Introduction to Bayesian Statistics - STAT 446/646

Spring 2020—PE 104—Mon,Wed 2:30pm - 3:45pm

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Office: DMSC 224 **Hours**: TBD and by appointment

This course introduces Bayesian statistics to a technical audience. Early on, we focus on the logic behind Bayesian statistics, including the mathematical formalization of updating beliefs under uncertainty. Then we describe Bayesian methods for well-known probability models and compare these methods to classical (frequentist) alternatives. Topics include Bayes' Theorem, prior specification, Bayesian inference for discrete and continuous univariate random variables, and linear regression. We'll implement methods analytically and using software such as Minitab, R, and Stan.

The latter portions of the course focus on implementing more advanced Bayesian methods through modern computational techniques to sample posterior distributions including Markov Chain Monte Carlo (MCMC) and Hamiltonian Monte Carlo (HMC). The aim will be to provide the concepts and technical skills to conduct a realistic Bayesian data analysis.

Catalog Description

Statistical inference using Bayes' Theorem. Topics include posterior analysis for continuous and discrete random variables, prior specification, Bayesian regression, multivariate inference, and posterior sampling through Markov Chain Monte Carlo.

Course Pre-requisites

STAT 352 or STAT 467/667 or with instructor approval. STAT 445/645 is a suggested preparation.

400-level Student Learning Outcomes

UG1 Students will be able to demonstrate understanding of the concepts that underlie Bayesian inference and compare the results to frequentist alternatives.

UG2 Students will be able to conduct Bayesian inference analytically and interpret the results.

UG3 Students will be able to perform a Bayesian analysis using professional statistical packages (e.g., Minitab, R, and Stan).

600-level Student Learning Outcomes

In addition to the above 400-level outcomes, graduate students will:

GRAD1 Students will be able to synthesize course concepts to apply Bayesian modeling techniques to real-world data in the pursuit of scientific inquiry.

Required text

Introduction to Bayesian Statistics, 3rd edition, by William M. Bolstad and James M. Curran
Textbook website:
https://www.wiley.com/en-us/Introduction+to+Bayesian+Statistics%2C+3rd+Edition-p-9781118091562

Supplemental texts

For more theory:
Bayesian Data Analysis, 3rd edition, by Andrew Gelman et al
Textbook website: http://www.stat.columbia.edu/~gelman/book/

For more applied:
Data Analysis Using Regression and Multilevel/Hierarchical Models, by Andrew Gelman and Jennifer Hill
Textbook website: http://www.stat.columbia.edu/~gelman/arm/
Statistical Rethinking, by Richard McElreath
Textbook website: https://xcelab.net/rm/statistical-rethinking/
Doing Bayesian Data Analysis, by John K. Krushchke
Textbook website: https://sites.google.com/site/doingbayesiandataanalysis/

Assignments

Exercises will be assigned approximately weekly. You are encouraged to discuss assignments between each other and with instructor. However, the assignment must be completed and submitted individually.

Midterms

There will be three midterms, the first on Wednesday, February 5, the second on Wednesday, March 11, and the third on Wednesday, April 8.

Final exam

Due to the computational complexity involved in latter topics, the final exam will be take home.

Exam policy

You will be allowed at one 8.5x11in page of handwritten (on both sides) notes for the first midterm. And one additional page of notes for each following midterm (three total pages). If you believe that your grade for exam or assignment is incorrect, contact instructor at the office hours with a rational justification. All such requests must be submitted to instructor within one week after a grade is announced; late requests will not be granted. Please understand that everyone can make a mistake, and that mistakes can go both ways: higher or lower than original grade.

400/600 Students

As indicated above, the student learning outcomes differ at the 400 and 600 levels. 600-level students must complete a **term project** in addition to all 400-level requirements.

Makeup, Late Policy

Late assignments, exams, and projects will be graded with a 5 point (out of 20) penalty per day. Exceptions will be made when a student misses work due to a documented (doctor's note) illness or an extraordinary situation (up to the discretion of the instructor). There will be no early or make-up exams. However, if you need to miss an exam due to participation in a religious holiday or an official university activities (including athletics and other sanctioned activities), you must make arrangements with the instructor at least two weeks prior to the exam in question. **I'll drop your lowest grade in the "Assignments" category to give a more realistic description of your performance, if you aren't able to finish all assignment on time.**

Grading

We'll use a point system to evaluate student learning. There are four categories of assignments. Table 1 shows the total points possible within each category before dropping any low scores.

