

Introduction to Bayesian Statistics (STA 360)

Professor Rebecca Steorts

Welcome!

What is Bayesian Statistics?

"Bayesian statistics is a theory in the field of statistics based on the Bayesian interpretation of probability where probability expresses a degree of belief in an event. The degree of belief may be based on prior knowledge about the event, such as the results of previous experiments, or on personal beliefs about the event. This differs from a number of other interpretations of probability, such as the frequentist interpretation that views probability as the limit of the relative frequency of an event after many trials. ."

[-Wikipedia](#)

Instructor

[Prof. Rebecca Steorts](#)

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📁 988 1669 9435

📅 Class: Tues/Th, 1:45 - 3:00 PM EST

📅 OH: Tues/Th, 3:00 - 4:00 PM EST

Teaching Assistants

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- 👛 949 7135 3069 (OH ID)
- 📅 Lab-01: Fri, 12:00 - 1:15 PM EST
- 📅 OH: Wed, 9:00 - 10:00 AM EST

Teaching Assistants

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- 📅 OH: Mon, 9:00 - 10:00 AM EST

Teaching Assistants

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Where to find information

- Course website (all major course information here):
<https://resteorts.github.io/teach/bayes20.html>
- Google group (course forum):
<https://groups.google.com/forum/#!forum/bayes20>
- Sakai (upload homeworks):
<https://shib.oit.duke.edu/idp/authn/external?conversation=e1s1>
- Duke Gradescope (upload homeworks):
<https://gradescope.com/auth/saml/duke>
- Course syllabus <https://github.com/resteorts/modern-bayes/blob/master/syllabus/syllabus-sta360-fall20.pdf>

Remark: Videos on Github are too large to view, so you will need to download these if you wish to watch them. The fastest way, is to clone the repository and they will all download. They are stored this way in case your internet connection is slow.

Other resources

- Review of probability material: <https://github.com/resteorts/modern-bayes/blob/master/reading/statistical-inference.pdf>
- Simon Mak's Quick Guide to Prob. Distributions
<https://github.com/resteorts/modern-bayes/blob/master/reading/distribution-quick-reference.pdf>
- A One Pager on Prob Distributions
<https://github.com/resteorts/modern-bayes/blob/master/reading/common-distributions-one-pager.pdf>

Where can you find all the course information

Course website (all major course information here):

<https://resteorts.github.io/teach/bayes20.html>

Course cheat sheet (a summary of course information)<https://github.com/resteorts/modern-bayes/blob/master/syllabus/deadlines-cheatsheet.pdf>

Prior Knowledge

- STA 210 <https://www2.stat.duke.edu/courses/Spring19/sta210.001/>
- STA 230 <https://www2.stat.duke.edu/courses/Fall18/sta230/>
- Linear algebra
http://www.stat.columbia.edu/~fwood/Teaching/w4315/Fall2009/lecture_12
- R programming (STA 199)
<https://www2.stat.duke.edu/courses/Spring18/Sta199/>
- github (STA 199) <https://www2.stat.duke.edu/courses/Spring18/Sta199/>

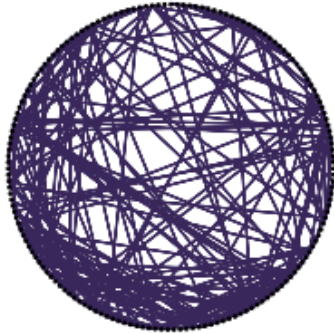
Course Objectives

- Provide a foundation to Bayesian statistical methods
- Explore, visualize, and analyze data in a reproducible and shareable manner using Bayesian methods from the course
- Gain experience in data wrangling and munging, building Bayesian models, visualizing them, and interpreting them
- Work on problems and case studies inspired by and based on real-world questions and data
- Learn to effectively communicate results through written assignments and exams

