MA 556, Applied Bayesian Statistics Fall 2019

COURSE OUTLINE **09/28/19**

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Office: Stratton 002A; Office Hours: Wed: 2:00-4:00; other times by appointment

Class SH304: Wed 5:30-6:25; Break; 6:30-7:25; Break; 7:30-8:20.

Teaching Assistant: Yang Liu; Office: SH012, Tue 9:00-11:00am;
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Theme: Applications of methods of Bayesian data analysis to real problems

The emphasis is on Applied Bayesian Statistics. Some knowledge of a programming language (e.g., Fortran, C, Mathlab) and a statistical software (e.g., SAS, Stan, INLA) would be useful but these are not required. However, you are strongly advised to learn to use R. [The appendix of my lecture notes shows how to get started using R.]

Recommended Readings

(a) Andrew Gelman, John B. Carlin, Hal S. Stern, David Dunson, Aki Vehtari, and Donald B. Rubin (2004), Bayesian Data Analysis, Third Edition, Chapman & Hall, New York.

(b) Peter Lee (2012), Bayesian Statistics, An Introduction, Fourth Edition, Wiley, New York.

(c) Jean-Michel Marin and Christian Robert (2012), Bayesian Essentials with R, Second Edition, Springer, New York.

The text books are not required, and I will use my own materials to teach the course. However, these text books will be placed on short-term use in the library. Additional reading materials (papers and books) will be kept on my website via Canvas. Some of these are my own contributions to the subject. This website is particularly important for Applied Bayesian Statistics.

Please note that, to be successful in this course, students must have experience at the level of MA541 or equivalent. I will allow students, who are currently taking MA541 or equivalent, in MA556 and you must discuss this issue with me up front.

A list of topics, which we would cover, is shown below. However, these topics would not be covered in any specific order.

(1) **One Sample Problems**

Conditional probability and Bayes' Theorem; Coherence; Exchangeability; Priors (conjugate/nonconjugate, non-informative, Jeffreys'); Prior-Posterior Analysis; Propriety; Binomial, Normal, Gamma models; Loss functions and Bayes estimators (2 weeks)

(2) **Inference**

HPD interval; Marginal likelihood; Bayes factor; Prediction; Model selection; Bayesian density estimator (1 week)

(3) **Extra Variation-type problems**

Hierarchical models including Beta-binomial, normal means, exponential means, Poisson means, multinomial model, multivariate normal and Wishart (3 weeks)

(4) **Numerical Computations**

Laplace approximation; Monte Carlo (MC) methods; Rao-Blackwellization; Logconcavity and adaptive rejection sampling; Markov chain Monte Carlo (MCMC) methods; slice sampler; SIR sampler; Gibbs sampler; Metropolis sampler; Metropolis-Hastings sampler; Diagnostics; Goodness of fit tests; Cross validation; Model uncertainty and model averaging (RJMCMC); Integrated nested Laplace approximation (INLA); Bayesian filtering (3 weeks)

(5) **Generalized Linear Models**

Logistic regression, Probit regression and Poisson regression models (1 week)

(6) **Some Applications**

Survey sampling; Categorical data analysis; Time series; Missing data; Spatial Statistics; Small Area Estimation, etc. (3 weeks)

(7) **Nonparametric Bayesian Statistics**

A gentle introduction to Nonparametric Bayesian Statistics (e.g., Dirichlet process, Dirichlet process mixture model - Stick-breaking and slice sampler) (1 week, if time permits)

Course Activities

(1) **Homework Assignments**

There will be one assignment roughly four or five problems every two weeks; the number of problems will depend on the amount of work required. The problems will be constructed by the instructor. Many of the problems will be of a practical nature and you will need to use a computer. Some problems will be of a theoretical nature and will require analytical skills. A group of one-three (not more) students can turn in a single homework report; you must state the names of the students who worked on the homework assignment when it is turned in. A subset of the problems may be selected for grading.

(2) **Project**

A few students will form a small team to work on the mini-project that will be assigned shortly after mid semester. This project must draw materials from the course content and numerical work using a computer is essential. The project team can propose the project its team members want to work on. The proposal must clearly show where the course contents will be used. Writing of the project's report will be emphasized. The team must be clear about its objectives and how they are met. A clear summary of the results must be presented.

(3) **Bi-Weekly Tests**

A test will be given on the day a homework assignment is due, and it will be individual-based (not group work). Students are required to have a deep understanding of the materials covered on the homework assignment. There will be one question and you will be given up to twenty-five (25)minutes (strictly not more) to do the test. The good news is that there are no other lengthy tests in this course. These weekly tests will give you a much better understanding of the course materials and will give you a better chance to do well in the course.

(4) **Final Exam**

The final exam is comprehensive (i.e., you are expected to understand everything), but it will be based on a few topics. It is individual-based and it will last one hour. The Instructor will inform the students about the topics on the Exam a few weeks before. This exam is important because it gives you an opportunity to know everything at one time and to understand how different topics fit together.

Homework Assignments	20
Project	15
Weekly Tests	45
Final Exam	20
	100

Final Grade (A, B, C, D, F)

F: less than or equal to 49.9
D: 50 to 59.9
C: 60 to 74.9
B: 75 to 84.9
A: greater than or equal to 85

To get an A in this course, you must get As in all *four* aspects of the course, and you MUST participate in all four aspects of the course. However, if it becomes necessary, the instructor would use his discretion.

Important Dates

Home Work	Due date will be announced
Weekly Tests	After the first 90 minutes' class
Project	Wednesday, December 4, 2019
Final Exam	Wednesday, December 11, 2019

Disability

If you need course adaptations or accommodations because of a disability, or if you have medical information to share with me, please make an appointment with me as soon as possible; see my office hours on the first page of this document. If you have not already done so, students with disabilities, who believe that they may need accommodations in this class, are encouraged to contact the Disability Service Office (DSO) as soon as possible to ensure that such accommodations are implemented in a timely fashion. The DSO is located in the Student Development and Counseling Center, the phone number is 508-831-4908 and e-mail is DSO@WPI.EDU.

Academic Dishonesty

The web site, http://www.wpi.edu/Pubs/Policies/Honesty, states "Any act that interferes with the process of evaluation by misrepresentation of the relation between the work being evaluated (or the resulting evaluation) and the student's actual state of knowledge is an act of academic dishonesty." See the web site for the procedures associated with academic dishonesty.