THE OHIO STATE UNIVERSITY

COLLEGE OF ARTS AND SCIENCES

SYLLABUS: STAT 7730
ADVANCED COMPUTATIONAL STATISTICS
SPRING 2021

Course overview

Instructor

Instructor: Lo-Bin Chang
Email address: lobinchang@stat.osu.edu
Class website: https://osu.instructure.com/courses/97725

Lecture: On CarmenZoom, Monday, Wednesday, and Friday, 8:35am-9:30am (some of these lectures will be presented asynchronously; see Course delivery below)

Office hours: Virtual Hours via Carmen Zoom: Tuesday 8 am-9 am, Thursday 8am-9am.

Grader

Xiaohan Fu
Email: fu.688@osu.edu

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. Students can use *any* programming language for this course. **Note:** Students who have had no prior programming experience should expect to spend extra time outside of class reviewing how to write computer code and familiarizing themselves with a statistical programming environment.

Prerequisites: STAT 6802 (622) and STAT 6950 (645) or permission of instructor. Additionally, working knowledge of linear algebra, advanced calculus, and some programming background is helpful.

Course learning outcomes

Upon successful completion of the course, students will be able to:

- Familiarize the algorithms, theorems, and applications related to computational statistics;
- Carry out appropriate approaches for optimization problems, random sample generation, and calculation of expectation;
- Improve their programming skills;
- Interpret the results from computer examperiments.

Course materials

The course materials are mostly from the following references (not required):

- Computational Statistics by G. Givens and J. Hoeting
- Monte Carlo Statistical Methods by C. Robert and G. Casella
- An Introduction to the Bootstrap by B. Efron and R. Tibhsirani
- Pattern Recognition and Machine Learning by Christopher M.Bishop
- Information Theory, Inference, and Learning Algorithms by David MacKay
- Statistical computing with R by Maria L. Rizzo

Other Optional materials

I will highlight other useful references as the course progresses.

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 online courses

- Basic computer and web-browsing skills

- Navigating Carmen

Technology skills necessary for this specific course

- CarmenZoom

Necessary equipment

- Computer: current Mac (OS X) or PC (Windows 10+) with high-speed internet connection
- Webcam: built-in or external webcam, fully installed
- Microphone: built-in laptop or tablet mic or external microphone

Necessary software

This class requires you to use a software package (e.g. R, Matlab, Python).

Course delivery

The course will be a mix of synchronous and asynchronous content. Synchronous content will be presented live over CarmenZoom, and asynchronous content will be delivered by recorded lectures posted on the class website. Detailed instructions for asynchronous learning will be posted prior to commencing of such activities.

Each week, we will cover approximately 165 minutes of content in total. You will be responsible for watching any live content or recorded videos and studying the material that is assigned. In addition to the lecture videos, assignments will be posted on the class website. You will be given ample time to complete the assignments.

The instructor will hold weekly office hours via CarmenZoom. The times are given above.

Grading and faculty response

Homework and exams

Assignment or category	Percentage
Homework	70
Final Project	30
Total	100

Grades will be recorded on the class websites.

Homework will be given 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.

Students may consult with each other on the homework problems, but each student must complete and submit his or her own work. Feel free to ask me for help after you have made an attempt to solve the problems. DO NOT copy or use computer code written by another student. *Late assignments will generally not be accepted unless with my permission*.

The grader for the course does not have the time to provide detailed explanations on each question that is graded. To make up for this, I will endeavor to create homework solutions that are detailed enough to allow you to understand how the question could be approached.

The Final Project is a team work project of three students working together. Each team will read a research article, submit a report of approximately 5 pages, and have a presentation in the last three classes of this semester. Further details will be given six weeks before the first presentation.

Faculty feedback and response time

I am providing the following list to give you an idea of my intended availability throughout the course. (Remember that you can call **614-688-HELP** at any time if you have a technical problem.)

Grading and feedback

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

E-mail

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

Attendance, participation, and discussions

Students may miss class, for a variety of reasons related to COVID-19. As much as possible, please stay in contact with the instructor so that we can discuss accommodations should they be needed.

