STAT8150

Bayesian Data Analysis

Session 1, In person-scheduled-weekday, North Ryde 2023

School of Mathematical and Physical Sciences

Contents

General Information

Unit convenor and teaching staff
Unit Convenor/Lecturer
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Unit Convenor/Lecturer
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Credit points
10

Prerequisites
((Admission to MAppStat or GradCertAppStat or GradDipAppStat or MDataSc or MActPrac) and (STAT806 or STAT810 or STAT6110 or STAT8310)) or (Admission to BMathScMAppStat and permission by special approval)

Corequisites

Co-badged status

Unit description
This unit introduces the main concepts and methods of Bayesian analysis with a clear comparison with frequentist statistical methods. Both single-parameter and multi-parameter models are derived. In addition, Bayesian computation techniques and Bayesian regression models, which include linear, GLM and hierarchical models, are studied in the unit. Using the latest computational tools, this unit highlights and exploits computational aspects of Bayesian data analysis, including Markov Chain Monte Carlo (MCMC) methods, such as Gibbs sampling and Metropolis sampling.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

ULO1: Explain and communicate to a non-expert audience the fundamentals of the Bayesian approach to Statistics

ULO2: Construct conjugate families of prior distributions for common sampling distributions

ULO3: Formulate and carry out Bayesian inference procedures such as point and interval estimation and hypothesis testing, for common sampling distributions

ULO4: Develop, analytically describe, and implement both single and multiparameter probability models in the Bayesian framework

ULO5: Solve real world problems using Bayesian Methods and state-of-art software tools

ULO6: Design hierarchical models exploiting Markov chain Monte Carlo (MCMC) simulation methods, and apply them to common statistical models including Generalised Linear Models

General Assessment Information

Requirements to Pass this Unit

To pass this unit you must:

- Attempt all assessments, and
- Achieve a total mark equal to or greater than 50%

Late Assessment Submission Penalty

Unless a Special Consideration request has been submitted and approved, a 5% penalty (of the total possible mark of the task) will be applied for each day a written report or presentation assessment is not submitted, up until the 7th day (including weekends). After the 7th day, a grade of '0' will be awarded even if the assessment is submitted. The submission time for all uploaded assessments is **11:55 pm**. A 1-hour grace period will be provided to students who experience a technical concern.

For any late submission of time-sensitive tasks, such as assessments and presentations, please apply for Special Consideration.

Assessments where Late Submissions will be accepted

Report 1 – YES, Standard Late Penalty applies

Report 2 – YES, Standard Late Penalty applies

Report 3 – YES, Standard Late Penalty applies

Media Presentation – YES, Standard Late Penalty applies

Special Consideration

The Special Consideration Policy aims to support students who have been impacted by short-term circumstances or events that are serious, unavoidable and significantly disruptive and which may affect their performance in assessment. If you experience circumstances or events that

affect your ability to complete the assessments in this unit on time, please inform the convenor and submit a Special Consideration request through ask.mq.edu.au.

Assessment Tasks

Name	Weighting	Hurdle	Due
Report 1	25%	No	Week 5
Report 2	25%	No	Week 8
Report 3	30%	No	Week 12
Media presentation	20%	No	Week 13

Report 1

Assessment Type [1]: Quantitative analysis task
Indicative Time on Task [2]: 20 hours
Due: **Week 5**
Weighting: **25%**

Written assignment

On successful completion you will be able to:

- Explain and communicate to a non-expert audience the fundamentals of the Bayesian approach to Statistics
- Construct conjugate families of prior distributions for common sampling distributions
- Formulate and carry out Bayesian inference procedures such as point and interval estimation and hypothesis testing, for common sampling distributions

Report 2

Assessment Type [1]: Quantitative analysis task
Indicative Time on Task [2]: 20 hours
Due: **Week 8**
Weighting: **25%**

Written assignment

On successful completion you will be able to:

- Explain and communicate to a non-expert audience the fundamentals of the Bayesian approach to Statistics
- Construct conjugate families of prior distributions for common sampling distributions
- Formulate and carry out Bayesian inference procedures such as point and interval estimation and hypothesis testing, for common sampling distributions
- Develop, analytically describe, and implement both single and multiparameter probability models in the Bayesian framework
- Solve real world problems using Bayesian Methods and state-of-art software tools

Report 3

Assessment Type [1]: Quantitative analysis task
Indicative Time on Task [2]: 20 hours
Due: **Week 12**
Weighting: **30%**

Written assignment

On successful completion you will be able to:

- Explain and communicate to a non-expert audience the fundamentals of the Bayesian approach to Statistics
- Construct conjugate families of prior distributions for common sampling distributions
- Formulate and carry out Bayesian inference procedures such as point and interval estimation and hypothesis testing, for common sampling distributions
- Develop, analytically describe, and implement both single and multiparameter probability models in the Bayesian framework
- Solve real world problems using Bayesian Methods and state-of-art software tools
- Design hierarchical models exploiting Markov chain Monte Carlo (MCMC) simulation methods, and apply them to common statistical models including Generalised Linear Models

Media presentation

Assessment Type [1]: Media presentation
Indicative Time on Task [2]: 13 hours
Due: **Week 13**
Weighting: **20%**

Students are required to produce a media presentation demonstrating a unit topic of their choice. This demonstration needs to be brief and accessible to other students that have not studied the specific topic but have similar Mathematics/Statistics backgrounds.

