MATH 3427 Bayesian Statistics

Course Outline – Fall 2024

1. **Instructor**

Name: Dr. Chi-Wai YU
Contact Details: Rm 3419; phone: 2358-7429; e-mail: macwyu@ust.hk

2. **Teaching Assistants**

T1A
Name: GU, Yanwu
Contact Details: e-mail: ygubg@connect.ust.hk

3. **Meeting Time and Venue**

Lectures:
Date/Time: Tue (03:00pm – 04:20pm) and Thu (03:00pm – 04:20pm)
Venue: LSK 1032

Tutorials:
T1A
Date/Time: Mon (10:30am-11:20am) **Venue:** Rm6580

4. **Course Description**

Credit Points: 3 units
Pre-requisite: MATH 2421 or equivalence
Exclusion: NIL
Brief information:
This course provides a basic training of Bayesian statistics. Some ideas and principles of Bayesian including Bayesian decision theory, prior and posterior distributions, conjugate priors, Bayesian estimates and Bayesian hypothesis testing, are covered.

Other Bayesian tools such as Bayesian model selection, Bayesian networking, Bayesian data analysis, and Bayesian computational skills will also be discussed. An open-source, freely available software R will be used to implement these computational and data analytics skills.

5. **Intended Learning Outcomes**

Upon successful completion of this course, students are expected to

No.	ILOs
1	elaborate the concept and philosophy of Bayesian statistics and its main difference form the frequentist statistical approach.

2	explain the importance of prior distribution (e.g. flat and conjugate priors) in Bayesian inference and how we can conduct posterior inference by using Bayesian estimates and Bayesian hypothesis testing.
3	formulate a Bayesian solution to some real-data problems and interpret the results.
4	apply the conceptual and practical skills in Bayesian statistics to problems in statistics, data science, and other areas.

6. Assessment Scheme

a. Examination duration: 3 hrs for Final Examination

b. Percentage of assignments and examination.

Assessment	Assessing Course ILOs
20% by Assignment*	1, 2, 3, 4
30% (0%, resp) by Midterm	1, 2, 3, 4
50% (80%, resp) by Final exam	1, 2, 3, 4

*All assignments will receive feedback within 10 working days

Related to the policy on GenAI for teaching and learning, there is No restrictions on use of generative AI for an assessment task.

- For Assignment, no late submission will be accepted.
- No make-up midterm exam will be arranged for any reason.
- If a student misses the final exam, s/he must fill in a form to apply for a make-up final exam with evidence officially.

The maximum score from the above two different schemes will then be taken to determine the student's final grade.

c. Grades will be given by criteria referencing.

7. Student Learning Resources

Lecture Notes: The course notes are available online. They give a concise (to the point) presentation of the course material, usually enough for most students. Some supplementary materials can also be found and downloaded on the course webpage.

Reference books:

1. Hoff, Peter D., 2009, "A First Course in Bayesian Statistical Methods", Springer.
2. Gelman, A., Carlin, J.B., Stern, H.S., Dunson, D.B., Vehtari, A., and Rubin, D.B., 2013, "Bayesian Data Analysis", Chapman & Hall/ CRC Texts in Statistical Science.
3. Turkman, M.A.A, Paulino, C.D., and Müller, P., 2019, "Computational Bayesian Statistics: Introduction", Cambridge University Press.
4. Albert, J., 2009, "Bayesian Computation with R", Springer.

8. Teaching

Weekly schedule: 3 hrs for lecture and 1 hr for tutorial

9. Course Schedule

Chapter 1: Introduction to Bayesian decision theory

1.1. Review of Bayes rule, and Introduction of loss and risk functions.
1.2. An overview of Statistical and Bayesian decision theory
1.3. Choice of Priors, Posteriors, and Bayesian Predictive models.

Chapter 2: Bayesian Inference

2.1 Bayesian Estimation with commonly used loss functions.
2.2 Empirical Bayes
2.3 Bayesian credibility interval and Bayesian Hypothesis Testing.
2.4 Multi-parameter models
2.5 Brief introduction to asymptotics and connections to Frequentist Approaches

Chapter 3: Bayesian Data Analysis with R

3.1 Bayesian Factors
3.2 Bayesian Model Averaging and Model Comparison
3.3 Bayesian network, naïve Bayes classifiers
3.4 Case Study: Pattern Recognition, naïve Bayes spam filtering

Chapter 4: Bayesian Computation with R

4.1. Introduction to Monte Carlo methods
4.2. Markov Chain Monte Carlo Methods:
Metropolis–Hastings algorithm, Gibbs Sampling, OpenBUGS, etc.
4.3. Posterior Computations
4.4 Case Study