STAT 7270

Bayesian Inference (A01)

Winter Term 2021

Class Time: M.W.F. 1:30 - 2:20 p.m.
Location: Online
CRN: 59796

Instructor: Saman Muthukumarana
Office: 371 Machray Hall
Telephone: 474-6274
Email: Saman_Muthukumarana@UManitoba.CA
Web: https://www.samanmuthukumarana.com

Office Hours: Online by appointment.

Calendar Description: Bayesian decision problems, priors, Jeffrey's Rule, robustness of posteriors, Bayesian justification of ANOVA

Prerequisite: consent of instructor.

Course Website: The course website is accessible via UM Learn management system.

Computing: This course will expose you to Bayesian Analysis and Computing using R, Python and BUGS computing languages throughout the course. This will also help you to select a suitable computing method for a given problem based on your interest and the scope of the problem.

R is a free software environment for statistical computing and runs on Windows, Linux, UNIX and Mac. You can download your own copy from R Project (CRAN) homepage at http://www.r-project.org/. The introductory tutorial for R can be found here. RStudio can be downloaded from https://www.rstudio.com/.

Python is freely available and a collection of useful resources for Python beginners, including installation and introductory self-learning resources can be found at https://www.python.org/about/gettingstarted/. You can also use Anaconda Navigator https://docs.anaconda.com/anaconda/navigator/ which will give you a desktop graphical user interface (GUI) with access to Jupyter Notebook and R studio.

You will also have access to Python and R through syzygy at https://intro.syzygy.ca/. Syzygy gives you direct interactive computing environment to R and Python with Jupyter notebooks at a single access point. You can log into the syzygy service using your UoM account credentials at https://umanitoba.syzygy.ca/.

The BUGS project at the University of Cambridge offers the BUGS language in various forms. It does both Gibbs and Metropolis-Hastings sampling and can be downloaded here.

Grading Scheme: The minimum percentage final mark required to receive each of the various letter grades are A+ (90%), A (80%), B+ (75%), B (70%), C+ (65%), C (60%), D (50%). The final course mark will be determined as follows. You will have access to your assignments and mid term marks via UM Learn Grade-book.

UM Learn Assignments (4)	30%
In Class Mid-term Test	30%
Take-home Final Exam	40%

Assignments: There will be four assignments with written and computing components throughout the term. All assignments must be submitted electronically by their due date using **UM Learn Dropbox**. Make sure to follow the assignment submission guideline and late assignments will not be accepted. You are encouraged to discuss your problems with your classmates, TA and me, but final submission must be developed independently. Assignments will be marked using Brightspace Assignment Grader and specific submission instructions will be posted on UM Learn. Assignments will include problems which require computing and your submission must accompany the code written by you. Your grades for assignments will be returned within two week of the due date.

Mid-term Test: The in-class mid-term test is tentatively scheduled on **March 19, 2021**. There will be no makeup tests for any reason. If you miss the exam due to a legitimate reason, your exam weight will transfer to the final exam. Your answers must be submitted electronically using **UM Learn Dropbox**.

Final Exam: The final exam covers all course materials and will be an open-book take-home test. The take-home exam will consist of written and computing components and must be submitted electronically using **UM Learn Dropbox**.

Class and Computer Lab Attendance: Online lectures will be conducted during class times over Zoom and you will also attend a mandatory computer lab session once per week starting from 2nd week. The lab sessions will be held on Tuesdays at 2:30 – 3:45 pm. Zoom access details for classes and labs will be posted on course website. I will introduce, discuss and demonstrate materials, computing platforms and codes in these sessions to understand the course materials. Therefore, I encourage you to attend the classes and labs regularly to avoid falling behind. The exams will also resemble in part on problems discussed in these sessions.

Textbook: You will have access to my lecture notes via course website and there is no required textbook for this course. However, the following textbooks are recommended for reading and the additional material will also be borrowing from journal papers. Note that e-copies of first three books are freely available to download from UoM Library server. For some lectures, specific sections from these books will be assigned as reading assignments.

