STAT*6841: Computational Statistical Inference

Winter 2020

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.

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

Office hour: Mon and Wed 1-2pm, Fri 10-11am, MACN 540

Lecture Time and Location: Mon and Wed 10-11:20am, MCKN 342

Prerequisites: Stat*4340 Statistical Inference.

Final Exam: Apr 20, 2:30-4:30pm, Room TBA

2 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.

3 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 and concepts 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 distribution
- 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 22, February 5, March 4, March 18 (all on Wednesday)
- Midterm 25%, Wednesday, February 26, in class
- Final exam 45%, April 20, 2:30 - 4:30 pm
- Bonus 5%, problem solving presentation, in class.

4 Course policies

Assignments are due in class on the due dates. No late assignments will be accepted, and late or missed assignments will receive a grade of 0 automatically. While you are encouraged to discuss the assignment problems with fellow students, each student must hand in an individual solution which is the result of his/her own effort.

Midterm test will be held in class and therefore no student should have a conflict with the date or time. If a conflict does exist (e.g., athletic competition), it is your responsibility to resolve it immediately.

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. Material recorded with permission is restricted to use for that course unless further permission is granted.

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

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.

Drop Date
Students will have until the last day of classes to drop courses without academic penalty.For regulations and procedures for Dropping Courses, see the Graduate Calendar:
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml