Introduction to Bayesian Statistics in Life Sciences- FNR 6560

1 Overview

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Credits: 3

Bayesian statistics have been extensively adopted and used in multiple scientific fields due to the flexibility of the models that can be created in this framework. In particular, the Bayesian framework has enabled modelers to create customized models to tackle large and complex statistical problems that often times cannot be dealt with in a frequentist setting. Finally, Bayesians model results have a much more straight-forward interpretation than their frequentist counterparts.

The aim of the course is to introduce life scientists to Bayesian statistics. We will explore basic ideas regarding integration through simulation (Monte Carlo integration), the philosophy and strengths of Bayesian statistics, and the Markov Chain Monte Carlo (MCMC) algorithms needed to fit such models. We will focus on several real-world examples and how to transform these problems into statistical models. This course will rely on substantial extra-class work, in order to provide students with extensive hands on experience on conceptualizing, implementing, and interpreting the results of these models. Ideally, this experience will be enough to enable students to develop their own Bayesian models after this course is over. We will try to cover simple, mixed effect and multi-level regression models but this will fundamentally depend on the speed with which the class is able to follow the course. Implementation of these models will be done both with JAGS as well as customized R code.

Format: blended. This is a face-to-face and online ***synchronous*** course. What this means is that, while classes will be recorded and available online, this course requires that all students be present (physically or remotely) during each class.

Textbook(s) and/or readings: There is no required text for the course. Readings will be provided for each learning topic as listed in section 5, Readings.

Required software:

- R, freely available at http://www.r-project.org
- JAGS, freely available at http://mcmc-jags.sourceforge.net/
- A text editor, such as RStudio (http://www.rstudio.com/)

Course Prerequisites:

- Conceptual understanding of integrals

- The student should be comfortable programming in R (e.g., be comfortable creating and manipulating vectors and matrices, creating loops and your own functions, creating queries using Boolean logic, etc.)
- STA6166, STA6093, or a similar introductory statistics course are highly recommended.
- One mathematical statistics course is highly recommended. For example:
- "ZOO6927 Statistical Principles for the Biological Sciences" by Jose Ponciano
- "STA 5325 Fundamentals of Probability"
- "Foundations of Probability & Math Statistics: a scientific computing approach" by Nikolay Bliznyuk).

2 Learning Outcomes

At the end of this course, each student will be able to:

- Solve real problems: think through a problem and how to translate that into a biologically sensible statistical model (instead of pre-built standard models).
- Interpret MCMC output.
- Implement Bayesian models in JAGS.
- Read and modify R code that implements a Gibbs sampler from scratch.

3 Course Logistics

My philosophy is that you learn best by doing, thus this course is heavily based on extra-class work and reading.

Technology Requirements in addition to software:

- A computer or mobile device with high-speed internet connection.
- A headset and/or microphone and speakers; a web cam is suggested.
- Latest version of web browser. Canvas supports only the two most recent versions of any given browser. What browser am I using?

3.1 Assignments & Deliverables

Participation

I expect students to read the lecture notes before-hand and actively participate during class. Furthermore, students are required to send one question per week reflecting "the muddiest point" of the upcoming week to the TA and myself by Saturday night. I will address the most common questions on Monday.

Weekly Assignments

These assignments are due on Saturdays and should be handed-in as word documents, basically showing how you solved the different problems (include your commented code) and the final results, together with their interpretation. I think it is important to emphasize that modeling is best learnt individually. You can certainly discuss with your colleagues if you get stuck but you should try as much as possible to solve these individual assignments by yourself. All individual assignments are graded from 0 to 1 and the

overall grade for these assignments is the arithmetic average of all grades. I will provide my answers/code to solve the assignments with the goal of helping students identify and correct the mistakes they have made.

Quizzes & Exams

We will occasionally have surprise 5-min quizzes in the beginning of the class, focused on the posted reading material.

3.2 Grades & Grading Scale

60% Weekly Assignments

30% Quizzes

10% Participation

For information on current UF policies for assigning grade points, see https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Grading Scale (%)	
A	90-100
A-	86.7-89.9
B+	83.3-86.6
B	80-83.2
B-	76.7-79.9
C+	73.3-76.6
C	70-73.2
C-	66.7-69.9
D+	63.3-66.6
D	60-63.2
D-	56.7-59.9

4 Course Content

Week	Topic
1	Intro. frequentist and Bayesian statistics Review: Joint, conditional and marginal probabilities; law of total probability; Bayes theorem
2	Review: Likelihood, priors, posterior, pmf/pdf and their characteristics (e.g., moments)
3	Conjugate likelihood-prior pairs: simple examples
4	Monte Carlo integration
5	Introduction to conceptual (generative) models / generating fake data Inverse modeling
6	Gibbs sampling and full conditionals
7	Estimating population size from mark-recapture data
8	Metropolis-Hastings algorithm and Poisson regression
9	Predictive distribution and sources of uncertainty
10	Linear and robust regression
11	Models with latent variables
12	Mixed models
13	Latent Dirichlet Allocation model
14	Model selection

5 Reading List

Textbooks (Not required): sections of these books will be used and will be made available when needed to registered students.

- P. D. Hoff. 2009. A first course in Bayesian statistical methods. Series: Springer Texts in Statistics. Chapters 1 (Introduction and Examples) and 9 (Linear regression).

