STAT*6841: Computational Statistical Inference

Winter 2021

Department of Mathematics and Statistics, University of Guelph

Disclaimer Please note that 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.

Final Exam: Day and time TBA, online exam on Courselink

Instructor: Prof. Zeny Feng
Email: zfeng@uoguelph.ca

Office hour: Monday and Wednesday 11:30am-12:00pm, 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 21, February 4, March 4, March 18 (all on Thursday)

- Midterm 25%, Wednesday, February 24, in class

- Final exam 45%, TBA

- 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, Jollieffe, 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 is 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.

5 University Policies

Email Communication:
As per university regulations, all students are required to check their e-mail 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. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

Academic Accommodation of Religious Obligations
If you are unable to complete a course requirement due to religious obligations, please let the instructor know within the first two weeks of class. See the academic calendar for more information:
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Illness
The University will not normally require verification of illness (doctor's notes) for fall 2020 or winter 2021 semester courses. However, requests for Academic Consideration may still require medical documentation as appropriate.

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 detailed in Graduate Calendar:
`https://www.uoguelph.ca/registrar/calendars/graduate/2014-2015/genreg/sec_d0e2097.shtml`

Accessibility

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability or a short-term disability should contact the Centre for Students with Disabilities as soon as possible. Contact CSD at: 519-824-4120 ext 56208, or email: csd@uoguelph.ca.

Course Policy regarding use of electronic devices and recording of lectures:

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer.

Course Evaluation Information:

Please see `http://www.mathstat.uoguelph.ca/files/TeachevaluationformF10.pdf`

Last day to drop the course:

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last

day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses
`https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml`

Graduate Calendar - Registration Changes
`https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml`

Associate Diploma Calendar - Dropping Courses
`https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml`