STAT7016

Introduction to Bayesian Data Analysis

The Bayesian approach to statistics assigns probability distributions to both the data and unknown parameters in the problem. This way, we can incorporate prior knowledge on the unknown parameters before observing any data. Statistical inference is summarised by the posterior distribution of the parameters after data collection, and posterior predictions for new observations. The Bayesian approach to statistics is very flexible because we can describe the probability distribution of any function of the unknown parameters in the model. Modern advances in computing have allowed many complicated models, which are difficult to analyse using 'classical' (frequentist) methods, to be readily analysed using Bayesian methodology.

The aim of this course is to equip students with the skills to perform and interpret Bayesian statistical analyses. The first part of the course is devoted to describing the fundamentals of Bayesian inference by examining some simple Bayesian models. More complicated models will then be explored, including linear regression and hierarchical models in a Bayesian framework. Bayesian computational methods, especially Markov Chain Monte Carlo methods will progressively be introduced as motivated by the models discussed. Emphasis will also be placed on model checking and evaluation.

Mode of Delivery	On Campus
Prerequisites	Successful completion of STAT2001 and STAT2008
Incompatible Courses	NA
Co-taught Courses	STAT4116/STAT3016 (graduate students attend joint classes with undergraduates but are assessed separately with additional assignment questions)
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Office hours for student consultation:	TBA
Tutor(s)	Mr Le Chang

SEMESTER 2
2017

COURSE OVERVIEW

Learning Outcomes

Upon successful completion of the requirements for this course, students should have the knowledge and skills to:

1. Explain in detail the Bayesian framework for data analysis and its flexibility and be able to demonstrate when the Bayesian approach can be beneficial.
2. Develop, analytically describe, and implement both single and multiparameter probability models in the Bayesian framework.
3. Demonstrate the role of the prior distribution in Bayesian inference and be able to articulate the usage of non-informative priors and conjugate priors.
4. Show high level Interpretation of Bayesian Analysis Results and be able to readily perform Bayesian model evaluation and assessment.
5. Demonstrate the necessary skills to: fit hierarchical models, provide thorough technical specifications for these models.
6. Perform Bayesian computation using Markov chain Monte Carlo methods using R
7. Demonstrate how Bayesian Methods can be used to solve real world problems.
8. Communicate complex statistical ideas to a diverse audience.
9. Demonstrate the necessary research skills to form a hypothesis, collect and analyse data, and reach appropriate conclusions

Assessment Summary

Assessment Task	Value	Due Date	Date for Return of Assessment
1. **Assignment 1**	**12.5%**	Thursday 17 August 3pm	Thursday 24 August
2. **Assignment 2**	**12.5%**	Thursday 31 August 3pm	Thursday 21 September
3. **Assignment 3**	**12.5%**	Thursday 28 September 3pm	Thursday 5 October
4. **Assignment 4**	**12.5%**	Thursday 12 October 3pm	Thursday 19 October
5. **Final Project**	**50%**	Friday 27 October 3pm	Exam period

Research-Led Teaching

Throughout the course, relevant journal articles may be discussed as supplementary material. The final project will involve the application of methodology learned in the course to a real data set. Students will be required to formulate their own research questions, select and implement the appropriate statistical model(s), and write a report to communicate their findings.

Feedback

Staff Feedback
Students will be given feedback in the following forms in this course:

- written comments
- verbal comments
- feedback to the whole class.

Student Feedback
ANU is committed to the demonstration of educational excellence and regularly seeks feedback from students. One of the key formal ways students have to provide feedback is through Student Experience of Learning Support (SELS) surveys. The feedback given in these surveys is anonymous and provides the Colleges, University Education Committee and Academic Board with opportunities to recognise excellent teaching, and opportunities for improvement.

For more information on student surveys at ANU and reports on the feedback provided on ANU courses, go to
http : //unistats.anu.edu.au/surveys/selt/students/ and
http : //unistats.anu.edu.au/surveys/selt/results/learning/

Policies

ANU has educational policies, procedures and guidelines, which are designed to ensure that staff and students are aware of the Universitys academic standards, and implement them. You can find the Universitys education policies and an explanatory glossary at: http : //policies.anu.edu.au/

Students are expected to have read the Academic Misconduct Rule before the commencement of their course.

Other key policies include:

- Student Assessment (Coursework)
- Student Surveys and Evaluations

Required Resources

Textbook:
"A First Course in Bayesian Statistical Methods", Hoff, P. (2009). Springer: New York. (available on eReserve at the library)

Technology, Software, Equipment:
You will be expected to perform data analyses using statistical software as part of your course work. The official computer package for this course is R, which runs on Windows, MacOS and UNIX platforms. The software is free and available online through www.rproject.org. It is assumed students have a working knowledge of R from the pre-requisite course STAT2008. The use of other statistical programs is permitted but support will be provided solely for R.

Examination material or equipment

There are no examinations for this course

Recommended Resources

”Bayesian Data Analysis”. Gelman, A., Carlin, JB., Stern, HS., Dunson, DB., Vehtari, A., and Rubin, DB. (third edition) (2014). CRC Press: Florida. (available on short term loan reserve at Hancock library)

“Bayesian methods for data analysis”, Carlin, BP. and Louis, TB. (third edition) (2009). CRC Press: Florida. (available on short term loan reserve at Hancock library)

“Introduction to Bayesian statistics”, Bolstad, WM. (2004). Wiley: New Jersey. (available online at ANU library)

“Applied Bayesian Modelling”, Congdon, P (2014). (second edition). Wiley: New Jersey. (available online at ANU library)

“Bayesian ideas and data analysis : an introduction for scientists and statisticians”, Christensen, R. et al. (2011). CRC Press: Floriday (available on short term loan reserve at Hancock library)