On successful completion you will be able to:

- Explain and communicate to a non-expert audience the fundamentals of the Bayesian approach to Statistics
- Construct conjugate families of prior distributions for common sampling distributions
- Formulate and carry out Bayesian inference procedures such as point and interval estimation and hypothesis testing, for common sampling distributions
- Develop, analytically describe, and implement both single and multiparameter probability models in the Bayesian framework
- Solve real world problems using Bayesian Methods and state-of-art software tools
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[1] If you need help with your assignment, please contact:

- the academic teaching staff in your unit for guidance in understanding or completing this type of assessment
- the Writing Centre for academic skills support.

[2] Indicative time-on-task is an estimate of the time required for completion of the assessment task and is subject to individual variation

Delivery and Resources

Classes

Lectures (beginning in Week 1): A two-hour lecture each week.

SGTA classes (beginning in Week 2): Students must register for the SGTA class.

The timetable for classes can be found on the University website at: http://www.timetables.mq.edu.au

Enrolment can be managed using eStudent at: https://students.mq.edu.au/support/technology/systems/estudent.

Computing and Software

R and Rstudio: These are freely available to download from the web and will be used for data analysis in this unit.

Suggested Textbook

- Peter Hoff. *A First Course in Bayesian Statistical Methods.* Springer Texts in Statistics, Springer, 2009.
- Reich, Brian J. and Ghosh Sujit K. *Bayesian Statistical Methods.* Chapman and Hall/ CRC, 2019.
- Lambert B. *A Student's Guide to Bayesian Statistics.* SAGE Publications Ltd, 2018.
- Kruschke JK. *Doing Bayesian Data Analysis: A Tutorial with R, JAGS and Stan.* Academic Press/Elsevier, 2015.
- McElreath R. *Statistical Rethinking: A Bayesian Course with Examples in R and Stan.* CRC Press/Taylor and Francis/Chapman and Hall, 2016.
- Gelman A, Carlin JB, Stern HS, Dunson DB, Vehtari A, Rubin DB. *Bayesian Data Analysis (3rd Edition)*. CRC Press/Taylor and Francis/Chapman and Hall, 2014.

Method of Communication

We will communicate with you via your university email or through announcements on iLearn. Queries to convenors can be placed on the iLearn discussion forum.

COVID Information

For the latest information on the University's response to COVID-19, please refer to the Coronavirus infection page on the Macquarie website: https://www.mq.edu.au/about/coronavirus-faqs. Remember to check this page regularly in case the information and requirements change during the semester. If there are any changes to this unit in relation to COVID, these will be communicated via iLearn.

Unit Schedule

Week 1: Introduction to Bayesian Analysis.

Week 2: Prior Specification. How to set a prior distribution in Bayesian statistics? Conjugate priors, improper priors and Jeffrey's priors.

Week 3: One Parameter Model. Binomial model and Poisson model, obtain posterior distribution and make the inference.

Week 4: Introduction to Monte Carlo Method.

Week 5: Multi-parameter Models. Normal model and make inferences for mean, variance, and posterior predictive checks.

Week 6: Hierarchical Modelling.

Week 7: Markov Chain Monte Carlo Part One. Gibbs sampling, convergence diagnostics

Week 8: Markov Chain Monte Carlo Part Two. Metropolis sampling, tuning parameters in Metropolis samplers.

Week 9: Bayesian Linear Regression.

Week 10: Bayesian Generalized Linear Models.

Week 11: Model Comparison. Hypothesis testing and Bayes factors cross-validation and information criteria.

Week 12: Frequentist Properties of Bayesian Methods.

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://policies.mq.edu.au). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- Academic Appeals Policy
- Academic Integrity Policy
- Academic Progression Policy
- Assessment Policy
- Fitness to Practice Procedure
- Assessment Procedure
- Complaints Resolution Procedure for Students and Members of the Public
- Special Consideration Policy

Students seeking more policy resources can visit Student Policies (https://students.mq.edu.au/support/study/policies). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

To find other policies relating to Teaching and Learning, visit Policy Central (https://policies.mq.edu.au) and use the search tool.

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/admin/other-resources/student-conduct

Results

Results published on platform other than eStudent, (eg. iLearn, Coursera etc.) or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in eStudent. For more information visit ask.mq.edu.au or if you are a Global MBA student contact globalmba.support@mq.edu.au

Academic Integrity

At Macquarie, we believe academic integrity – honesty, respect, trust, responsibility, fairness and

courage – is at the core of learning, teaching and research. We recognise that meeting the expectations required to complete your assessments can be challenging. So, we offer you a range of resources and services to help you reach your potential, including free online writing and maths support, academic skills development and wellbeing consultations.

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

The Writing Centre

The Writing Centre provides resources to develop your English language proficiency, academic writing, and communication skills.

- Workshops
- Chat with a WriteWISE peer writing leader
- Access StudyWISE
- Upload an assignment to Studiosity
- Complete the Academic Integrity Module

The Library provides online and face to face support to help you find and use relevant information resources.

- Subject and Research Guides
- Ask a Librarian

Student Services and Support

Macquarie University offers a range of Student Support Services including:

- IT Support
- Accessibility and disability support with study
- Mental health support
- Safety support to respond to bullying, harassment, sexual harassment and sexual assault
- Social support including information about finances, tenancy and legal issues
- Student Advocacy provides independent advice on MQ policies, procedures, and processes

Student Enquiries

Got a question? Ask us via AskMQ, or contact Service Connect.

IT Help

For help with University computer systems and technology, visit http://www.mq.edu.au/about_us/

offices_and_units/information_technology/help/.

When using the University's IT, you must adhere to the Acceptable Use of IT Resources Policy. The policy applies to all who connect to the MQ network including students.