM algorithm, and the bootstrap.

II. Course Prerequisites

This course is intended primarily for MPH, MS, or PhD students in Biostatistics and Statistics with at least one previous semester of courses. Familiarity with regression (e.g., PUBH 7405), statistical inference, random variables, and common probability distributions will be expected. Some familiarity with R or some high-level programming language is not necessary but will be useful.

III. Course Goals and Objectives

Upon completion of this course, students should

- have knowledge of and be able to implement a collection of simulation methods to solve a given problem;
- have the ability to develop and implement an MCMC algorithm;

- have the ability to use deterministic or probabilistic methods to optimize a given function.

IV. Methods of Instruction and Work Expectations

Slide decks and other supplementary reading will be available on Moodle. Students are expected to attend class and participate in in-class activities, which will include group activities and discussion on designing and coding algorithms in R. Some classes will be conducted in a computer-lab-like manner; students will receive advanced notice when these classes will take place so that they can prepare accordingly. Collaborative work will be stressed and encouraged, unless otherwise stated. However, each student is expected to independently write up their own solutions and code for each homework assignment.

For the semester-long course project, in pairs, students will select a paper, or more generally, a topic of interest related to computational methods in statistics. The proposed paper and plan for the project must be approved by the instructor. Students will read the paper and implement the method including a reproduction of one or more examples in the paper. (Use of the author's code is not permitted, unless the students plan to extend their method.) At the end of the semester, students will present the method and submit a written report. A list of potential papers to pick for the course project will be made available on Moodle.

V. Course Text and Readings

There is no required text for the class. Suggested readings to supplement lectures include notes on Monte Carlo methods by Adam Johansen (which will be available on Moodle), and the following books:

Givens, G. and Hoeting, J. (2012). *Computational Statistics*. John Wiley & Sons.

Robert, C. and Casella, G. (2013). *Monte Carlo Statistical Methods*. Springer.

Robert, C., and Casella, G. (2009). *Introducing Monte Carlo Methods with R*. Springer.

A list of papers for potential projects will be available on Moodle.

VI. Course Outline/Weekly Schedule

| | |
|------------------------------|---|
| 6, 8 September 2016 | Inverse Transformation and Rejection Sampling |
| 13, 15 September 2016 | Rejection Sampling and Importance Sampling |
| 20, 22 September 2016 | Importance Sampling |
| 27, 29 September 2016 | Monte Carlo Optimization |
| 4, 6 October 2016 | Monte Carlo Optimization |
| 11, 13 October 2016 | Bayesian Statistics |
| 18, 20 October 2016 | Review and Exam |
| 25, 27 October 2016 | Metropolis Hastings |
| 1, 3 November 2016 | Gibbs Sampler |
| 8, 10 November 2016 | Optimization |
| 15, 17 November 2016 | Optimization and the EM Algorithm |
| 22 November 2016 | EM Algorithm |
| 29 November, 1 December 2016 | Bootstrap |
| 6, 8 December 2016 | Project Presentations |
| 13 December 2016 | Project Presentations |

Tentative Deadlines:

| | |
|-------------------|------------------------------|
| 20 September 2016 | Homework 1 |
| 4 October 2016 | Homework 2, project proposal |
| 18 October 2016 | Homework 3 |

| | |
|-------------------------|----------------------------|
| 1 November 2016 | Project status update |
| 15 November 2016 | Homework 4 |
| 1 December 2016 | Homework 5 |
| 14 December 2016 | Project reports due |

VII. Evaluation and Grading

Class participation and attendance: 15%

Homework: 25%

Exam: 25%

Group project: 35%

The University utilizes plus and minus grading on a 4.000 cumulative grade point scale in accordance with the following:

- A 4.000 - Represents achievement that is outstanding relative to the level necessary to meet course requirements
- A- 3.667
- B+ 3.333
- B 3.000 - Represents achievement that is significantly above the level necessary to meet course requirements
- B- 2.667
- C+ 2.333
- C 2.000 - Represents achievement that meets the course requirements in every respect
- C- 1.667
- D+ 1.333
- D 1.000 - Represents achievement that is worthy of credit even though it fails to meet fully the course requirements
- S Represents achievement that is satisfactory, which is equivalent to a C- or better.

For additional information, please refer to:

<http://policy.umn.edu/Policies/Education/Education/GRADINGTRANSCRIPTS.html>.

Course Evaluation

The SPH will collect student course evaluations electronically using a software system called CoursEval: www.sph.umn.edu/courseval. The system will send email notifications to students when they can access and complete their course evaluations. Students who complete their course evaluations promptly will be able to access their final grades just as soon as the faculty member renders the grade in SPHGrades: www.sph.umn.edu/grades. All students will have access to their final grades through OneStop two weeks after the last day of the semester regardless of whether they completed their course evaluation or not. Student feedback on course content and faculty teaching skills are an important means for improving our work. Please take the time to complete a course evaluation for each of the courses for which you are registered.

