Advanced (Bayesian) Statistical Computation - STAT 605
Fall 2018 (Monday / Wednesday: 2:30 – 3:45 pm) at Blocker 411

Course description: The course will cover advanced computational algorithms designed primarily for fitting complex Bayesian models. These include MCMC, variational inference, Hamiltonian Monte Carlo, stochastic optimization, discrete first order methods, 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.

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

Instructor Information: Dr. Debdeep Pati
- Email: debdeep@stat.tamu.edu (When you send me an e-mail, use subject-line “[STAT605]”)
- Office: Blocker 401C, Ph: (979) 845-3141
- Office Hours: Monday / Wednesday: 3:45 – 4:45 pm (If you are unable to meet at these times, then schedule an appointment with the instructor for an alternative time.)
- No Teaching Assistants are assigned for this course. Feel free to ask questions anytime by email or schedule appointment for meeting.

Course Webpage:
- The class web site will have important information about the course.
- Ecampus: To access the blackboard site go to http://ecampus.tamu.edu and login using your NetID and password. Only grades will be posted on that site and you can access it. All the important information will be posted on the course webpage.

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.
- Andrew Gelman, John Carlin, Hal Stern, David Dunson, Aki Vehtari, and Donald Rubin, Bayesian Data Analysis, 3rd Edition

Course objective: 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.

Course topics & calendar of activities: Tentatively, we will cover following topics.

Probabilistic models for complex data:
1. Review of Parametric Bayesian models and computation (Week 1)
2. Introduction to probabilistic modeling for distributions. (Weeks 2-3)
3. Mixture models and clustering. (Week 3)
4. Latent feature models. (Week 4)
5. Introduction to Bayesian curve fitting, construction of Gaussian processes, properties, applications in regression and classification. (Weeks 5-8)

6. Variable selection in high-dimensions, shrinkage priors. (Weeks 9-11)

7. Bayesian models for graphs and probability tensors. (Week 12-13)

Computational methods:
1. Variational inference and stochastic optimization (Week 3)
2. Hamiltonian Monte Carlo, Langevin dynamics and Metropolis-adjusted Langevin (Weeks 5-10)
3. General techniques to speed up MCMC (matrix inversion techniques, subsampling, distributed stochastic gradient MCMC, elliptical slice sampler). (Weeks 5-10)
4. Discrete first order methods (Weeks 8-10)

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

Grading policies: Your grade will be based on attendance and in-class participation (10%), homeworks (35%), 1 final (group) project (55%). The project involves a proposal submission by Oct 15 and a presentation (last week of classes) & final report submission by Dec 11. 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.

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 nineth week.
- Homework 4: End of eleventh week.

Important dates:
- Project proposal submission: Oct 15 (Mon), 5 pm CT by email to me.
- Project presentation: Last week.
- Final project report submission: Dec 11 (Tue), 5 pm CT by email to me.
**Attendance:** You will get the 10% 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 [http://student-rules.tamu.edu/rule07](http://student-rules.tamu.edu/rule07).

**Make up policy:** If an absence is excused, the instructor will either provide the student an opportunity to make up any quiz, exam or other work that contributes to the final grade or provide a satisfactory alternative by a date agreed upon by the student and instructor. If the instructor has a regularly scheduled make up exam, students are expected to attend unless they have a university approved excuse. The make-up work must be completed in a timeframe not to exceed 30 calendar days from the last day of the initial absence. The student is responsible for providing satisfactory evidence to the instructor to substantiate the reason for the absence. Among the reasons absences are considered excused by the university are the following (see Student Rule 7 for details [http://student-rules.tamu.edu/rule07](http://student-rules.tamu.edu/rule07)). The fact that these are university-excused absences does not relieve the student of responsibility for prior notification and documentation. Failure to notify and/or document properly may result in an unexcused absence and the student will get 0% on the attendance. Falsification of documentation is a violation of the Honor Code.

1. Participation in an activity that is required for a class and appears on the university authorized activity list at [https://stuactonline.tamu.edu/app/sponsauth/index](https://stuactonline.tamu.edu/app/sponsauth/index)

2. Death or major illness in a student’s immediate family.

3. Illness of a dependent family member.

4. Participation in legal proceedings or administrative procedures that require a student’s presence.

5. Religious holy day. NOTE: Prior notification is NOT required.

6. Injury or illness that is too severe or contagious for the student to attend class.
   
   (a) Injury or illness of three or more class days: Student will provide a medical confirmation note from his or her medical provider within one week of the last date of the absence (see Student Rules 7.1.6.1)
   
   (b) Injury or illness of less than three class days: Student will provide one or both of these (at instructor’s discretion), within one week of the last date of the absence:
      
      i. Texas A&M University Explanatory Statement for Absence from Class form available at [http://attendance.tamu.edu](http://attendance.tamu.edu).
      
      ii. Confirmation of visit to a health care professional affirming date and time of visit.
   
   (c) An absence for a non-acute medical service does not constitute an excused absence.

7. Required participation in military duties.

8. Mandatory admission interviews for professional or graduate school that cannot be rescheduled.

9. Mandatory participation as a student-athlete in NCAA-sanctioned competition.

10. In accordance with Title IX of the Educational Amendments of 1972, Texas A&M University shall treat pregnancy (childbirth, false pregnancy, termination of pregnancy and recovery therefrom) and related conditions as a justification for an excused absence for so long a period of time as is deemed medically necessary by the student’s physician. Requests for excused absence related to pregnancy should be directed to the instructor.

Other absences may be excused at the discretion of the instructor with prior notification and proper documentation. In cases where prior notification is not feasible (e.g., accident or emergency) the student must provide notification by the end of the second working day after the absence, including an explanation of why notice could not be sent prior to the class. Accommodations sought for absences due to the observance of a religious holiday can be sought either prior or after the absence, but not later than two working days after the absence.

**Statement on Disabilities:** The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other
things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact Disability Services, currently located in the Disability Services building at the Student Services at White Creek complex on west campus or call 979-845-1637. For additional information visit [http://disability.tamu.edu/](http://disability.tamu.edu/)

**Statement on Plagiarism:** The handouts used in this course are copyrighted. By “handouts”, I mean all materials generated for this class, which include but are not limited to syllabi, quizzes, exams, lab problems, in-class materials, review sheets, and additional problem sets. Because these materials are copyrighted, you do not have the right to copy the handouts, unless I expressly grant permission. As commonly defined, plagiarism consists of passing off as one’s own ideas, words, writing, etc., which belong to another. In accordance with this definition, you are committing plagiarism if you copy the work of another person and turn it in as your own, even if you should have the permission of that person. Plagiarism is one of the worst academic sins, for the plagiarist destroys the trust among colleagues without which research cannot be safely communicated. If you have any questions regarding plagiarism, please consult the latest issue of the Texas A&M University Student Rules, under the Section “Honor System Rules.” Refer to [http://aggiehonor.tamu.edu](http://aggiehonor.tamu.edu) if you have questions or concerns.

**Academic Honor System:** “An Aggie does not lie, cheat, or steal or tolerate those who do”. Academic dishonesty cases will be handled in accordance the University’s policies. Please see [http://aggiehonor.tamu.edu](http://aggiehonor.tamu.edu) for the complete Honor Council Rules and Procedures.