MSc in Analytics

Course Syllabus

BAYESIAN METHODS
MSCA 32014
Gleacher Center Room (TBD)

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COURSE DESCRIPTION

Bayesian inference is a method of statistical learning in which Bayes' theorem is used to understand probability distributions of unobserved variables, like model parameters or predictions for future observations. Bayesian analysis is especially important because it naturally allows updating the probability for a model or hypothesis as more evidence or information becomes available. This property of Bayesian approach plays significant role in dynamic analysis of a sequences of data.
Applications of Bayesian analysis have exploded in recent period thanks to advances in computing techniques that made Bayesian approaches like Gibbs sampling, Markov Chain Monte Carlo, Dirichlet processes the main tools for advanced machine learning.
The focus of this course is on foundations of Bayesian approach, its applications via hierarchical models, linear and generalized linear models, mixed models and various types of Bayesian decision making.
Students will learn necessary facts of probability theory, fundamentals of Bayesian method as well as most modern applications of the approach by accessing through R important software products for efficient sampling: JAGS and STAN.
Students, are expected to be comfortable with coding in R and ready to learn new concepts of theory and practice of Bayesian approach. Prerequisites: Linear and Nonlinear Models (31010).

This 10-week course is an elective course of the MSc in Analytics program. Grades will be assigned for this course and the course will appear on your official transcript. All registered students must obtain a passing grade of at least B-.

PREREQUISITES

Linear and Non-Linear models (31010)

RECOMMENDED BOOKS

1. A. Gelman, J. Carlin, H. Stern, D. Dunson, A. Vehtari, D. Rubin, Bayesian Data Analysis, Third Edition, CRC Press, 2013 (Recommended)
2. J. Kruschke, Doing Bayesian Data Analysis: A Tutorial with R, JAGS, and STAN, Elsevier Inc., 2015 (Recommended)

SOFTWARE AND HARDWARE

We will be using R with related packages (http://cran.r-project.org), JAGS and STAN
It is recommended that students have their laptops with necessary software installed during the class. We will use them for data assignments in class.

LEARNING OBJECTIVES

After completing this course, students should be able to:

- Design, conduct and interpret Bayesian statistical analysis
- Read and implement results of scientific research requiring background in Bayesian analysis
- Understand and efficiently use the process of appropriate model selection.
- Discover patterns hidden in data.
- Understand assumptions behind the covered methods

EVALUATION:

Your course grade will be calculated as follows:

- 40% Weekly Assignments
- 20% Class Participation
- 40% Final Project

GRADING SCALE

A = 93%–100%
A- = 90%–92%
B+ = 87%–89%
B = 83%–86%
B- = 80%–82%
C+ = 77%–79%
C = 73%–76%

ATTENDANCE

This course will meet once a week on Friday from 6:00 to 9:00 p.m. Your attendance is required and very important not only for your own results in this class, but also for the development of the course. You are allowed to miss at most two sessions, provided that you make arrangements with the instructor in advance.

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FINAL PROJECT

Final course project is submitted in the form of written report summarizing the methods used for the inference, justification of their assumptions and interpretation of the results.

Additional information and details of the assignment will be given by the instructor at least 5 weeks before the due date.

The final project will be graded out of 100 points.

LATE WORK

All assignments must be submitted to the site of the course on the due date before 11:59 pm. If you turn in an assignment late, 10% will be deducted from the total score for each day after the deadline. Assignments turned in more than one week late will not receive credit. In the case of unexpected events, you must contact the instructor before the assignment due date in order to receive a grace period. Students can only receive up to two grace periods in the course.

REQUESTING REASONABLE ACCOMODATIONS

If you are interested in requesting disability accommodations, you may want to begin by reading through the information published on this website https://disabilities.uchicago.edu/. Also, please do communicate your requests as soon as possible to Gregory Moorehead, director of disability services, at 773.702.7776 or gmoorehead@uchicago.edu.

ACADEMIC HONESTY & PLAGIARISM

It is contrary to justice, academic integrity, and to the spirit of intellectual inquiry to submit another's statements or ideas of work as one's own. To do so is plagiarism or cheating, offenses punishable under the University's disciplinary system. Because these offenses undercut the distinctive moral and intellectual character of the University, we take them very seriously.

Proper acknowledgment of another's ideas, whether by direct quotation or paraphrase, is expected. In particular, if any written or electronic source is consulted and material is used from that source, directly or indirectly, the source should be identified by author, title, and page number, or by website and date accessed. Any doubts about what constitutes "use" should be addressed to the instructor.

At any time during or after the course students are encouraged to help developing this course by providing their feedback to the instructor in any form, as long as it is constructive, respectful and in compliance with the ethical norms of The University of Chicago.

COURSE TOPICS

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Important Note: Changes may occur to the syllabus at the instructor's discretion. When changes are made, students will be notified via email and in-class announcement.

TOPIC 1
Probability, conditional probability, conditional mathematical expectation, Bayes theorem, steps of Bayesian inference

TOPIC 2
Probability, conditional probability, examples of application of Bayes theorem, general framework of Bayesian approach

TOPIC 3
Conjugate distributions. Conjugate priors for binomial, Gaussian, exponential and Poisson distributions. Examples of Bayesian analysis with conjugate priors

TOPIC 4
Random effects. Hierarchical models as an explanation of random effects. Shrinkage and Stein paradox. Role of exchangeability in hierarchical models

TOPIC 5
Markov Chain Monte Carlo, JAGS, Metropolis algorithm, Gibbs sampling

TOPIC 6
Mixing models: joint posterior distribution of parameters including index of models. Bayes factor and its interpretation. Dependence on prior distribution, averaging models. Nested models.

TOPIC 7
Simple linear regression in Bayesian approach. Review of generalized linear model: simple assumption, robust assumption

TOPIC 8
Multiple regression, describing multiple groups, ANOVA: traditional and hierarchical Bayesian approach

TOPIC 9
Problem of variable selection. Model with one nominal predictor and metric output, or metric predictor and nominal output. Robust logistic regression

TOPIC 10
Ordinal predicted variables. Ordinal logistic regression Count predicted variables. Poisson regression

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