- Michael A. McCarthy. 2007. Bayesian methods for ecology. Cambridge University Press. Chapters 1 (Introduction), 2 (Critiques of statistical methods), and 5 (Regression and correlation).
- Andrew Gelman and Jennifer Hill. 2007. Data analysis using regression and multilevel/hierarchical models. Cambridge University Press. Chapters 8 (Simulation for checking statistical procedures and model fits) and 12 (Multilevel linear models: the basics)
- Allen B. Downey. 2012. Think Bayes: Bayesian statistics made simple. Green Tea Press (available at http://www.greenteapress.com/thinkbayes/). Chapter 1 (Bayes' theorem)
- Benjamin Bolker. 2008. Ecological models and data in R. Princeton University Press. Chapter 4 (Probability and stochastic distributions for ecological modeling)
- Robert Winkler. 2003. An Introduction to Bayesian inference and decision. Probabilistic publishing. Chapter 2 (Probability: measuring uncertainty)

6 Policies and Requirements

This syllabus represents current plans and objectives for this course. As the semester progresses, changes may need to be made to accommodate timing, logistics, or to enhance learning. Such changes, communicated clearly, are not unusual and should be expected.

6.1 Late Submissions & Make-up Requests

Computer or other hardware failures, except failure of the UF e-Learning system, will not excuse students for missing assignments. Any late submissions due to technical issues MUST be accompanied by the ticket number received from the Helpdesk when the problem was reported to them. The ticket number will document the time and date of the problem. You MUST e-mail your instructor within 24 hours of the technical difficulty if you wish to request consideration.

For computer, software compatibility, or access problems call the HELP DESK phone number—352-392-HELP = 352- 392-4357 (option 2).

Requirements for class attendance and make-up exams, assignments and other work are consistent with university policies that can be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx

6.2 Semester Evaluation Process

Student assessment of instruction is an important part of efforts to improve teaching and learning.

At approximately the mid-point of the semester, the School of Forest Resources & Conservation will request anonymous feedback on student satisfaction on various aspects of this course. These surveys will be sent out through Canvas and are not required, but encouraged. This is not the UF Faculty Evaluation!

At the end of the semester, students are expected to provide UF with feedback on the quality of instruction in this course using a standard set of university and college criteria (UF Faculty Evaluations). These evaluations are conducted online at https://evaluations.ufl.edu. Evaluations are typically open for students to complete during the last two or three weeks of the semester; students will be notified of the

specific times when they are open. Summary results of these assessments are available to students at https://evaluations.ufl.edu/results.

6.3 Netiquette: Communication Courtesy

All members of the class are expected to follow rules of common courtesy in all email messages, threaded discussions and chats. Failure to do so may result in loss of participation points and/or referral to the Dean of Students' Office. http://teach.ufl.edu/docs/NetiquetteGuideforOnlineCourses.pdf

6.4 Academic Honesty Policy

As a student at the University of Florida, you have committed yourself to uphold the Honor Code, which includes the following pledge: *"We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity."*

You are expected to exhibit behavior consistent with this commitment to the UF academic community, and on all work submitted for credit at the University of Florida, the following pledge is either required or implied*: "On my honor, I have neither given nor received unauthorized aid in doing this assignment."*

It is assumed that you will complete all work independently in each course unless them instructor provides explicit permission for you to collaborate on course tasks (e.g. assignments, papers, quizzes, exams). Furthermore, as part of your obligation to uphold the Honor Code, you should report any condition that facilitates academic misconduct or appropriate personnel. It is your individual responsibility to know and comply with all university policies and procedures regarding academic integrity and the Student Honor Code. Violations of the Honor Code at the University of Florida will not be tolerated.

Violations will be reported to the Dean of Students Office for consideration of disciplinary action. For more information regarding the Student Honor Code, please see: http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code.

6.5 University Policy on Accommodating Students with Disabilities:

Students requesting accommodation for disabilities must first register with the Dean of Students Office (http://www.dso.ufl.edu/drc/). The Dean of Students Office will provide documentation to the student who must then provide this documentation to the instructor when requesting accommodation. You must submit this documentation prior to submitting assignments or taking the quizzes or exams. Accommodations are not retroactive, therefore, students should contact the office as soon as possible in the term for which they are seeking accommodations.

6.6 Software Use

All faculty, staff and students of the university are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against university policies and rules, disciplinary action will be taken as appropriate.

7 Getting Help

For issues with technical difficulties for e-learning in Canvas, please post your question to the Technical Help Discussion in your course, or contact the UF Help Desk at:

- Learning-support@ufl.edu | (352) 392-HELP - select option 2 | http://elearning.ufl.edu
- Library Help Desk support http://cms.uflib.ufl.edu/ask
- SFRC Academic Hub https://ufl.instructure.com/courses/303721

7.1 Student Life, Wellness, and Counseling Help

- Counseling and Wellness resources http://www.counseling.ufl.edu/cwc/
- U Matter, We Care http://www.umatter.ufl.edu/
- Career Resource Center http://www.crc.ufl.edu/
- Other resources are available at http://www.distance.ufl.edu/getting-help for online students.

7.2 Student Complaint Process

The School of Forest Resources & Conservation cares about your experience and we will make every effort to address course concerns. We request that all of our online students complete a course satisfaction survey each semester, which is a time for you to voice your thoughts on how your course is being delivered.

If you have a more urgent concern, your first point of contact should be the SFRC Academic Coordinator or the Graduate/Undergraduate Coordinator for the program offering the course. You may also submit a complaint directly to UF administration:

- Students in online courses: http://www.distance.ufl.edu/student-complaint-process
- Students in face-to-face courses: https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf