SCHOOL OF MATHEMATICS AND STATISTICS

MATH3871/MATH5960
Bayesian Inference and Computation

Term 3, 2022

Units of Credit: 6
Exclusions: MATH3871, MATH5960.
Course Instructor Dr Sahani Pathiraja

MATH3871

Wednesday	2:00-4:00pm	Lectures	online	Weeks 1{5,7{10
Thursday	9:00-11:00am	Tutorial/Lab	RC-1041	Weeks 2{5,7{10
Thursday	11:00am-1:00pm	Tutorial/Lab	RC-1041	Weeks 2{5,7{10
Thursday	2:00-4:00pm	Tutorial/Lab	RC-1041	Weeks 2{5,7{10
Thursday	4:00am-6:00pm	Tutorial/Lab	RC-1041	Weeks 2{5,7{10

MATH5960

Wednesday	2:00-4:00pm	Lectures	online	Weeks 1{5,7{10
Thursday	3:00-5:00pm	Tutorial/Lab	OMB-149	Weeks 2{5,7{10
Monday	2:00pm-4:00pm	Tutorial/Lab	online	Weeks 2{5,7{10

Planned lecture topic schedule:

Week 1	Introduction to Bayesian inference and Monte Carlo
Week 2	Priors and inversion sampling
Week 3	Multivariate models, Monte Carlo integration and rejection sampling
Week 4	Loss functions, asymptotics and importance sampling
Week 5	Markov chain Monte Carlo, Gibbs sampling, assessing convergence
Week 6	! Flex Week - Guest Lecture from Quant Researcher
Week 7	Metropolis-Hastings, conditional independence graphs, Stan
Week 8	Bayesian hypothesis/model testing & Bayes Factors
Week 9	Hierarchical models
Week 10	Mixture models

NB: No tutorials will be held on Thursday 22nd September (Week 2) due to Public Holiday. If you are enrolled in that tute, please attend the (online) tutorial on Monday or view the recording.

Course Overview

Bayesian statistics could be described as the systematic application of probability to decision making in the face of uncertainty. It is a completely probabilistic approach to inference where we set up a full probability model for the data and unknowns in a problem and then condition on the data, making inference about unknowns from the conditional distribution of the unknowns given data (the so-called posterior distribution). Speci cation of a full probability model in a decision making problem involves determination of the likelihood function from classical inference but also speci cation of a prior distribution which expresses probabilistically what we know about the unknowns before observing data.

After describing the fundamentals of Bayesian inference this course will examine speci cation of prior distributions, links between Bayesian and classical frequentist inference, Bayesian model comparison and Bayesian computational methods. Markov chain Monte Carlo (MCMC) methods for computation will be described and implemented. We will illustrate the advantages of the Bayesian approach by describing Bayesian inferential methods for a variety of models including linear models and various kinds of hierarchically structured models.

Course Aims

This course aims to:

1. provide a background in the concepts and philosophy of Bayesian inference;

2. instil an appreciation of the exibility of many standard modelling frameworks;

3. provide opportunities to implement these models in practice (essential for employment prospects);

Student Learning Outcomes

In attending this course students will:

1. extend their statistical knowledge beyond the \classical" statistical methodology, and understand when the Bayesian approach can be bene cial;

2. understand how the various standard models work, and be able to construct new models for the problem at hand;

3. gain rst-hand experience in performing real-world Bayesian data analyses;

Teaching Strategies

Students will be provided electronic copies of lecture notes and used during lecture times and lectures will be recorded. However, students are encouraged to read selected reference books papers in order to gain a solid grasp of the topics taught (see Recommended Reading Material)

Students will be given tutorial problems that are a mixture of theory and coding for practice and to develop understanding of the course material. It is advised that students work through these problems at their own pace, before the tutorial session. This will provide an opportunity for students to ask questions during the tutorial, where discussion will be encouraged. Partial solutions to tutorials will be provided for guidance, usually one week after the relevant tutorial.

Assessment

Assessment	Weight	Due Date
(Online) Final Exam	60%	See examinations timetable.
Assignment 1 (Individual)	15%	Week 4
(Online) Mid-session Test	10%	Week 7
Assignment 2 (Group)	15%	Week 9

Course assessment will consist of 60% nal examination. Two written assignments (15% each) will be set on computational, modelling and theoretical aspects of the course. The rst assignment should be completed individually, whereas the second assignment can be completed in groups (although you may also complete it individually, if you wish). A statement of contribution of all group members should be provided. Assignments will be graded and returned with comments where appropriate in order to provide feedback and encourage student re ection. 5% of marks for written assignments will be given for presentation. Assignments will be released 2 weeks before the due date. There will be a mid-session test (10%) covering all topics from the rst 5 weeks of the course. This will be time-limited.

Late Submission of Assessment Tasks

A late penalty of 5% of the maximum mark for the task will be applied per day or part day any assessment task is submitted more than 1 hour late. (Where "late" in this context means after any extensions granted for Special Consideration or Equitable Learning Provisions.) For example, an assessment task that was awarded 75% would be given 65% if it was 1-2 days late. Any assessment task submitted 7 or more days late will be given zero. Note that the penalty does not apply to

- Assessment tasks worth less than 5% of the total course mark, e.g. weekly quizzes, weekly class participation, or weekly homework tasks.
- Examinations and examination-style class tests
- Pass/Fail Assessments

Applications for Special Consideration for Missed Assessment

Please adhere to the Special Consideration Policy and Procedures provided on the web page below when applying for special consideration. https://student.unsw.edu.au/special-consideration

Please note that the application is not considered by the Course Author-

Recommended Reading Material

Course Evaluation and Development

The School of Mathematics and Statistics evaluates each course each time it is run. We carefully consider the student responses and their implications for course development. It is common practice to discuss informally with students how the course and their mastery of it are progressing. Feedback to the course instructor on any course aspect at any time is strongly encouraged.

School and UNSW policies

The School of Mathematics and Statistics has adopted a number of policies relating to enrolment, attendance, assessment, plagiarism, cheating, special consideration etc. These are in addition to the Policies of The University of New South Wales. Individual courses may also adopt other policies in addition to or replacing some of the School ones. These will be clearly noti ed in the Course Initial Handout and on the Course Home Pages on the Maths Stats web site.

Students in courses run by the School of Mathematics and Statistics should be aware of the School and Course policies by reading the appropriate pages on the Maths Stats web site starting at:https://www.maths.unsw.edu.au/currentstudents/assessment-policies

The School of Mathematics and Statistics will assume that all its students have read and understood the School policies on the above pages and any individual course policies on the Course Handout and Course Home Page. Lack of knowledge about a policy will not be an excuse for failing to follow the procedure in it.

Academic Integrity and Plagiarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW sta and students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. Plagiarism at UNSW is de ned as using the words or ideas of others and passing them o as your own.

The UNSW Student Code provides a framework for the standard of con-