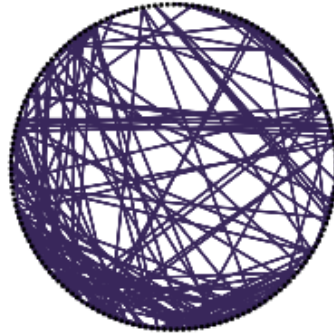
Examples of Bayesian Statistics

Social Networks

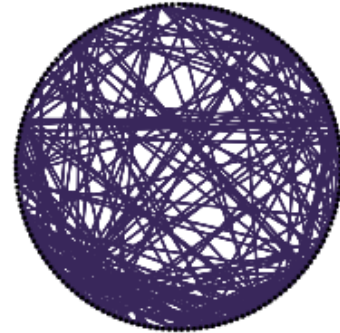
Exchange money



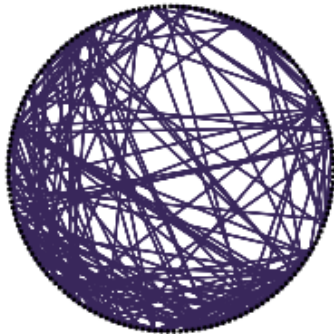
Exchange goods



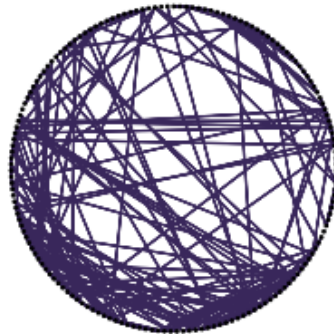
Interact socially



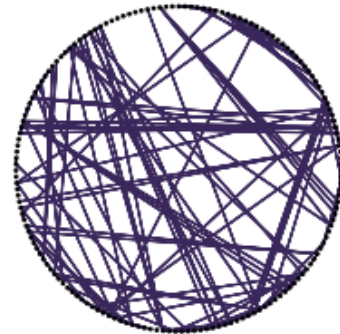
Personal decision



Medical advice



Family



Precision Medicine

Unstable/slow internet?

Go to <https://github.com/resteorts/modern-bayes/> and fork the repository.

- The videos are compressed, and this was done on purpose for those in the class that might have slow internet. I would suggest that everyone forks the repository to avoid any issues.
- Verify that you can play them (otherwise install something on your machine).
- Make sure to pull the repository each day. I update the repository very often as all the course resources are here (homeworks, lectures, data, videos). If you don't pull often, you might run into some issues!

Your Turn!

Create a GitHub account

Go to <https://github.com/>, and create an account (unless you already have one). After you create your account, click [here](#) and enter your GitHub username.

Tips for creating a username from [Happy Git with R](#).

- Incorporate your actual name!
- Reuse your username from other contexts if you can, e.g., Twitter or Slack.
- Pick a username you will be comfortable revealing to your future boss.
- Shorter is better than longer.
- Be as unique as possible in as few characters as possible.
- Make it timeless. Don't highlight your current university, employer, or place of residence.
- Avoid words laden with special meaning in programming, like **NA**.

Login to github with your username (handle)

- Go to <https://github.com/>, and login with your github credentials.

Clone the class repository

- Clone the class repository modern-bayes

The screenshot shows the GitHub repository page for 'modern-bayes' by 'resteorts'. At the top, the repository name is displayed with icons for Unwatch (4), Star (24), and Fork (33). Below this is a navigation bar with links for Code, Issues (0), Pull requests (1), Actions, Projects (0), Wiki, Security (0), Insights, and Settings. The repository description is 'Modern Bayesian statistics, STA 360/602, Duke University, Department of Statistical Science' with a link to 'https://stat.duke.edu/courses/STA360' and an 'Edit' button. Below the description is a 'Manage topics' link. A progress bar shows repository statistics: 373 commits, 1 branch, 0 packages, 0 releases, 1 contributor, and GPL-3.0 license. Below the progress bar are buttons for 'Branch: master', 'New pull request', 'Create new file', 'Upload files', 'Find file', and 'Clone or download'. A dropdown menu is open for 'Clone or download', showing options to 'Clone with HTTPS' (with a question mark icon) and 'Use SSH'. The 'Clone with HTTPS' option includes the URL 'https://github.com/resteorts/modern-b' and a copy icon. Below the URL are buttons for 'Open in Desktop' and 'Download ZIP'. The repository file list is visible on the left, showing folders like 'deprecated', 'exercises', 'homeworks', 'labs', and 'lecturesModernBayes20' with their respective descriptions and commit times.

resteorts / modern-bayes

Unwatch 4 Star 24 Fork 33

<> Code Issues 0 Pull requests 1 Actions Projects 0 Wiki Security 0 Insights Settings

Modern Bayesian statistics, STA 360/602, Duke University, Department of Statistical Science <https://stat.duke.edu/courses/STA360> Edit

Manage topics

373 commits 1 branch 0 packages 0 releases 1 contributor GPL-3.0

Branch: master New pull request Create new file Upload files Find file Clone or download

resteorts Merge branch 'master' of <https://github.com/resteorts/modern-bayes>

deprecated	tentative readme and schedule.
exercises	update.
homeworks	uploaded data for hw 1.
labs	org.
lecturesModernBayes20	update lectures

Clone with HTTPS ? Use SSH

Use Git or checkout with SVN using the web URL.

<https://github.com/resteorts/modern-b> Copy

Open in Desktop Download ZIP

10 days ago 3 hours ago

Raise your hand if you have any questions.

Clone the class repository

[Demo of cloning the class repository]

Discussion

Discuss the following with a partner (in a breakout room).

