THE OHIO STATE UNIVERSITY

COLLEGE OF ARTS AND SCIENCES

SYLLABUS: STAT 7730
ADVANCED COMPUTATIONAL STATISTICS
SPRING 2025

Course overview

Instructor

Instructor: Dr. Sebastian Kurtek
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Phone number: 614-292-0463 (contact via e-mail is highly preferred)
Office hours: Wednesdays 4PM-5PM
Office location: Cockins Hall 440B

Graduate teaching associate: Mr. Kiljae Lee
GTA email address: lee.10428@osu.edu
GTA office hour: Wednesdays 9:10AM-10:10AM
GTA office hour location: Zoom (link posted in announcements)

Course description

STAT 7730 is a graduate level course in modern statistical computing methods. This course is not about the use of pre-packaged statistical software. The main goal of this course is to gain an understanding of advanced techniques and ideas used in implementing mathematical/statistical formulations on computers, with a focus on common statistical approaches. Students will be expected to implement the methods we cover in class by programming in a language of their choice (preferably R, although Matlab is acceptable). I will provide example R code that goes along with the material covered in class. Students are expected to be able to analyze the code, and apply the basic structure of the code to new problems assigned as homework.
Note: Students who have had no prior programming experience should expect to spend extra time outside of class reviewing the example code and familiarizing themselves with a statistical programming environment.

Tentative schedule of topics

(1) **Linear Methods for Regression Analysis/Matrix Decomposition:** basic numerical analysis, multiple regression analysis, orthogonalization by Householder transformation, singular value decomposition, QR decomposition, principal component analysis, linear discriminant analysis - 2 weeks

(2) **Numerical Methods for Maximum Likelihood Estimation:** univariate/multivariate numerical optimization, maximum likelihood estimation, expectation-maximization (EM) algorithm and extensions - 3 weeks

(3) **Random Number and Variable Generation:** uniform random number generators, modular arithmetic, combination generators, discrete and continuous random variables, inverse transform method, acceptance-rejection method and extensions, tilted sampling - 2 weeks

(4) **Monte Carlo Integration:** general formulation, importance sampling, variance reduction, numerical integration and differentiation - 2 weeks

(5) **Markov Chain Monte Carlo (MCMC) Methods:** properties of Markov chains, Metropolis-Hastings algorithm, Gibbs sampler, extensions - 2 weeks

(6) **Bootstrap:** plug-in estimator, non-parametric/parametric bootstrap, bootstrap estimate of standard error, confidence intervals based on bootstrap - 1 week

(7) **Additional Topics -** time permitting

Course learning outcomes

By the end of this course, students should:

- Be familiar with common computational statistics methods, e.g., optimization, random variable generation, Markov chain Monte Carlo, and their practical limitations;
- Be able to implement algorithms associated with the methods and apply them to real data;
- Be able to interpret output from computational algorithms;
- Improve their statistical programming skills.

Prerequisites

STAT 6802 and STAT 6950 or permission of instructor. Additionally, working knowledge of linear algebra, advanced calculus, and some programming background is helpful.

Course materials

The primary resources will be notes and additional references assigned for reading by the instructor.

Helpful Textbooks

- Givens and Hoeting, Computational Statistics
- Robert and Casella, Monte Carlo Statistical Methods
- Efron and Tibshirani, An Introduction to the Bootstrap
- Monahan, Numerical Methods of Statistics
- Rizzo, Statistical Computing with R

Course technology

For help with your password, university e-mail, Carmen, or any other technology issues, questions, or requests, contact the OSU IT Service Desk. Standard support hours are available at https://ocio.osu.edu/help/hours, and support for urgent issues is available 24x7.

- **Self-Service and Chat support:** http://ocio.osu.edu/selfservice
- **Phone:** 614-688-HELP (4357)
- **Email:** 8help@osu.edu
- **TDD:** 614-688-8743

Baseline technical skills necessary for this course

- Basic computer and web-browsing skills
- Navigating Carmen
- CarmenZoom

Necessary equipment

- Computer: current Mac (OS X) or PC (Windows 10+) with high-speed internet connection

Necessary software

Students are expected to have basic familiarity with a scientific computing environment such as R, S-PLUS or Matlab. We will use the R language and environment for statistical computing and graphics as an aid to learning about statistical computing methods. R is available for free at http://www.r-project.org. I will provide example R code in class. Students are highly encouraged to use R; check with the instructor to see if use of another language/environment is acceptable. Some students in the past have successfully completed the course using Matlab.

Course delivery

- This class will take place in-person three times per week on Mondays, Wednesday and Fridays, 11:30AM-12:25PM in Cockins Hall 232.

- All assignments will be posted on the Carmen class website. You will be given ample time to complete the assignments. Assignment due dates will be announced in class and on the Carmen course webpage.
- I will hold weekly office hours in Cockins Hall 440B.

Grading and faculty response

Grades

Assignment or category	Percentage
Discussion/Participation	**10**
Homework	**30**
Midterm Project	**30**
Final Project	**30**
Total	**100**

All course grades will be recorded on the class website (Carmen).

