➢ FALL 2019: MATH7/8680 SYLLABUS

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Class: Dunn 231, T, Thu, 9:40-11:05 am
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OBJECTIVE:
This course is an introduction the basic ideas of modern Bayesian inference and its applications. Since a good knowledge of parametric probability and statistical modeling is required, there will be an extensive review of standard univariate and multivariate probability distributions at the beginning of the course. Modern Bayesian inference involves multiparametric, multivariate distributions and the implementation of Bayesian procedures are highly computational requiring the knowledge of stochastic computational tools of Gibbs Sampling, Markov Chain Monte Carlo (MCMC) and Metropolis-Hastings procedures. The emphasis of this course will be on the understanding of the practical application of Bayesian methods to statistical modeling and inference. Elements of Bayesian methodology in data science in the context of analysis of big data will be covered. For the purpose of stochastic simulations involved, students will be expected to acquire familiarity with R. The first few weeks of the course will be used to review standard materials of elementary concepts of Bayesian probability. Each student will be required to have a laptop, download R, R Studio, and learn how to use it. Students are also encouraged to download WinBugs. I will be basing my lectures on several sources:

Main Text: Bayesian Statistics: An Introduction by Bayesian Statistics: An Introduction, 4th Edition: An Introduction, 4th Edition, by Peter M. Lee, Wiley, (2012).

Supplementary Text: Learning Bayesian Models in R , by Hari Koduvely [PACKT] Publishing, (2015).

Journal Articles: These will include:

- “Explaining the Gibbs sampler” *The American Statistician* **46**:167–74, Casella and Berger. (2002)
- “Bayesian Analysis of Binary and Polychotomous Response Data” *Journal of the American Statistical Association* **88,** 669-679, Albert and Chib (1993)
- "A Bayesian analysis of clustered discrete and continuous outcomes." Journal of Applied Statistics **45,** 438-449, Bowman and George. (2018).
- Others

- “Informed Bayesian t-Tests”, *The American Statistician* https://doi.org/10.1080/00031305.2018.1562983, Gronau and Wagenmarkers (2019)

TOPICS:

REVIEW OF PROBABILITY

- Probability Function
- Conditional Probability
- Bayes Theorem
- Prior and Posterior Distributions
- Parametric Probability Models

PARAMETRIC MODELS

- Likelihood Function
- Conjugate Prior Distributions
- Bayes Theorem for Discrete and Continuous Distributions
- Models generated by Bernoulli experiments
  - Binomial, Geometric, Negative Binomials Distributions
  - Poisson Models
- and Beta Models
- Exponential and Gamma Models
- Pareto Model
- Exponential Family Models

- Multinomial Models
- Exchangeable Binary Models
- Exchangeable Multinomial Models
- De Finetti’s Theorem
- Multivariate Normal
- The Wishart and Inverse –Wishart Distributions
- Multivariate t-Distribution

MIXTURE MODELS

- Gaussian Mixture Models
- General Mixture Models

- THE UNIVARIATE NORMAL MODEL
    a. Conjugate posterior computations of mean and variance
    b. The Student-t posterior
    c. Posterior computations under other prior specifications
    d. The Normal model for Non-Normal data
- POSTERIOR COMPUTATIONS with GIBBS SAMPLING
    a. Fully conditional (semi-conjugate) prior distributions
    b. Gibbs Sampling, and Properties of Gibbs Sampler
    c. MCMC Diagnostics
- THE MULTIVARIATE NORMAL MODEL
    a. Fully conditional priors for mean vector and covariance matrix
    b. Missing Data and Imputations
- LINEAR REGRESSION
    a. Bayesian Estimation
    b. Uninformative and weakly informative priors
    c. Bayesian Model Selection

- NONCONJUGATE PRIORS AND METROPOLIS –HASTINGS ALGORITHMS
    a. Generalized Linear Models
    b. Binary Regression Models with Latent Variables
    c. Metropolis Algorithm for Poisson Regression
    d. Comparison of the Metropolis, Metropolis-Hasting and Gibbs Algorithms
    e. Regression Models with Correlated Errors
    f. Dirichlet Priors and Multinomial Regression
- NONPARAMETRIC BAYESIAN METHODS

HOME WORK Home work will be assigned bi-weekly

- 4-5 of the assigned problems will be graded
- N**o homework will be accepted for any reason after the due date TESTS:** There will be ONE CLASS TEST

PRESENTATION: Each Student will be expected to make a presentation of a project with substantial Bayesian content and computations

FINAL EXAM: There will be a comprehensive take-home final.

GRADING:

- Homework – 100points
- Test- 100 points

- Project -100 points
- Final Exam -100points

LECTURES: I will give be giving very comprehensive lectures, with many handouts The syllabus is intended as a guideline for expectation and evaluation in this course. The instructor reserves the right to make any changes that may be deemed necessary .