Bayesian Modeling

Course Logistics

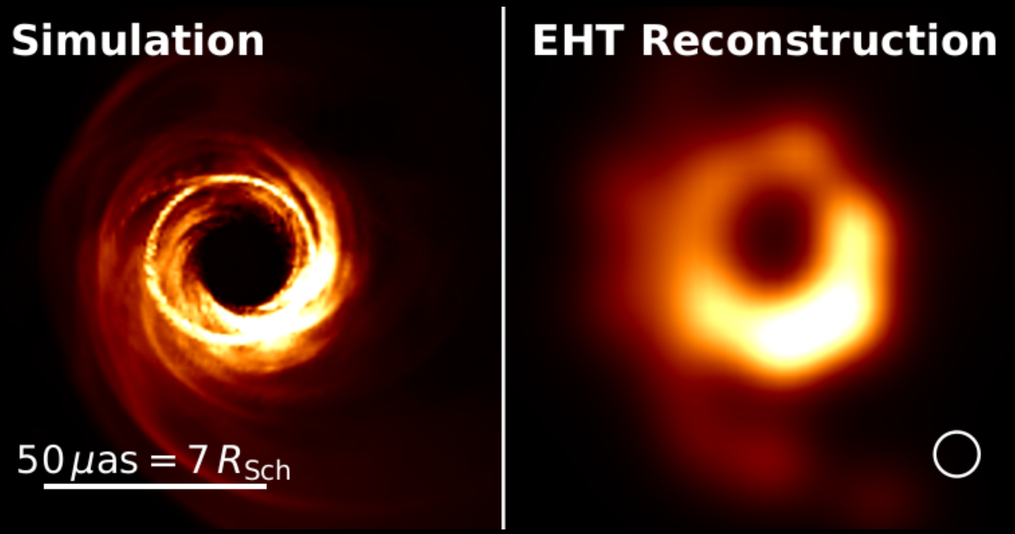
Yixin Wang

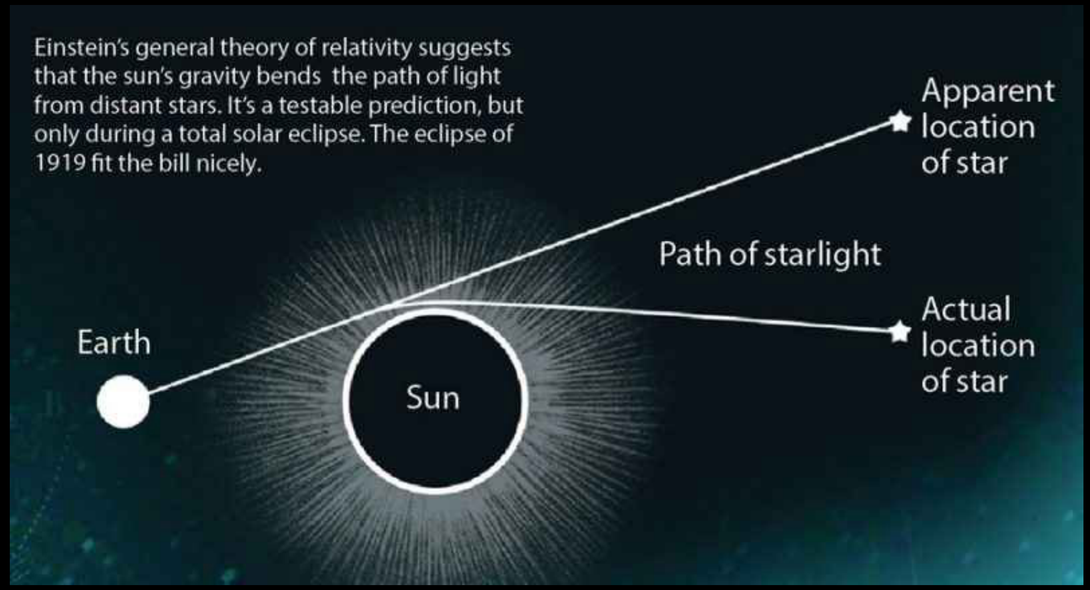
What can Bayesian data analysis do?

First Blackhole Image

CHIRP (Continuous High-resolution Image Reconstruction using Patch priors) is a Bayesian algorithm

- https://www.tiktok.com/@toknerdytome/video/7096841960765312302?is_copy_url=1&is_from_webapp=v1&q=first%20blackhole%20image%20katie%20bowman&t=1661737799054





Bayes Theorem cracked the Nazi Enigma code during World War II

(IV) INTERCEPTED MESSAGES

MESSAGE 1	68076	19368
-		
MESSAGE 2	46505	29928
=	22571	10660

(V) "GOOD"-GROUPS

		DIFFERENCE	ADDITIVE
70863	32151	22571	98213
70863	24132	54379	
32151	24132	18029	
		...	

(VI) TEST ADDITIVE

		- 98213
MESSAGE 1	68076	70863
MESSAGE 2	46505	32151
MESSAGE 3	12345	24132
MESSAGE 4	23415	35202
MESSAGE 5	...	...

	Message is about Naval Activity	Message is about Something Else	
There is Naval Activity	20	30	*Probability of Activity: 50%*
There is *not* Naval Activity	0	50	*Probability of No Activity: 50%*
	Message is about Naval Activity at all: 20%	*Message is about Something Else at all: 80%*	

Bayesian Modeling Helps Identify Ancestry from Genetic Measurments

Goals for This Week

- Course logistics
- Conceptual framework of Bayesian data analysis.
  - Two foundational ideas:
    - Bayesian inference is reallocation of credibility across possibilities.
    - The possibilities, over which we allocate credibility, are parameter values in meaningful mathematical models.