Student participation requirements

Because this is a distance-education course, your attendance is based on your online activity and participation. The following is a summary of everyone's expected participation:

- **In live lectures:**
  Students will be expected to participate, discuss, and answer questions in online live Lectures.
- **Logging in: AT LEAST THREE TIMES 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.
- **Office hours: OPTIONAL OR FLEXIBLE**
  All office hours, are optional. If you are not available during my scheduled office hours, you can email me to schedule a different time to get my help.

Discussion and communication guidelines

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

- **Writing style**: While there is no need to participate in class discussions as if you were writing a research paper, you should remember to write using good grammar, spelling, and punctuation. Informality (including an occasional emoticon) is fine for non-academic topics.
- **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.)
- **Backing up your work**: Consider composing your academic posts in a word processor, where you can save your work, and then copying into the Carmen discussion.

Other course policies

Health and safety

The Ohio State University Wexner Medical Center's Cornavirus Outbreak site (https://wexnermedical.osu.edu/features/coronavirus) includes the latest information about COVID-19 as well as guidance for students, faculty and staff. Guidelines and requirements for campus safety from the University's COVID-19 Transition Task Force were published on July 1 on the Safe and Healthy website (https://safeandhealthy.osu.edu).

Potential disruptions to instruction

Contingencies to be addressed:

- As much as is possible, students will have access to material online if they are unable to attend class because of positive diagnosis, symptoms, or quarantine required following contact tracing.
- If the instructor is unable to be present in person because of positive diagnosis, symptoms, or quarantine following contact tracing a new instructor will be assigned to the course. Details will be given on the course website.

Student academic services

Student academic services offered on the OSU main campus http://advising.osu.edu/welcome.shtml.

Student support services

Student support services offered on the OSU main campus http://ssc.osu.edu.

Academic integrity policy

Policies for this online course

- **Written assignments and the final project**: Your written assignments and project, including discussion posts and presentation, should be your own original work.
- **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 library research look more successful than it was.

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 (Recommended)

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 make all learning experiences as accessible as possible. 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. SLDS contact information: slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

Accessibility of course technology

This online course requires use of Carmen (Ohio State's learning management system) and other online communication and multimedia tools. If you need additional services to use these technologies, please request accommodations with your instructor.

- Carmen (Canvas) accessibility
- Streaming audio and video
- Synchronous course tools

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 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 through the 24/7 National Suicide Prevention Hotline at 1-800-273- TALK or at suicidepreventionlifeline.org

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.

Course schedule (tentative)

Week	Dates	Topics
1	Jan 11, 13, 15	basic numerical analysis, multiple linear regression analysis, QR decomposition
2	Jan 20, 22	QR decomposition, singular value decomposition, principal component analysis
3	Jan 25, 27, 29	maximum likelihood estimation, univariate/multivariate numerical optimization (gradient methods, Newton's methods),
4	Feb 1, 3, 5	large deviation theory, information theory, maximum entropy principle
5	Feb 8, 10, 12	MM and EM algorithm and extensions, variance estimation, missing information principle, bootstrapping method
6	Feb 15, 17, 19	uniform random number generators, modular arithmetic method, inverse transform method, acceptance-rejection method
7	Feb 22, 24, 26	Monte Carlo integration, variance reduction, importance sampling
8	Mar 1, 3, 5	antithetic sampling, control vitiates, Rao-Blackwellization, ergodic sequence, Markov chain Monte Carlo,
9	Mar 8, 10, 12	Markov chain Monte Carlo, Metropolis-Hastings algorithm
10	Mar 15, 17, 19	Gibbs sampler, perfect sampling, graphical models
11	Mar 22, 24, 26	undirected graph, Markov random field, Gibbs random field
12	Mar 29, Apr 2	derived graphs, dynamic programming
13	Apr 5, 7, 9	directed acyclic graph, Bayesian network, moral graph
14	Apr 12, 14, 16	Gaussian random field, classification problems, optimal classifier

15	Apr 19, 21	K-nearest neighbor classifier, deep learning, convolutional neural network