- *Bayesian computation with R* (Second Edition),
  Jim Albert, Springer (2009).
- *Applied Bayesian Statistics With R and OpenBUGS Examples*,
  Mary Kathryn Cowles, Springer (2013).
- *Introduction to Bayesian Statistics* (Third Edition),
  William Bolstad and James Curran, Wiley (2017).
- *Bayesian Theory* (Second Edition),
  José M. Bernardo and Adrian F. M. Smith, Wiley Series (1994).
- *Bayesian Data Analysis* (Second Edition),
  Andrew Gelman, John B. Carlin, Hal S. Stern and Donald B. Rubin, Chapman and Hall/CRC (2003).
- *The Bayesian Choice*, Christian P. Robert, Springer (1994).

Course Outline: The course aims to cover the following topics.

- Basic Review and Some History
  - The Role of Statistics in the Scientific Method
  - Main Approaches to Statistics
  - Sufficiency, Likelihood and Conditionality Principles
  - Computing via syzygy
- Introduction to Bayesian Paradigm
  - Likelihood, Prior and Posterior
  - Sequential Bayesian Updating
  - Types of Priors
  - Predictive Distributions
  - Credible Intervals
  - Hypothesis Testing
- Simulation Based Inference
  - Monte Carlo Methods in Bayesian Inference
  - Importance Sampling
  - Markov Chain Monte Carlo - MCMC
  - Gibbs and Metropolis-Hastings Algorithms
  - Assessing Convergence in MCMC
- Bayesian Models with Applications
  - Bayesian Inference for Statistical Distributions
  - Bayesian Regression Models
  - Handling Missing Data in Bayesian Models
- Further Topics
  - Hierarchical Models
  - Model Selection
  - Robustness and Sensitivity Analysis
  - Bayesian Decision-theoretic methods
  - Dirichlet Process
  - Bayesian Computation using BUGS

Important Dates: These dates are tentative and subject to change at the discretion of the instructor and/or based on the learning needs of the students but such changes are subject to Section 2.8 of the ROASS Procedure.

Preliminary Schedule	
Date	Task
Jan 18	First class - Online
Jan 26	First Lab - Online
Feb 8	Assignment 1 Due
Feb 16 – 19	Winter Term Break
Feb 26	Assignment 2 Due
March 15	Assignment 3 Due
March 19	In class Mid-Term Test
March 31	Voluntary Withdrawal (VW) Deadline
April 9	Assignment 4 Due
April 16	Last Class – Review

Other Important Information:

- **Academic Dishonesty:** It is important that you understand what constitutes academic dishonesty and that you are familiar with the very serious consequences. Links to resources that describe academic dishonesty (including plagiarism, cheating, inappropriate collaboration and examination impersonation, as well as typical penalties) can be found at: https://umanitoba.ca/student-supports/academic-supports/academic-integrity.
- **Class Communication:** The University requires all students to activate an official University email account. All communication between your instructor and you as a student must comply with the Electronic Communication with Students Policy. Please click here for further details. You are required to obtain and use your U of M email account for all communication between yourself and the university.
- **Student Accessibility Services:** If you are a student with a disability, please contact SAS for academic accommodation supports and services such as note-taking, interpreting, assistive technology and exam accommodations. Students who have, or think they may have, a disability (e.g. mental illness, learning, medical, hearing, injury-related, visual) are invited to contact SAS to arrange a confidential consultation. The details can be found at https://umanitoba.ca/student-supports/accessibility.
- **Copyrighted Material:** All course notes, assignments, tests, exams, computer codes and solutions are the intellectual property of your instructor. Reproduction or distribution of these materials is strictly forbidden without instructor's consent.
- **Recording of Class Lectures:** Your instructor and the University of Manitoba hold copyright over the course materials, presentations and lectures which form part of this course. No audio or video recording of lectures or presentations is allowed in any format, openly or surreptitiously, in whole or in part without permission from your instructor.
- **Use of Electronics in the Classroom:** It is the general University of Manitoba policy that all technology resources are to be used in a responsible, efficient, ethical and legal manner. A student may use technology in the classroom setting only for educational purposes approved by the instructor and/or the University of Manitoba Student Accessibility Services.
- **ROASS Schedule:** Schedule A of the Responsibilities of Academic Staff with regards to Students (ROASS) policies of the University of Manitoba lists resources and policies for students. It is important that you familiarize yourself with these resources and policies. Schedule A is available at https://sci.umanitoba.ca/statistics/courses-and-programs/outlines/.

Minimum technological requirements Students enrolled in this course must have are: access to a computer with an internet connection capable of streaming videos and downloading software, and access to a web-cam and microphone.