Item	400-level	600-level
Assignments	300	300
Midterm Exams	150	150
Final Exam	150	150
Term project	–	150

Table 1: Total points available within each assignment category (ignoring any extra credit).

The sum of all points earned determine the final letter grades, according to the thresholds listed in Table 2.

Letter grade	400-level	600-level
A ($\geq 92\%$)	534 or above	672 or above
A- ($\geq 90\%$)	522 to 533	657 to 671
B+ ($\geq 88\%$)	511 to 521	643 to 656
B ($\geq 82\%$)	476 to 510	599 to 642
B- ($\geq 80\%$)	464 to 475	584 to 598
C+ ($\geq 78\%$)	453 to 463	570 to 583
C ($\geq 72\%$)	418 to 452	526 to 569
C- ($\geq 70\%$)	407 to 417	511 to 525
D+ ($\geq 68\%$)	395 to 406	497 to 510
D ($\geq 62\%$)	360 to 394	453 to 496
D- ($\geq 60\%$)	348 to 359	439 to 452
F ($< 60\%$)	347 or below	438 or below

Table 2: Conversion table between points and letter grades, after dropping the lowest "Assignments" grade (20 points dropped).

The instructor reserves the right to deviate from the above thresholds, including assigning $+$ or $-$.

Diversity Statement

The University of Nevada, Reno is committed to providing a safe learning and work environment for all. If you believe you have experienced discrimination, sexual harassment, sexual assault, domestic/dating violence, or stalking, whether on or off campus, or need information related to immigration concerns, please contact the

Universitys Equal Opportunity & Title IX Office at (775) 784-1547. Resources and interim measures are available to assist you. For more information, please visit http:www.unr.edu/equal-opportunity-title-ix.

Disability Statement

Any student with a disability needing academic adjustments or accommodations is requested to speak with the Disability Resource Center as soon as possible to arrange for appropriate accommodations.

Academic Conduct

No laptops, cell phones, mp3 players, or other electronics are to be used for personal reasons in class. If you are being disruptive during class you will be asked to leave. Disruptions in this context include inadequate participation. You must come to class on time and stay until the end of lecture. Tardy students will not be admitted to class. Please visit http:www.unr.edu/student-conduct for our official student code of conduct.

Academic Success Services

Your student fees cover usage of the University Math Center, University Tutoring Center, and University Writing Center. These centers support your classroom learning; it is your responsibility to take advantage of their services. Keep in mind that seeking help outside of class is the sign of a responsible and successful student

University Recording Policy

Surreptitious or covert videotaping of class or unauthorized audio recording of class is prohibited by law and by Board of Regents policy. This class may be videotaped or audio recorded only with the written permission of the instructor. In order to accommodate students with disabilities, some students may have been given permission to record class lectures and discussions. Therefore, students should understand that their comments during class may be recorded.

Academic Dishonesty

Cheating, plagiarism, or otherwise obtaining grades under false pretenses constitutes academic dishonesty according to the code of this university. Academic dishonesty will not be tolerated and penalties can include canceling a students enrollment without a grade or giving an F for the assignment or for the entire course. See the University Academic Standards policy: UAM 6,502.

Tentative course schedule

Week	Monday	Wednesday	Notes
1	MLK Day	Why Bayes?/Syllabus/expectations	Ch.1-3
2	Probability/Bayes' Rule	Discrete random variables (RVs)	Ch.4-6
3	Discrete RVs	**Midterm 1**	Ch.1-6
4	Continuous RVs	Continuous RVs	Ch.7-10
5	President's Day	Continuous RVs	Ch.7-10
6	Continuous RVs	Continuous RVs	Ch.7-10
7	Continuous RVs	Continuous RVs	Ch.11-13
8	Continuous RVs	**Midterm 2**	Ch.1-13
9	–	–	Spring break
10	Bayesian model development/Regression	Regression	Ch.14
11	Computing/MCMC	Computing/MCMC	Ch.20
12	Computing/MCMC	**Midterm 3**	Ch.20
13	HMC	Applied Bayesian modeling	Course notes
14	Applied Bayesian modeling	con'd	Course notes
15	Applied Bayesian modeling	con'd	Course notes
16	Student talks/posters	Prep Day	Course notes
17	**Take-home final exam**		