1. Start by introducing yourself! Name, year, major/ academic interest, favorite hobby.
2. Make sure that you can clone the repository and that your partner could as well.
3. Check to see that you're able to navigate the course webpage (in case that you lose access to the internet).

Tip: Make sure to pull from the repository quite often as the class webpage and materials will be frequently updated.

Course Policies

Class Meetings

Lecture

- Learn Bayesian statistical methods
- Lectures will consist of learning methodology and applied coding techniques
- You might find it useful to have a tablet/document camera for homeworks/OH/exams
- An alternative to this is using your phone to take pictures using Evernote (students have said this worked well in the spring). Please test things out in advance and make sure things are legible!

Lab

- Labs will reinforce concepts learned in class using R
- Apply concepts from lecture to real or synthetic data
- Many labs will be finished as part of your homework
- Bring fully-charged laptop to every lab

Required Textbooks

- [A First Course in Bayesian Statistical Methods, Peter Hoff]
 - Free PDF available online through the library. Hard copy available for purchase.
 - Assigned readings on github.
- [Some of Bayesian Statistics: The Essential Parts](#)
 - Assigned readings.

Supplemental Textbooks

- [Statistical Inference](#)
- [Baby Bayes using R](#)
- [Bayesian Data Analysis](#)
- [The R Cookbook](#)
- [Github Setup Video](#)
- [Github Tutorial](#)

Activities & Assessments

- **Homework:** Individual assignments combining conceptual and computational skills along with lab exercises. *Lowest score dropped.*
- **Labs:** Attending lab is highly encouraged, and, there will be a lab problem on each homework each week.
- **Class/Lab:** You will be responsible for keeping up with all class and lab material on a weekly basis (even though there are recordings)!

Lab Engagement

1. Students are expected to have attempted the lab solutions before coming to lab and have watched the lab videos provided if they had trouble.
2. Students are encouraged to post lab questions in advance to the Google group regarding lab, which should be posted no later than each Thursday at 5 PM EST.
3. Each lab TA will go over all lab tasks, providing clarifications, solutions/advice, and more advanced insights.
4. Each lab TA will take questions (in person) or go over those posted to the Google group or via email.
5. You should always indicate what lab you are in on the Google group. You can also reach out to Olivier for his lab at olivier.binette@gmail.com and to Michael at michael.f.christensen@duke.edu
6. Attendance is highly encouraged in order to learn tips and tricks and in order to get hints/advice which are important for homeworks and exams.

Class Engagement

1. Students are expected to have read the assigned reading before coming to class.
 2. Students are expected to have watched the pre-recorded videos.
 3. Prof. Steorts will go through the concepts in class again, highlighting the most important parts, providing clarifications, solutions/advice, and more advanced insights.
 4. Prof. Steorts will take questions (in person) or those that are posted in advance on the Google Group by Monday at 10 AM EST and Wed at 10 AM EST.
 5. Prof. Steorts will provide exercises for the class to work through, practice exams, and an interactive environment.
 6. TAs will be present to help in these activities such that we can break into small groups and students can receive more individualized attention.
- **Exams:** Two exams.
 - **Final Exam:** You must take the final exam to pass the course.

Homeworks

1. All code must be written to be reproducible in Markdown.
2. All derivations can be done in any format of your choosing (word, latex, markdown, written by hand) but must be converted to a pdf document. It must be legible.
3. All files must be zipped together and submitted to Sakai as one file (including Rmd and pdf). Your pdf document must be uploaded to Duke GradeScope. Please make sure to upload early to avoid issues.
4. Ask questions early if you have a problem to a TA regarding submission issues.
5. Your lowest homework will be dropped.
6. The first two homeworks can be submitted in Sakai and on GradeScope.

Remark: Sakai is for reproducible code. Gradescope is to make grading easier for everyone. Unfortunately, there is not a platform that handles both.

Please see the syllabus for all homework guidelines.

Why Sakai + Gradescope?

1. Sakai will be used for reproducibility so this can be checked. This will account for
2. Gradescope will be used to:
 - return homework/exams more promptly
 - ensure complete fairness
 - allow students to continue to learn from homeworks by reworking problems without the right answer written out to the side

Exam 1

Exam 1 will be an **in class exam** with two offerings depending on your time zone.

- There will be two exams given. The first exam will be for international students (Vietnam, China, India) between 8:00 AM -- 9:15 AM EST. The second exam will be during the class period.
- Students will have 30 minutes after the exam ends to upload their solutions (in one .pdf) to Gradescope.
- During this time period, you are not to discuss the exam with anyone except the TA's and myself.
- The exam is closed note and closed book.

