

Syllabus

Advanced Statistical Computation (STAT 605)

I Course Information

Course Details:

- Course Number: STAT 605
- Course Title: Advanced (Bayesian) Statistical Computation
- Section: 600
- Time: Monday / Wednesday: 12:40 – 1:55 pm
- Location: Blocker 411
- Credit Hours: 3

Instructor Details:

- Instructor: Dr. Debdeep Pati
- Office: Blocker 401 C
- Phone: (979) 845-3141
- E-Mail: debdeep@stat.tamu.edu (*When you send me an e-mail, use subject-line “[STAT605]”*)
- Office Hours: Monday / Wednesday: 4:00 – 5:00 pm **Online via zoom** (*If you are unable to meet at these times or want to meet in person, then schedule an appointment with the instructor for an alternative time.*)

Teaching Assistant Details: There is no teaching assistant for this course.

Course description: The course will cover advanced computational algorithms designed primarily for fitting complex Bayesian hierarchical models. These include MCMC, variational inference, Hamiltonian Monte Carlo, stochastic optimization among others. Lectures involve a general description of methodology followed by demonstration of algorithms. The computational techniques will be discussed without a concrete focus on a particular programming language. General guidance will be provided on how to make the codes/algorithms efficient, devise and run large scale simulations and submit jobs to high performance computing.

Course Prerequisites: Familiarity with basic parametric Bayesian hierarchical models and Markov chain Monte Carlo (MCMC) computation is assumed (STAT 632 or equivalent).

Course Learning Outcomes: The objective of the course is to familiarize students with Bayesian methods and advanced computational techniques for complex multivariate data. Methods will be motivated by real data applications in machine learning and biomedical science. The course will primarily have an applied and computational focus.

Textbooks (Recommended): The material will be based on the referred papers in class and the following books.

- *Christopher M. Bishop. Pattern Recognition and Machine Learning.*
- *Carl Edward Rasmussen and Christopher K. I. Williams. Gaussian Processes for Machine Learning, The MIT Press, 2006. ISBN 0-262-18253-X.* (Entire book available online at [\[Link\]](#))
- *Andrew Gelman, John Carlin, Hal Stern, David Dunson, Aki Vehtari, and Donald Rubin, Bayesian Data Analysis, 3rd Edition*
- *Peter Müller and Abel Rodriguez, Nonparametric Bayesian Inference, NSF-CBMS Conference Series in Probability and Statistics, 2013.*

Course Webpage:

- **Class website:** [\[Link\]](http://stat.tamu.edu/~debdeep/605_f21.html) http://stat.tamu.edu/~debdeep/605_f21.html.
- The class web site will have important information about the course.
- **Canvas:** To access the blackboard site go to <http://canvas.tamu.edu> and login using your NetID and password. Homeworks will be uploaded at canvas and will be required to be submitted via canvas. All other important information will be posted on the course webpage.

Grading policies: Your grade will be based on attendance and in-class participation (5%), homeworks (30%), paper presentation (25%), a final takehome (40%). The grade cutoffs are 90.0% for the lowest A, 80.0% for the lowest B, and 70.0% for the lowest C. However, these grade cutoffs may be adjusted downward at my discretion.

Late Work Policy: Late homeworks are not accepted.

Course schedule: Tentatively, we will cover following topics.

Probabilistic models for complex data:

1. Review of sampling techniques, bridge sampling (Week 1)
2. Random measures and clustering. (Weeks 2-3)
3. Latent feature models. (Week 3)
4. Variational Bayes. (Week 4)
5. Stochastic variational inference. (Weeks 4-5)
6. More expressive variational families. (Weeks 5-6).
7. Variable selection and shrinkage priors. (Week 7).
8. Hamiltonian dynamics and HMC. (Week 8).
9. Introduction to Bayesian curve fitting, construction of Gaussian processes, properties, applications in regression and classification. (Week 9)
10. Elliptical Slice sampling. (Week 10).
11. Shape constrained inference. (Week 11).
12. Categorical data analysis. (Week 12).
13. Distributed computation. (Week 13).
14. Paper presentation. (Last 2 classes: Week 14).

