

MATH 574 Bayesian Computational Statistics

Lecture Notes

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Thursday 3:10-5:10 pm or by appointment.

Course Information on Blackboard via <http://blackboard.iit.edu>



Welcome to MATH 574

- Tuesday & Thursday, 1:50–3:05 pm, RE-036.
- Instructor: Lulu Kang. lkang2@iit.edu
- Office Hour: Thursday 3:10–5:10 pm or by appointment. RE-105B.
- TA: Kan Zhang. Email: kzhang23@hawk.iit.edu
- TA hour: TBA in RE-129.



Objectives of MATH 574

Students will learn

- 1 fundamental theories of Bayesian statistics, Bayesian computational theories and techniques for modeling and drawing inferences from data sets,
- 2 visual and numerical diagnostics to assess the soundness of Bayesian modeling,
- 3 the computational requirements and compromises to be made in analyzing data sets,
- 4 how to implement and use these numerical methods in R,
- 5 how to analyze real data sets and communicate their results,
- 6 presentation and writing skills.



Why you want to take this course

- Bayesian statistics is one of the most important area in statistics or data science in general. This course covers the fundamental theories, methodologies, and computational techniques.
- Not only these contents are important in the theoretical sense, they are also extremely practical for any statistician or data scientist to solve problems in the real world.



My Philosophy

- You have to ENJOY!
- Some “*hardwork*” needed: this is a 500-level advanced graduate MATH course that introduces rigorous theories on Bayesian statistical inference and data analysis, and Bayesian computation theories and methods.
- Very useful: this course will introduce how to implement the Bayesian theories and computation methods to analyze real data and solve problems.
- The many **modes of learning** include: reading the text and reference material, participating in lectures, studying with classmates, doing assignments, undertaking an independent project, and taking the exams.



My Philosophy

- You must **take responsibility** for your own learning, by keeping pace with the course, monitoring your progress, and working on those areas you find challenging.
- I will **endeavor** to make the lectures and other classwork interesting and helpful, and flexibly adjust my presentation to student needs.
- I will conduct mid-semester survey of the course and my teaching. I expect you to give me feedbacks, positive or negative. Of course, feel free to give me any suggestions or comments any time.



Topics Covered

- 1 Fundamentals of Bayesian Inference Ch. 1–5
- 2 Fundamentals of Bayesian Data Analysis Ch. 6–8
- 3 Advanced Computation Ch. 10–13
- 4 Regression Models Ch. 14–16



Online Resources

- Course materials, grades, discussion forum, announcements are available on <http://blackboard.iit.edu>.
- Please do not share my course materials with anyone outside of this class. Particularly, please do not post them on the websites like Coursehero. We, as instructors, put a lot of efforts, time, and thoughts into our course materials. Please respect our hard work and our intellectual property.
- Students taking this class online should refer to <https://online.iit.edu/> for more information.
- Lecture videos are available to all students. You can access them in Blackboard under the IIT Online tab about one day after the lectures are given.



Software: R

- Some of the assignments, your project, and the mid and final exam will use the statistical software R, which is open source and free.
- If you choose to not learn R (use R) for this course, you are on your own to study other language and implement the necessary methods for homework, exams, and course project.
- R is the most popular and powerful statistical software.
- You may also download the installation packages of R from <https://cran.r-project.org>.
- I will only use 1–2 sessions to introduce R. It is **your responsibility** to learn and familiarize yourself with R. Two references you must read “*An Introduction to R*” and “*Bayesian Computation with R*”. They are available on Blackboard, together with some other useful manuals.



Assessments

Homework assignments (≈ 10)	25%
Mid-Exam (03/10/2020)	25%
Final Exam (exam week)	30%
Course Project	20%



Grading Policy

- A: Excellent top $\sim 30\%$
- B: Above and around average $\sim 30\%$
- C: Below average $\sim 30\text{--}40\%$
- E: Very terrible performances.

Note: the grading policy will be applied with certain flexibility at the discretion of the instructor.



Discussion and Communication

- Major news will be sent to you as announcements in Blackboard.
- If you wish to raise questions related to the course, as long as the questions are not personal, you should post your questions or comments in the discussion forum in Blackboard, so that other students would also benefit from the discussion.
- The discussion forum is also a venue for students to communicate with each other, especially for the online students. You can also post any other useful information or write any essays about the Bayesian statistics, or statistics in general.
- Please be professional, respectful, and considerate to each other while writing your posts.



Course projects

- Students can working in group of 2-3 members for the course projects.
- You can choose one of the two types of course projects: literature reading or real application.



Literature Reading Project

The requirements for literature reading project:

- Choose one of the paper from the “Suggested Literature Reading List”.
- Carefully study this paper, including its backgrounds and detailed methodologies, examples, etc.



Literature Reading Project

- Write a report (6-10 pages). In this report, you have to summarize the content of the paper, what you have learned, the important contribution of the paper.
- You must implement the method proposed in the paper. In your report, you must contain a section on examples. In this section, you must (1) repeat one of the example from the paper; (2) find an another data set outside of the paper and apply your implementation.
- Besides the report, you also need to submit a zip file that containing all of your codes.
- The project report and codes are due on 05/01/2020.



Real Application Project

- Apply the methodologies you have learnt from this course, or more advanced Bayesian statistical methods to a real-world problem.
- Data must come from a real world problem.
- If you are not sure about your topic, it is a good idea to discuss it with me. My approval is necessary.



Real Application Project

- Write a report (6-10 pages). In this report, detailed explain the background of the application, the detailed implementation of the statistical methodologies and presentation of the analysis results, the conclusion of the analysis in the sense of the real-world problem.
- Besides the report, you also need to submit a zip file that containing all of your codes.
- The project report and codes are due on 05/01/2020.



Important Guidelines for Assignments

- There will be 9–10 homework assignments.
- Homework will be assigned from the textbook: Gelman, A., Carlin, J. B., Stern, H. S., Rubin, D. B. (2013) *Bayesian Data Analysis*, 3rd Edition. Chapman & Hall/CRC.
- Assignments should be handed on the due date in class.



Important Guidelines for Mid and Final Exam

- Mid-exam is going to be held on 03/10/2020 in class.
- You are allowed to bring two sheets of double-sided, letter-sized paper with anything written on them that you think might help for the mid-exam. For the final exam you may bring four sheets of double-sided, letter-sized paper.
- You are also encouraged to bring your calculator.
- Cellphone use is prohibited during exams.



Honor the course policy

- **Respect the deadlines. No late submission** will be accepted.
- Exams: no make-up exams. If the date does not work for you, you have to notify me at least one-week before the exam date, unless emergency.
- Please follow Code of Academic Honesty, Code of Conduct, and IIT Code of Ethics.