What to expect from this course?

- Basics of Bayesian Modeling
- Principled ways of conducting Bayesian inference
- Computational algorithms in Bayesian statistics
- Modern developments of Bayesian methods
- Solving real-world problems with Bayesian analysis

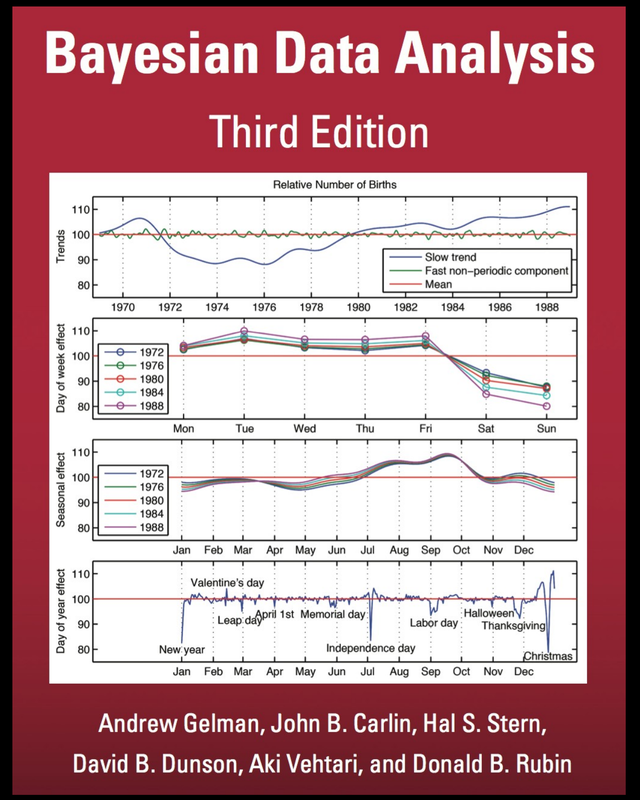
Bayesian modeling and inference

What is the end goal?

- Predict: given features, estimate labels or outputs
- Simulate: given partial observations, generate the rest
- Summarize: given high dimensional data, find low-dimensional factors of variation
- Visualize: given high dimensional data, find informative 2D/3D plots
- Decide: given past actions/outcomes, which choice is best?
- Understand: what generative mechanisms gave rise to this data?

Course Logistics

Books



You don’t have to buy anything! Links to these book in Syllabus.

Course communication tools

- Website: https://yixinwang.github.io/courses/bayesian-master/fall24/bayesian24f.html
- Canvas: https://umich.instructure.com/courses/628123
- Piazza: https://piazza.com/umich/fall2024/statdatasci551/home (also linked from canvas)
- Please sign up for Piazza! All annoucements about the course will be made through Piazza.
- All communications with the teaching team should be conducted over Piazza; please do NOT email.

Teaching team (aka your supporters)

- Faculty Instructor: Yixin Wang.
- Graduate Student Instructor: Paolo Borello

Reading assignments

- Tentative course schedule is on the course website
- Every topic has associated reading assignments
- Material not available on the web will be under “Files” in Canvas
- It is your responsibility to read the required materials
- Recommendation: read it at least twice, preferably thrice. At least once before lecture and once afterwards

Programming Languages

- We will mainly demo in R or Python.
- Please feel free to use other languages (R, Julia, Python, PyTorch etc.)
- The only requirement: It runs in Jupyter notebook; R, Python, and Julia can.

Homework assignments

- Bi-weekly homework
  - The first homework starts in two weeks.

Grading

- Bi-weekly homeworks (30%): We will allow one drop; submitted through gradescope
  - Drops are expected to accommodate late add/drop, personal/health reasons etc
- Midterm exam (30%): In person
- Final project (40%): Report + presentation; detailed guidelines on website
- Piazza participation bonus (up to 3%): Based on your Piazza contributions
  - **Please read the syllabus on the course website for detailed policies!**

    https://yixinwang.github.io/courses/bayesian-master/fall24/bayesian_syllabus_2024.pdf

Final project

Due 11:59 PM EST on Dec 18

- Final project report
  - 2-3 pages excluding figures or references; 4-6 pages if STATS/DATASCI 651
  - submit .pdf through gradescope
  - We provide an *example* final project report on Canvas. However, we note that this example is **not** a perfect project report according to the grading criteria.
- Final presentation
  - 5-7 min; submit .mp4 through gradescope
- Please read final project guidelines and grading criteria very carefully!
  https://yixinwang.github.io/courses/bayesian-master/fall24/bayesian_project.pdf

Feedback

- Your feedback and input are more than welcome!
- Will be soliciting feedback in homework as optional questions

Let us know how we can better support you!

Please feel free to post anonymous suggestions / complaints on Piazza.

Other logistics

- I teach two large classes in the fall semester.
- Please talk to me during office hours.
- I received some emails about potential COVID concerns in classroom.
  - To be considerate, I’m gonna wear a mask
  - Please feel free to make your own decision about masks.

Academic Integrity

- You can discuss homeworks with your classmates
- But all submitted work, including code, must be your own.
- Submitted work cannot make use of AI assistance, like ChatGPT etc.
- Misconduct will be reported to the Dean’s office
- When in doubt, ask!

Accommodation for Students with Disabilities

- Submit your VISA form as soon as possible
- Talk to me privately if you need any other accommodations

Mental Health and Well-Being

- Be aware of available resources
- Seeking help when needed is courageous!
- If this course is adding to your stress, talk to me privately

Questions?

The materials in this course are adapted from materials created by David Blei, Yang Chen, Andrew Gelman, Scott Linderman, Grant Sanderson, and the 3blue1brown channel.