Incomplete Contracts

A grade of incomplete "I" shall be assigned at the discretion of the instructor when, due to extraordinary circumstances (e.g., documented illness or hospitalization, death in family, etc.), the student was prevented from completing the work of the course on time. The assignment of an "I" requires that a contract be initiated and completed by the student before the last official day of class, and signed by both the student and instructor. If an incomplete is deemed appropriate by the instructor, the student in consultation with the instructor, will specify the time and manner in which the student will complete course requirements. Extension for completion of the work will not exceed one year (or earlier if designated by the student's college). For more information and to initiate an incomplete contract, students should go to SPHGrades at: www.sph.umn.edu/grades.

University of Minnesota Uniform Grading and Transcript Policy

A link to the policy can be found at onestop.umn.edu.

VIII. Other Course Information and Policies

Grade Option Change (if applicable):

For full-semester courses, students may change their grade option, if applicable, through the second week of the semester. Grade option change deadlines for other terms (i.e. summer and half-semester courses) can be found at onestop.umn.edu.

Course Withdrawal:

Students should refer to the Refund and Drop/Add Deadlines for the particular term at onestop.umn.edu for information and deadlines for withdrawing from a course. As a courtesy, students should notify their instructor and, if applicable, advisor of their intent to withdraw.

Students wishing to withdraw from a course after the noted final deadline for a particular term must contact the School of Public Health Office of Admissions and Student Resources at sph-ssc@umn.edu for further information.

Student Conduct Code:

The University seeks an environment that promotes academic achievement and integrity, that is protective of free inquiry, and that serves the educational mission of the University. Similarly, the University seeks a community that is free from violence, threats, and intimidation; that is respectful of the rights, opportunities, and welfare of students, faculty, staff, and guests of the University; and that does not threaten the physical or mental health or safety of members of the University community.

As a student at the University you are expected adhere to Board of Regents Policy: *Student Conduct Code*. To review the Student Conduct Code, please see: http://regents.umn.edu/sites/default/files/policies/Student_Conduct_Code.pdf.

Note that the conduct code specifically addresses disruptive classroom conduct, which means "engaging in behavior that substantially or repeatedly interrupts either the instructor's ability to teach or student learning. The classroom extends to any setting where a student is engaged in work toward academic credit or satisfaction of program-based requirements or related activities."

Use of Personal Electronic Devices in the Classroom:

Using personal electronic devices in the classroom setting can hinder instruction and learning, not only for the student using the device but also for other students in the class. To this end, the University establishes the right of each faculty member to determine if and how personal electronic devices are allowed to be used in the classroom. For complete information, please reference: <http://policy.umn.edu/Policies/Education/Education/STUDENTRESP.html>.

Scholastic Dishonesty:

You are expected to do your own academic work and cite sources as necessary. Failing to do so is scholastic dishonesty. Scholastic dishonesty means plagiarizing; cheating on assignments or examinations; engaging in unauthorized collaboration on academic work; taking, acquiring, or using test materials without faculty permission; submitting false or incomplete records of academic achievement; acting alone or in cooperation with another to falsify records or to obtain dishonestly grades, honors, awards, or professional endorsement; altering, forging, or misusing a University academic record; or fabricating or falsifying data, research procedures, or data analysis. (Student Conduct Code)

http://regents.umn.edu/sites/default/files/policies/Student_Conduct_Code.pdf) If it is determined that a student has cheated, he or she may be given an "F" or an "N" for the course, and may face additional sanctions from the University. For additional information, please see: <http://policy.umn.edu/Policies/Education/Education/INSTRUCTORRESP.html>.

The Office for Student Conduct and Academic Integrity has compiled a useful list of Frequently Asked Questions pertaining to scholastic dishonesty: <http://www1.umn.edu/oscai/integrity/student/index.html>. If you have additional questions, please clarify with your instructor for the course. Your instructor can respond to your specific questions regarding what would constitute scholastic dishonesty in the context of a particular class-e.g., whether collaboration on assignments is permitted, requirements and methods for citing sources, if electronic aids are permitted or prohibited during an exam.

Makeup Work for Legitimate Absences:

Students will not be penalized for absence during the semester due to unavoidable or legitimate circumstances. Such circumstances include verified illness, participation in intercollegiate athletic events, subpoenas, jury duty, military service, bereavement, and religious observances. Such circumstances do not include voting in local, state, or national elections. For complete information, please see: <http://policy.umn.edu/Policies/Education/Education/MAKEUPWORK.html>.