Computational methods:

1. Variational inference and stochastic optimization (Weeks 5 ,6, 7)
2. Hamiltonian Monte Carlo, Langevin dynamics and Metropolis-adjusted Langevin (Weeks 9, 11)
3. General techniques to speed up MCMC (matrix inversion techniques, subsampling, distributed stochastic gradient MCMC, elliptical slice sampler). (Weeks 5-10)

Software: We will primarily use R & MATLAB for data analysis. You are free to use whichever software you prefer.

Homeworks:

- There will be about 5 homeworks starting with homework zero (designed to evaluate preparedness for taking the course). Solution sketches may be provided or discussed in class. To receive credit for the homework you must show **all** work neatly, write in blue or black pen or pencil (never in red), clearly **label** each problem, **circle** your final answers (if applicable), **staple** your entire assignment together in the correct order with your **full name printed** (as appeared in the blackboard) on the first page. Assignments written in latex are also acceptable. Any homework violating any of these rules will receive a grade of **zero** for the entire assignment.
- Each homework carries equal weight.
- You are allowed to work with other students on the homework problems, however, verbatim copying of homework is absolutely forbidden and constitutes a violation of the Honor Code. Therefore, each student must ultimately produce his or her own homework to be turned in and graded.

Homework give out dates:

- Homework 0: End of first week.
- Homework 1: End of third week.
- Homework 2: End of fifth week.
- Homework 3: End of ninth week.
- Homework 4: End of eleventh week.

In-class paper presentation:

- Choose a paper of interest by Nov 1. (Should be related to the course content).
- Individual presentation during last week of classes. Time allotted: 15 minutes per person and 5 minutes for questions.
- You do not need to replicate results of the paper. You'll be evaluated based on your understanding of the ideas and quality of presentation.

Important dates:

- First date of classes: Aug 30
- Last day for adding/dropping courses for the fall semester. September 3, 5 p.m.
- Last day for all students to drop courses with no penalty (Q-drop). Nov 19, 5 p.m.
- Presentation group formed: Oct 1
- Choose paper of interest: Nov 1
- Reading day: Nov 24 (no class)
- In-class presentations: Dec 6 and Dec 8
- Last date of classes: Dec 8
- Take home give out date: Dec 14, 5 pm on canvas.
- Take home due date: Dec 16, 5 pm on canvas.

Attendance: You will get the 5% points for attendance and class participation if you do not miss more than four classes and actively participate in the discussion. Please note that if you miss more, except in very special cases, you will get 0% on attendance. You are strongly encouraged to attend all classes. Regarding the university attendance policy, refer to [Student Rule 7](#).

II University Policies

Attendance policy: The university views class attendance and participation as an individual student responsibility. Students are expected to attend class and to complete all assignments. Please refer to [Student Rule 7](#) in its entirety for information about excused absences, including definitions, and related documentation and timelines.

Makeup Work Policy: Students will be excused from attending class on the day of a graded activity or when attendance contributes to a student's grade, for the reasons stated in [Student Rule 7](#), or other reason deemed appropriate by the instructor. Please refer to [Student Rule 7](#) in its entirety for information about makeup work, including definitions, and related documentation and timelines.

Absences related to Title IX of the Education Amendments of 1972 may necessitate a period of more than 30 days for make-up work, and the timeframe for make-up work should be agreed upon by the student and instructor ([Student Rule 7, Section 7.4.1](#)).

"The instructor is under no obligation to provide an opportunity for the student to make up work missed because of an unexcused absence" ([Student Rule 7, Section 7.4.2](#)).

Students who request an excused absence are expected to uphold the Aggie Honor Code and Student Conduct Code. (See [Student Rule 24](#)).

Academic Integrity Statement and Policy:

"An Aggie does not lie, cheat or steal, or tolerate those who do."

Texas A&M University students are responsible for authenticating all work submitted to an instructor. If asked, students must be able to produce proof that the item submitted is indeed the work of that student. Students must keep appropriate records at all times. The inability to authenticate one's work, should the instructor request it, may be sufficient grounds to initiate an academic misconduct case. ([Section 20.1.2.3, Student Rule 20](#)).

