

STAT*6841: Computational Statistical Inference

Winter 2022

Department of Mathematics and Statistics, University of Guelph

Disclaimer Please note that from January 10 to 24, this course will be delivered remotely via Zoom. As the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings and academic schedules. Any such changes will be announced via CourseLink and/or class email. All University-wide decisions will be posted on the COVID-19 website <https://news.uoguelph.ca/2019-novel-coronavirus-information/> and circulated by email.

1 General information

Course description: Likelihood and Bayesian methods, large sample theory, nuisance parameters, EM algorithms and other optimization methods, estimating functions, Monte Carlo methods for exploring posterior distributions and likelihoods, data augmentation, importance sampling and MCMC methods.

Prerequisites: Stat*4340 Statistical Inference.

Campus: Guelph

Class Schedule and Location: Monday and Wednesday 10-11:20am, synchronous virtual lecture (AD-S) via Zoom, January 10 - 24.

After January 24, the format of lecture delivery might switch back to in-person setting where the lecture will be held in MACK Room 309. However, such decision will be announced according to the University-wide decision later.

Final Exam: April 25, Monday, 2:30-4:30pm Room TBA

Instructor: Prof. Zeny Feng

Email: zfeng@uoguelph.ca

Office hour: Tuesday 9:30-10:30am, Zoom live platform

2 Course Content

Specific Learning Outcomes:

By the end of this course, students should be able to

- understand the fundamental concepts in probability and large sample theory including sampling distribution and asymptotic properties of key statistics such as sample mean and moments;
- carry out inference procedure based on likelihood methods, such as point estimates, interval estimates, and hypothesis test;
- understand and utilize various likelihood based methods to handle more complex situations. For example, use computational software to implement the EM algorithm for fitting models involving missing data and fitting mixture models; use computational software to carry out regularized regression analysis;
- understand the basic principles, concepts, and theory of Bayesian methods: prior distribution, and posterior distribution for the parameter(s) of interest;
- work out the Bayesian estimates of parameters under special situations such as conjugate family of distributions;
- implement the Markov Chain Monte Carlo methods: Gibbs sampler, metropolis-Hasting algorithm, importance sampling, and adaptive sampling, to obtain the Bayesian estimate of parameters;
- know the connections and differences between likelihood based methods and Bayesian methods, and algorithms or procedures related to these two different approaches.

Lecture Content:

- Review of probability and distribution theory, random sample and sampling distribution
- Large sample theory, stochastic convergence
- Maximum likelihood estimation, properties of MLEs, profile likelihood, conditional likelihood, penalized likelihood, generalized linear models
- Expectation and Maximization algorithm
- Bayes methods, prior distributions, posterior distributions
- Bayesian inference: point estimation, interval estimation, and hypothesis testing
- Markov chain Monte Carlo methods: Rejection sampling, importance sampling, Gibbs sampler and Metropolis-Hastings algorithm

Course Assignments and Tests: This is a tentative schedule. Assignment due dates and test date are subject to change.

- Assignments 30%, due January 28, February 11, March 11, March 25 (all on Friday)
- Midterm 25%, Monday, February 28, in class
- Final exam 45%,
- Bonus 5%, problem solving presentation, in class.

3 Course Resources

Text: There is no required textbook for this course, as the course notes will serve as the primary resource for students. However, students are encouraged to access the following online textbooks or hard copies (and corresponding chapters), available through the University of Guelph Library, as additional resources:

1. Caseller and Berger's *Statistical Inference*, 2nd ed., by Duxbury.
2. Garthwaite, Jolliffe, and Jones' *Statistical Inference*, 2nd edition by Oxford Science Publications.

3. Carlin and Louis' *Bayesian Methods for Data Analysis*, 3rd edition by Chapman and Hall, CRC Press.
4. Gelman, Carlin, Stern, and Rubin's *Bayesian Data Analysis*, 2nd edition by Chapman and Hall, CRC Press.

Lecture Note: An (in)complete set of lecture notes is available from the CourseLink in advance of lectures. It is expected that students will bring a copy that can be completed during lectures. Completely filled lecture notes will not be posted online. The Lecture Notes are not to be re-distributed in any form.

Computer Software: The primary statistical software package that will be used in this course is R, which is freely available for download at <http://www.r-project.org/>. Students are strongly encouraged to install R on their personal computers. Students are allowed to use other softwares such as Python, Perl, Matlab and etc, whatever they find it suitable.

CourseLink: Course information and material (such as lecture notes, assignments, solutions, other course material, and announcements) will be available on CourseLink. Students are responsible to check the website regularly for undated information and announcements.

4 Online Behaviour

As this course will be conducted online, inappropriate online behaviour will not be tolerated. Examples of inappropriate online behaviour include:

- Posting inflammatory messages about your instructor or fellow students
- Using obscene or offensive language online
- Copying or presenting someone else's work as your own
- Buying or selling term papers or assignments
- Posting or selling course materials to course notes websites

- Having someone else to help out on your term test or exam, or help out another student on the test or exam
- Stating false claims about lost assignment submissions
- Threatening or harassing a student or instructor online
- Discriminating against fellow students, instructors
- Using the course website to promote profit-driven products or services
- Attempting to compromise the security or functionality of the learning management system
- Sharing your user name and password with others
- Sharing online meeting ID, password, or link with others
- Recording lectures without the permission of the instructor

General suggestions during a virtual class:

- Mute the microphone upon entry
- Use chat function to pose questions, you can send the question to everyone or just send to the instructor.
- If you prefer to ask question during the class with your own voice, please use the raise hand function or pose a request in chat box: “Can I ask a question.” Then after I call your name, you can unmute yourself and ask questions.
- I would suggest that you turn on your camera when you join the class. It is helpful to keep your attention to the class. It also make your instructor feel more like teaching in a class than talking to herself alone.

5 Standard Statements

Email Communication:

As per university regulations, all students are required to check their <

uoguelph.ca > email account regularly: e-mail is the official route of communication between the University and its students.

When You Cannot Meet a Course Requirement:

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons, please advise the course instructor in writing, with your name, id number, and e-mail contact. See the Graduate Calendar for information on regulations and procedures for Academic Considerations.

Drop Date Courses that are one semester long must be dropped by the end of the last day of classes. The regulations and procedures for Dropping Courses are available in the Graduate Calendar.

Copies of Out-Of-Class Assignments Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required, however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

More information: www.uoguelph.ca/sas

Academic Misconduct

The University of Guelph is committed to upholding the highest standards of

academic integrity and it is the responsibility of all members of the University community – faculty, staff, and students – to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University’s policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

The Academic Misconduct Policy is outlined in the Graduate Calendar.

Recording of Material:

Presentations which are made in relation to course work—including lectures—cannot be recorded or copied without the permission of the presenter, whether the instructor, a classmate or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

Resources

The Academic Calendars are the source of information about the University of Guelph’s procedures, policies and regulations which apply to undergraduate, graduate and diploma programs.

Disclaimer

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings, changes in classroom protocols, and academic schedules. Any such changes will be announced via CourseLink and/or class email.

This includes on-campus scheduling during the semester, mid-terms and

final examination schedules. All University-wide decisions will be posted on the COVID-19 website and circulated by email.

Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g., final exam or major assignment).

COVID-19 Safety Protocols

For information on current safety protocols, please visit the websites of Return to Campus and Classroom Health and Safe.

<https://news.uoguelph.ca/return-to-campus/how-u-of-g-is-preparing-for-your-safe-return/>

<https://news.uoguelph.ca/return-to-campus/spaces/#ClassroomSpaces>

Please note, that these guidelines may be updated as required in response to evolving University, Public Health or government directives.