STATS 551: Bayesian Modeling and Computation (2020 WIN)

Yang Chen
Department of Statistics and MIDAS
University of Michigan

Course Overview

This course focuses on Bayesian modeling and computational techniques to prepare graduate students to apply Bayesian methods in complex, real world problems. The course is application-oriented and addresses practical skills for principled data analysis. Relevant theoretical foundations will be mentioned briefly and references will be given for interested students.

Grades are based on weekly quizzes, homework (biweekly) and a final project (in groups of 2 to 4). For the final project, students are expected to apply Bayesian methods to analyze real data and write up a thorough report on the modeling, computation, and interpretation of the statistical analysis.

Prerequisites: STATS 426 & 413 or 510 & 500. Prior knowledge on Bayesian inference is helpful but not required. Familiarity with one programming language (R, Python, Julia, etc.) is needed.

References

Main references are the following textbooks. Others will be given during lectures. Lecture slides will be posted after (not before) each class.

- Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., & Rubin, D. B. (2014). Bayesian data analysis (Third Edition). Chapman & Hall/CRC Texts in Statistical Science.

- Hoff, Peter D. A first course in Bayesian statistical methods. Springer Science & Business Media, 2009.

Office Hours and Contact Information

- Instructor: Yang Chen, 445E West Hall, 1085 S. University Ave., Ann Arbor.
  Office hours: See Canvas Announcements.

- GSI: Wayne (Yu) Wang (50%), Daniel Iong (25%), Bach Viet Do (25%).
  Office hours: See Canvas Announcements.

- Emails: Please send via Canvas.

Course Outline

- Basics of Bayesian Modeling and Inference

    - Basic Concepts: Prior, Likelihood, Posterior
    - Examples: Single and Multi Parameter Models
    - Bayesian Hierarchical Model and Shrinkage Estimators

- Computational Methods

    - Importance Sampling and Sequential Monte Carlo Methods
    - Markov chain Monte Carlo and Extensions
    - Usage of the STAN Package
    - Approximate Bayesian Inference Methods
        * Variational Inference
        * Approximate Bayesian Computation
    - Bayesian nonparametrics
        * Dirichlet Process
        * Gaussian Process

- Bayesian Inference in Practice

    - Latent Variable Models
    - Regression Models
    - Missing Data and Causal Inference
    - Case Studies from Social and Natural Sciences

Grading Guideline

A total of 100 points is broken down into four parts.

- Quizzes (weekly): 30. Quizzes will be automatically graded on Canvas with a score of 0 (incorrect) or 1 (correct). Each quiz will be posted on Wednesday after the lecture and accessible on Canvas for 24 hours. If you miss the quiz submission deadline, you get a 0 for that quiz. The final quiz score is the sample mean of a student's quiz scores multiplied by 30. No lowest quiz score will be dropped.

- Homework: 30. Denote N homework scores by $x_1, x_2, \cdots, x_N$ where each $x_i \in [0, \, 100]$, $1 \leq i \leq N$. The final homework score is calculated as follows.

$$(N-1)^{-1} \sum_{1 \leq i \leq N, i \neq n_{\min}} x_i \ \cdot 40\%,$$

where $n_{\min} = \{i \, ; \, x_i = \min\{x_1, \, x_2, \, \cdots, \, x_N\} \}$.

- Final project presentation: 10. Final project report: 30.

- Bonus points: up to 5.

  - Active class participation: discussions (Q&A) on Canvas etc.
  - Filling out teaching evaluations and class surveys.
  - Posting and replying to discussions on optional reading materials.

- Penalty points: [-100, 0].

  - Penalty points will be given to those who violate academic misconduct such as plagiarism of homework or final projects. The exact points will be decided by the GSI and the instructor collectively.

Formula for letter grades:

Grade	Range
A+	100% to 94%
A	< 94% to 90%
A-	< 90% to 87%
B+	< 87%to 84%
B	< 84% to 80%
B-	< 80% to 77%
C+	< 77% to 74%
C	<74% to 70%
C-	< 70% to 67%
D+	< 67% to 64%
D	< 64% to 61%
F	< 61% to 0%

Homework Requirements

- E-submissions (**REQUIRED**) are via Canvas. You are encouraged (not required) to submit a hard/printed copy in order to get feedback from GSI.

- File format: '.pdf', '.Rmd', '.html', '.ipynb'. Preferred ones are compiled versions of

  - R Markdown
  - Jupyter Notebook

- The following grading criteria for homeworks is based on 100% maximum. Correctness of derivations: 20%. Correctness of results: 40%. Code: 30%. Writeup: 10%.