Appropriate Student Use of Class Notes and Course Materials:

Taking notes is a means of recording information but more importantly of personally absorbing and integrating the educational experience. However, broadly disseminating class notes beyond the classroom community or accepting compensation for taking and distributing classroom notes undermines instructor interests in their intellectual work product while not substantially furthering instructor and student interests in effective learning. Such actions violate shared norms and standards of the academic community. For additional information, please see: <http://policy.umn.edu/Policies/Education/Education/STUDENTRESP.html>.

Sexual Harassment:

"Sexual harassment" means unwelcome sexual advances, requests for sexual favors, and/or other verbal or physical conduct of a sexual nature. Such conduct has the purpose or effect of unreasonably interfering with an individual's work or academic performance or creating an intimidating, hostile, or offensive working or academic environment in any University activity or program. Such behavior is not acceptable in the University setting. For additional information, please consult Board of Regents Policy: <http://regents.umn.edu/sites/default/files/policies/SexHarassment.pdf>

Equity, Diversity, Equal Opportunity, and Affirmative Action:

The University will provide equal access to and opportunity in its programs and facilities, without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or gender expression. For more information, please consult Board of Regents Policy: http://regents.umn.edu/sites/default/files/policies/Equity_Diversity_EO_AA.pdf.

Disability Accommodations:

The University of Minnesota is committed to providing equitable access to learning opportunities for all students. The Disability Resource Center Student Services is the campus office that collaborates with students who have disabilities to provide and/or arrange reasonable accommodations.

If you have, or think you may have, a disability (e.g., mental health, attentional, learning, chronic health, sensory, or physical), please contact DRC at 612-626-1333 or drc@umn.edu to arrange a confidential discussion regarding equitable access and reasonable accommodations.

If you are registered with DS and have a current letter requesting reasonable accommodations, please contact your instructor as early in the semester as possible to discuss how the accommodations will be applied in the course.

For more information, please see the DS website, <https://diversity.umn.edu/disability/>.

Mental Health and Stress Management:

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of

motivation. These mental health concerns or stressful events may lead to diminished academic performance and may reduce your ability to participate in daily activities. University of Minnesota services are available to assist you. You can learn more about the broad range of confidential mental health services available on campus via the Student Mental Health Website: <http://www.mentalhealth.umn.edu>.

The Office of Student Affairs at the University of Minnesota:

The Office for Student Affairs provides services, programs, and facilities that advance student success, inspire students to make life-long positive contributions to society, promote an inclusive environment, and enrich the University of Minnesota community.

Units within the Office for Student Affairs include, the Aurora Center for Advocacy & Education, Boynton Health Service, Central Career Initiatives (CCE, CDes, CFANS), Leadership Education and Development – Undergraduate Programs (LEAD-UP), the Office for Fraternity and Sorority Life, the Office for Student Conduct and Academic Integrity, the Office for Student Engagement, the Parent Program, Recreational Sports, Student and Community Relations, the Student Conflict Resolution Center, the Student Parent HELP Center, Student Unions & Activities, University Counseling & Consulting Services, and University Student Legal Service.

For more information, please see the Office of Student Affairs at <http://www.osa.umn.edu/index.html>.

Academic Freedom and Responsibility: *for courses that do not involve students in research:*

Academic freedom is a cornerstone of the University. Within the scope and content of the course as defined by the instructor, it includes the freedom to discuss relevant matters in the classroom. Along with this freedom comes responsibility. Students are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth. Students are free to take reasoned exception to the views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled.*

OR:

Academic Freedom and Responsibility, for courses that involve students in research

Academic freedom is a cornerstone of the University. Within the scope and content of the course as defined by the instructor, it includes the freedom to discuss relevant matters in the classroom and conduct relevant research. Along with this freedom comes responsibility. Students are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth. Students are free to take reasoned exception to the views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled.* When conducting research, pertinent institutional approvals must be obtained and the research must be consistent with University policies.

Reports of concerns about academic freedom are taken seriously, and there are individuals and offices available for help. Contact the instructor, the Department Chair, your adviser, the associate dean of the college, (Dr Kristin Anderson, SPH Dean of Student Affairs), or the Vice Provost for Faculty and Academic Affairs in the Office of the Provost.

** Language adapted from the American Association of University Professors "Joint Statement on Rights and Freedoms of Students".*

Student Academic Success Services (SASS): <http://www.sass.umn.edu>:

Students who wish to improve their academic performance may find assistance from Student Academic Support Services. While tutoring and advising are not offered, SASS provides resources such as individual consultations, workshops, and self-help materials.

Template update 9/2014