You can learn more about the Aggie Honor System Office Rules and Procedures, academic integrity, and your rights and responsibilities at aggiehonor.tamu.edu.

Americans with Disabilities Act (ADA) Policy: Texas A&M University is committed to providing equitable access to learning opportunities for all students. If you experience barriers to your education due to a disability or think you may have a disability, please contact Disability Resources in the Student Services Building or at (979) 845-1637 or visit disability.tamu.edu. Disabilities may include, but are not limited to attentional, learning, mental health, sensory, physical, or chronic health conditions. All students are encouraged to discuss their disability related needs with Disability Resources and their instructors as soon as possible.

Title IX and Statement on Limits to Confidentiality: Texas A&M University is committed to fostering a learning environment that is safe and productive for all. University policies and federal and state laws prohibit gender-based discrimination and sexual harassment, including sexual assault, sexual exploitation, domestic violence, dating violence, and stalking.

With the exception of some medical and mental health providers, all university employees (including full and part-time faculty, staff, paid graduate assistants, student workers, etc.) are Mandatory Reporters and must report to the Title IX Office if the employee experiences, observes, or becomes aware of an incident that meets the following conditions (see [University Rule 08.01.01.M1](#)):

- The incident is reasonably believed to be discrimination or harassment.
- The incident is alleged to have been committed by or against a person who, at the time of the incident, was (1) a student enrolled at the University or (2) an employee of the University.

Mandatory Reporters must file a report regardless of how the information comes to their attention - including but not limited to face-to-face conversations, a written class assignment or paper, class discussion, email, text, or social media post. Although Mandatory Reporters must file a report, in most instances, you will be able to control how the report is handled, including whether or not to pursue a formal investigation. The University's goal is to make sure you are aware of the range of options available to you and to ensure access to the resources you need. Students wishing to discuss concerns in a confidential setting are encouraged to make an appointment with [Counseling and Psychological Services \(CAPS\)](#). Students can learn more about filing a report, accessing supportive resources, and navigating the Title IX investigation and resolution process on the University's [Title IX webpage](#).

Statement on Mental Health and Wellness: Texas A&M University recognizes that mental health and wellness are critical factors that influence a student's academic success and overall wellbeing. Students are encouraged to engage in proper self-care by utilizing the resources and services available from Counseling & Psychological Services (CAPS). Students who need someone to talk to can call the TAMU Helpline (979-845-2700) from 4:00 p.m. to 8:00 a.m. weekdays and 24 hours on weekends. 24-hour emergency help is also available through the National Suicide Prevention Hotline (800-273-8255) or at [suicidepreventionlifeline.org](https://www.suicidepreventionlifeline.org).

Personal Illness and Quarantine: Students required to quarantine must participate in courses and course-related activities remotely and must not attend face-to-face course activities. Students should notify their instructors of the quarantine requirement. Students under quarantine are expected to participate in courses and complete graded work unless they have symptoms that are too severe to participate in course activities.

Students experiencing personal injury or illness that is too severe for the student to attend class qualify for an excused absence (See [Student Rule 7, Section 7.2.2.](#)) To receive an excused absence, students must comply with the documentation and notification guidelines outlined in [Student Rule 7](#). While [Student Rule 7, Section 7.3.2.1](#), indicates a medical confirmation note from the student's medical provider is preferred, for Fall 2020 only, students may use the Explanatory Statement for Absence from Class in lieu of a medical confirmation. Students must submit the Explanatory Statement for Absence from Class within two business days after the last date of absence.

COVID Syllabus Statement for Fall 2021: To help protect Aggieland and stop the spread of COVID-19, Texas A&M University urges students to be vaccinated and to wear masks in classrooms and all other academic facilities on campus, including labs. Doing so exemplifies the Aggie Core Values of respect, leadership, integrity, and selfless service by putting community concerns above individual preferences. COVID-19 vaccines and masking - regardless of vaccination status - have been shown to be safe and effective at reducing spread to others, infection, hospitalization, and death.

III College and Department Policies

College and departmental units may establish their own policies and minimum syllabus requirements. As long as these policies and requirements do not contradict the university level requirements, colleges and departments can add them in this section.