  - Dispute of homework score MUST be within 7 business days of homework return.
  - Homework-grading-related questions are resolved at GSI or instructor's office hours.
  - Late homework policy. If "Submission Date - Homework Deadline > 7 days": Grade is 0. Otherwise, each student is allowed one late homework ($\leq$ 7 days) throughout the semester without penalty. Extra late homework (late for less than 7 days) will receive half of the total grade. Medical reasons for late homework: both a doctor's note and a signature from your graduate (or undergraduate) advisor are needed to be submitted to the instructor or the GSI prior to homework submission deadline.

Final Project Presentation

For collaborative projects, all group members are supposed to work on the presentation together. However, you can choose to have one or several of the members deliver the whole presentation. The grading criteria for final project presentation is as follows.

- Clear description of the problem (25%).

- Clear description/visualization of the data (25%).

- Clear and thorough description of statistical analysis (35%).

- Clear and thorough interpretation of results (15%).

Final Project Report

Each group needs to submit one thorough report (less than 10 pages, including figures and references), similar to the format of an academic paper. Annotated code which generates the results from the final project should also be submitted. Each member needs to submit a brief description of his/her contributions to the final project. The following grading criteria for the final project report is based on 100% maximum.

- Solid understanding and description of problem (**+5%**).

- Quality of data analysis.

  - Appropriateness of the statistical model (**+20%**).
  - Efficiency of the computational algorithms adopted (**+20%**).

- Presentation of results, including visualization (**+15%**).

- Proper interpretation of results (**+20%**).

- Well-organized and clean code (**+5%**) .

- Clarity of written report (**+15%**).

- Irrelevance with course materials (**-40%**).

- Plagiarism of code or written report (**-100%**).

- Lack of contribution to group project (varies from **-80%** to **-20%**).

A single grade is given to all members of a group except the case when one or two members of a group is reported as "lack of contribution", see the last point above. **NO late final projects. Students who submit final projects late will receive a score of 0.** In case of severe medical reasons for late final project, both a doctor's note and a signature from your graduate (or undergraduate) advisor are needed at least one week ahead of time.

Course Policy

- Q & A are handled **ONLY** on Canvas and office hours, thus please avoid asking technical questions via email. Students are encouraged to help solving each other's problems on Canvas. Students are encouraged to share notes on Canvas. Bonus points (up to 5%) will be given according to students' involvement and contributions on Canvas.

- Please come to the GSI or the instructor's office hours if you have any questions that you don't want to post on Canvas discussions. Emails sent to the GSI or instructor about (a) contents that can be found on Canvas, (b) technical questions including bugs in code, or (c) asking for homework / final project extensions (except medical conditions) won't be replied.

- Proper collaboration is highly recommended. However, you must recognize your collaborators by writing down their names clearly in the front when handing in your homework or final project. Refer to the Academic Misconduct for policies of plagiarism. The instructor will follow the university honor code policy strictly. Lack of knowledge of the academic honesty policy is not a reasonable explanation for a violation. If you discuss with other students about homework, you are supposed to write down your own homework/code independently after the discussions. Under any circumstances, two exact copies of homework/code are considered to be plagiarism. Students are under their own risk of any type of penalty from the university in violating academic honesty.

Miscellaneous

Academic Misconduct

The University of Michigan community functions best when its members treat one another with honesty, fairness, respect, and trust. The College of LSA promotes the assumption of personal responsibility and integrity, and prohibits all forms of academic dishonesty and misconduct. All cases of academic misconduct will be referred to the Office of the Assistant Dean for Undergraduate Education. Being found responsible for academic misconduct will usually result in a grade sanction, in addition to any sanction from the College. For more information, including examples of behaviors that are considered academic misconduct and potential sanctions, please see www.lsa.umich.edu/ academicintegrity.

Accommodations for Students with Disabilities

If you think you need an accommodation for a disability, please let me know at your earliest convenience. Some aspects of this course, the assignments, the in-class activities, and the way the course is usually taught may be modified to facilitate your participation and progress. As soon as you make me aware of your needs, we can work with the Services for Students with Disabilities (SSD) office to help us determine appropriate academic accommodations. SSD (734-763-3000; http://ssd.umich.edu) typically recommends accommodations through a Verified Individualized Services and Accommodations (VISA) form. Any information you provide is private and confidential and will be treated as such.

Other resources

As a student, you may experience a range of issues that can negatively impact your learning, such as anxiety, depression, interpersonal or sexual violence, difficulty eating or sleeping, loss/grief, and/or alcohol/drug problems. These mental health concerns or stressful events may lead to diminished academic performance and affect your ability to participate in day-to-day activities. In order to support you during such challenging times, the University of Michigan provides a number of confidential resources to all enrolled students, including Counseling and Psychological Services (CAPS) (734.764.8312), Sexual Assault Prevention and Awareness Center (SAPAC) (24-Hour Crisis Line: 734.936.3333), Psychiatric Emergency Services (734-996-4747), and Services for Students with Disabilities (734.763.3000; 734.615.4461 [TDD]; 734.619.6661 [VP]).