Assignment information

Homework

Homework will generally be assigned approximately once every two weeks. The assignments will require the derivation of analytical results as well as the implementation of the computational methods we discuss in class. Please write clear and detailed answers to the homework problems and provide a statement interpreting the obtained results. If a problem involves writing a program, submit a printout of the code with the solution. It is important to provide illustrative outputs of your programs to accompany the homework solutions. For instance, all graphs should be labeled and placed close to the associated written part. Points are allocated to both the correctness of the solution and the level of presentation.

Discussion

I will post discussion topics related to the content we are learning on Carmen. All students in the course are required to participate in the discussions.

Midterm and Final Projects

Details of project assignments will be given later in the course.

Late assignments

Generally, late assignments will not be accepted. However, if there are extenuating circumstances beyond your control, please contact the course instructor immediately.

Grading scale

93–100: A
90–92.9: A-
87–89.9: B+
83–86.9: B
80–82.9: B-
77–79.9: C+
73–76.9: C
70 –72.9: C-
67 –69.9: D+
60 –66.9: D
Below 60: E

Faculty feedback and response time

I am providing the following list to give you an idea of my intended availability throughout the course.

Grading and feedback

For homework, you can generally expect feedback within **7-14 days**.

E-mail

I will reply to e-mails within **24 hours on school days**.

Attendance and participation

Student participation requirements

Your participation is based on your in-person attendance. The following is a summary of everyone's expected participation:

- **Logging in**: **AT LEAST ONCE PER WEEK**
  Be sure you are logging in to the course in Carmen each week, including weeks with

holidays. During most weeks you will probably log in many times. If you have a situation that might cause you to miss an entire week of class, discuss it with me *as soon as possible.*

- **In-person class meetings**: **REQUIRED**

  You are required to attend all in-person lectures and you are responsible for all material presented during these lectures. However, formal attendance will not be taken during the class.

- **Office hours**: **OPTIONAL**
  My office hours will be held in-person in my office in Cockins Hall 440B. If you are required to discuss an assignment with me, please contact me at the beginning of the week if you need a time outside of my scheduled office hours.

Communication guidelines

The following are my expectations for how we should communicate as a class. Above all, please remember to be respectful and thoughtful.

- **Tone and civility**: Let's maintain a supportive learning community where everyone feels safe and where people can disagree amicably. Remember that sarcasm doesn't always come across online.
- **Citing your sources**: When we have academic discussions, please cite your sources to back up what you say. (For the textbook or other course materials, list at least the title and page numbers. For online sources, include a link.)

Other course policies

Academic integrity policy

Policies for this course

- **Homework and project assignments**: You are expected to produce original and independent work for homework and project assignments. Although students are often encouraged to work together on homework assignments, all students must submit their own written work **in their own words**. Note that allowing others to copy your work is considered academic misconduct.
- **Reusing past work**: In general, you are prohibited in university courses from turning in work from a past class to your current class, even if you modify it. If you want to build on past research or revisit a topic you've explored in previous courses, please discuss the situation with me.

- **Falsifying research or results**: All research you will conduct in this course is intended to be a learning experience; you should never feel tempted to make your results or your research look more successful than it was.
- **Collaboration and informal peer-review**: The course includes many opportunities for formal collaboration with your classmates. While study groups and peer-review of major written projects is encouraged, remember that comparing answers on an assignment is not permitted. If you're unsure about a particular situation, please feel free to ask ahead of time.

Ohio State's academic integrity policy

It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct http://studentlife.osu.edu/csc/.

Copyright disclaimer

The materials used in connection with this course may be subject to copyright protection and are only for the use of students officially enrolled in the course for the educational purposes associated with the course. Copyright law must be considered before copying, retaining, or disseminating materials outside of the course.

Statement on title IX

Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories (e.g., race). If you or someone you know has been sexually harassed or assaulted, you may find the appropriate resources at http://titleix.osu.edu or by contacting the Ohio State Title IX Coordinator at titleix@osu.edu.

Accessibility accommodations for students with disabilities

The university strives to maintain a healthy and accessible environment to support student learning in and out of the classroom. If you anticipate or experience academic barriers based on your disability (including mental health, chronic, or temporary medical conditions), please let me know immediately so that we can privately discuss

options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion.

If you are isolating while waiting for a COVID-19 test result, please let me know immediately. Those testing positive for COVID-19 should refer to the Safe and Healthy Buckeyes site for resources. Beyond five days of the required COVID-19 isolation period, I may rely on Student Life Disability Services to establish further reasonable accommodations. You can connect with them at slds@osu.edu; 614-292-3307; or http://slds.osu.edu.

Your mental health

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know are suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental health services available on campus via the Office of Student Life's Counseling and Consultation Service (CCS) by visiting http://ccs.osu.edu or calling 614-292-5766. CCS is located on the 4th Floor of the Younkin Success Center and 10th Floor of Lincoln Tower. You can reach an on call counselor when CCS is closed at 614-292-5766 and 24 hour emergency help is also available 24/7 by dialing 988 to reach the Suicide and Crisis Lifeline.

Disclaimer

This syllabus should be taken as a fairly reliable guide for the course content. However, you cannot claim any rights from it and in particular we reserve the right to change due dates or the methods of grading and/or assessment if necessary. Any changes will be communicated to you through official course announcements.