Exams (Continued)

1. The exam will be over zoom and will be recorded. You will be required to have your videos on while working and sign an honor pledge that you have not looked at any online resources, books, notes, etc.
2. The exam will be released via Duke Gradescope.
3. You will have 30 minutes to post your written solutions to Duke Gradescope in one .pdf.
4. You must have a note from your dean in order to be excused from an exam. There will be no make up exams, and all weight will move to the final exam in the case of an excused absense (such as a medical excuse).
5. Students will not discuss exam material (on either exam) until the exam grades are released back to the students.

Remark: The goal of these exams is to test your baseline knowledge of the course and not be stressful. Make sure you have a quiet place on the day of the exam during the class period.

Grade Calculation

Component	Weight
Homework	30%
Exam 1	20%
Exam 2	20%
Final Exam	30%

- See the syllabus for grade breakdowns.
- Grades will **never** be curved down.
- You are expected to attend lectures and labs in order to keep up with the course material. - - There will be no attendance grade or participation grade.

Excused Absences

- Students who miss a class due to a scheduled varsity trip, religious holiday, or short-term illness should fill out the respective form.
 - These excused absences do not excuse you from assigned work.
- If you have a personal or family emergency or chronic health condition that affects your ability to participate in class, please contact your academic dean's office.
- Exam dates cannot be changed and no make-up exams will be given.

Late Work & Regrade Requests

- No late homeworks will be accepted, so please do not ask.
- No make up exams will be given.
- Regrade requests must be submitted within one week of when the assignment was returned.

Academic Honesty

All work for this class should be done in accordance with the Duke Community Standard.

To uphold the Duke Community Standard:

- I will not lie, cheat, or steal in my academic endeavors;
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised. Any violations will automatically result in a grade of 0 on the assignment and will be reported to [Office of Student Conduct](#) for further action.

Reusing Code

- Unless explicitly stated otherwise, you may make use of online resources (e.g. StackOverflow) for coding examples on assignments. If you directly use code from an outside source (or use it as inspiration), you must or explicitly cite where you obtained the code. Any recycled code that is discovered and is not explicitly cited will be treated as plagiarism.
- On individual assignments, you may discuss the assignment with one another; however, you may not directly share code or write up with other students.
- On team assignments, you may not directly share code or write up with another team. Unauthorized sharing of the code or write up will be considered a violation for all students involved.

Where to find help

- **If you have a question during lecture or lab, feel free to ask it!** There are likely other students with the same question, so by asking you will create a learning opportunity for everyone.
- **Office Hours:** A lot of questions are most effectively answered in-person, so office hours are a valuable resource. Please use them!
- **Google group:** Outside of class and office hours, any general questions about course content or assignments should be posted on Google since there are likely other students with the same questions.

Academic Resource Center

Sometimes you may need help with the class that is beyond what can be provided by the teaching team. In that instance, I encourage you to visit the Academic Resource Center.

The [Academic Resource Center \(ARC\)](#) offers free services to all students during their undergraduate careers at Duke. Services include Learning Consultations, Peer Tutoring and Study Groups, ADHD/LD Coaching, Outreach Workshops, and more. Because learning is a process unique to every individual, they work with each student to discover and develop their own academic strategy for success at Duke. Contact the ARC to schedule an appointment. Undergraduates in any year, studying any discipline can benefit! Contact ARC@duke.edu, 919-684-5917, 211 Academic Advising Center Building, East Campus – behind Marketplace.

Technology/Other

- Make sure that you have your zoom ids organized so that you're not late for class.
- Ensure the volume on all devices is set to mute.
- Refrain from engaging in activities not related to the class discussion. Browsing the web and social media, excessive messaging, playing games, etc. is not only a distraction for you but is also a distraction for everyone around you.
- If you have a question, I don't mind if you interrupt me during class.
- If you find a **typo in the slides**, please write these down and email these to myself and Olivier so they can be fixed.

Accessibility

Please contact the [Student Disability Access Office \(SDAO\)](#), if there is an element of the course that is not accessible to you. There you can engage in a confidential conversation about the process for requesting reasonable accommodations.

Please note that accommodations are not provided retroactively, so please contact them as soon as possible. More information can be found online at access.duke.edu.

Inclusion

In this course, we will strive to create a learning environment that is welcoming to all students and that is in alignment with [Duke's Commitment to Diversity and Inclusion](#). If there is any aspect of the class that is not welcoming or accessible to you, please let me know immediately.

Additionally, if you are experiencing something outside of class that is affecting your performance in the course, please feel free to talk with me and/or your academic dean.

Questions?

Announcements

Anything else here....

- Please see me if you are on the waiting list
- If you're a student in the United States that cannot attend lectures/labs consistently due to being in a rural area or for any other reason, please see me after the first class.
- If your situation changes during the semester for any reason, please email myself and the TAs so that we can help you.
- In return, I would ask that everyone be flexible and understanding of everyone else (including instructors and TAs) as this is a very difficult and trying time.