COURSE SCHEDULE

Week/ Session	Summary of Activities	Assessment
1	Introduction to Bayesian inference; Review of probability (Hoff Chapters 1 and 2)	
2	Bayesian inference for one parameter models (Hoff Chapter 3)	
3	Bayesian inference for one parameter models (Hoff Chapter 3)	
4	Monte Carlo approximation and model checking (Hoff Chapter 4)	Assignment 1 Due
5	Bayesian inference for the normal model (Hoff Chapter 5)	
6	Gibbs sampling and MCMC convergence diagnostics (Hoff Chapter 6)	Assignment 2 Due
7	Multivariate Normal Distribution (Hoff Chapter 7)	
8	Hierarchical Models (Hoff Chapter 8)	Assignment 3 Due
9	Linear Regression (Hoff Chapter 9)	
10	Metropolis-Hastings Algorithm (Hoff Chapter 10)	Assignment 4 Due
11	Mixed effects models (Hoff Chapter 11)	
12	Further topics in Bayesian Computation and Analysis (TBA; topics may include missing data, latent variable methods for ordinal data, computationally efficient MCMC) (Hoff Chapter 7,12)	Final Project Due

ASSESSMENT REQUIREMENTS

Assignment submission

Hard Copy Submission: Assignment reports should be submitted to the appropriate box at the RSFAS School Office by the due date. Submitted assignments must include the cover sheet provided on Wattle. Please keep a copy of the assignment for your records.

All assessment is mandatory and individual-based

Collaboration policy: University policies on plagiarism will be strictly enforced. You are encouraged to (orally) discuss your assignments with your classmates, but each student must write up solutions separately. Be sure that you have worked through each problem yourself and that the answers you submit are the results of your own efforts. This includes all computer code and output.

For assignments involving mathematical manipulations, students can write answers by hand pro-

vided penmanship is neat; illegible answers will be marked as incorrect. For assignments requiring graphical displays, students must include the graphs in a word processor, e.g., LaTex or Word, with typed explanations about the graphs; graphs without explanations will be marked as incorrect. For assignments requiring text responses, students are strongly encouraged, but not required, to use a word processor.

As a further academic integrity control, students may be selected for a 15 minute individual oral examination of their written assessment submissions.

Any student identified, either during the current semester or in retrospect, as having used ghost writing services will be investigated under the Universitys Academic Misconduct Rule.

Assessment Tasks

Assignments 1-4
Details of task: These assignments will require students to implement the Bayesian methods discussed in class using a statistical software package. The problems are designed to develop computational and data analyses skills. Algebraic derivations, exploration of theoretical topics and explanation of theoretical results and concepts may also be required.

Final Project
Details of task: The final project will involve application of material learned in the course to a real data set. Students may analyse a data set of their own choice (subject to lecturer approval) or choose one of the data sets provided by the lecturer to analyse. Students will be required to formulate their own research question and demonstrate application of statistical methodology learned in STAT7016. Findings are to be communicated in a written report. Further instructions and grading guidelines will be provided later.

Extensions and penalties

Extensions and late submission of assessment pieces are covered by the Student Assessment (Coursework) Policy and Procedure.

The Course Convener may grant extensions for assessment pieces that are not examinations or take-home examinations. If you need an extension, you must request it in writing on or before the due date. If you have documented and appropriate medical evidence that demonstrates you were not able to request an extension on or before the due date, you may be able to request it after the due date

No submission of assessment tasks without an extension after the due date will be permitted. If an assessment task is not submitted by the due date, a mark of 0 will be awarded.

Returning assignments

Student assignments will be returned in lectures or may be collected from the lecturer's office.

Resubmission of assignments

Resubmission of assignments is not allowed after the due date.

Scaling

Your final mark for the course will be based on the **raw** marks allocated for each of your assessment items. However, your final mark may not be the same number as produced by that formula, as marks may be **scaled**. Any scaling applied will preserve the rank order of raw marks (i.e. if your raw mark exceeds that of another student, then your scaled mark will exceed the scaled mark of that student), and may be either up or down.

Privacy Notice

The ANU has made a number of third party, online, databases available for students to use. Use of each online database is conditional on student end users first agreeing to the database licensors terms of service and/or privacy policy. Students should read these carefully.

In some cases student end users will be required to register an account with the database licensor and submit personal information, including their: first name; last name; ANU email address; and other information.

In cases where student end users are asked to submit content to a database, such as an assignment or short answers, the database licensor may only use the students content in accordance with the terms of service including any (copyright) licence the student grants to the database licensor.

Any personal information or content a student submits may be stored by the licensor, potentially offshore, and will be used to process the database service in accordance with the licensors terms of service and/or privacy policy.

If any student chooses not to agree to the database licensors terms of service or privacy policy, the student will not be able to access and use the database. In these circumstances students should contact their lecturer to enquire about alternative arrangements that are available.

Tutorial Seminar Registration

Tutorial signup for this course will be done via the Wattle website. Detailed information about signup times will be provided on Wattle or during your first lecture. When tutorials are available for enrolment, follow these steps:

1. Log on to Wattle, and go to the course site
2. Click on the link 'Tutorial enrolment'
3. On the right of the screen, click on the tab 'Become Member of . . . .' for the tutorial class you wish to enter
4. Confirm your choice

If you need to change your enrolment, you will be able to do so by clicking on the tab 'Leave group. . . .' and then re-enrol in another group. You will not be able to enrol in groups that have reached their maximum number. Please note that enrolment in ISIS must be finalised for you to have access to Wattle.

SUPPORT FOR STUDENTS

The University offers a number of support services for students. Information on these is available online from http : //students.anu.edu.au/studentlife/