Key information

Course title: CSCI 599 Advanced Topics in Statistical Machine Learning
Instructor: Prof. Fei Sha (Office: RTH 403)
Time: Mondays and Wednesdays 10:00am – 11:30am
Classroom: TBD
Recommended Preparation: CSCI 567 (Machine Learning) or EE 559 (Mathematical Pattern Recognition), and an approval from the instructor
Enrollment limit: 25

Catalogue description: Advanced topics in machine learning, including algorithms and theoretical analysis of deep learning, kernel methods and computational statistics such as Monte Carlo Markov Chain (MCMC) methods

Course description: This course covers several advanced topics in machine learning, organized in three modules: deep learning, kernel methods and MCMC. Those topics are not only under active research by the machine learning community but also are of overwhelming success and great importance to many practical application areas. Specific topics include but are not limited to: various deep learning architectures and associated parameter estimation techniques, understanding why deep learning architectures are effective, large-scale kernel methods, novel applications of kernel methods for studying probabilistic structures in data, efficient MCMC sampling methods for exploring large spaces and methods for scaling MCMC to large problems. The course will be taught in instructor-led lectures and student-led discussion and presentations of original research articles. Students will be exposed to state-of-the-art research in machine learning through paper reading and presentation, and be assessed in their critical analysis of those research papers, as well as a course project.

Format

instructor-led lectures; student-led presentations, discussions and critical analysis; course project

Student Work and Grading Policy

- Each student is required to present 2 to 3 papers (depending on the enrollments) to the classroom. (Grading portion: 25%)

- Each student is required to participate a literature review/research-paper-selection process to select the most recent research papers to present. This process occurs 3 times and at each time, 4 papers need to be selected from the NIPS 2014 conference proceeding. (Grading portion: 15%)

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• Every student is required to write independently an at least two-page summary of the assigned readings for each week. (Grading portion: 20%)

• Each student is required to finish a course project by preparing a two-page project proposal, turn in a mid-term project report and a final project report. (If the enrollment is high, this could be relaxed into a group course project where the number of team members is at most 3.) (Grading portion: 40%)

Required textbooks

Required background reading material as well as original research articles are listed in detail in the planned schedule.

Tentative Schedule

Module I: Deep Learning Architectures

• Week 1 Introduction to Deep Learning Architectures
  Required reading

• Week 2 Deep Dive into Various Architectures (I)
  Required reading
  P. Vincent, et al. Stacked denoising autoencoders: Learning useful representations in a deep network with a local denoising criterion. JMLR. 2010

• Week 3 Deep Dive into Various Architectures (II)
  Required reading
R. Gens and P. Domingos. Discriminative Learning of Sum-Product Networks. NIPS 2012

- **Week 4** Dropout and regularization in (deep) learning
  **Required reading**
  S. Wang, C. Manning. Fast dropout training. ICML 2013
  I. Goodfellow et al. Maxout networks. ICML. 2013

- **Week 5** Is deep learning really needed?
  **Required reading**
  Y. Bengio and O. Delalleau. ?On the expressive power of deep architectures.? ALT. 2011
  Roi Livni, Shai Shalev-Shwartz, Ohad Shamir. Provably Efficient Algorithms for Training Deep Networks. ArXiv. 2013

- **Week 6** Selected papers in NIPS 2014 on Deep Learning
  **Required reading**
  Students are required to select 4 papers on deep learning from NIPS 2014 to present. The IDs of the papers are to be approved by the instructor at Week 4.
Module II: Kernel Methods

- **Week 7** *Introduction and Review of Kernel Methods*
  
  **Required reading**

- **Week 8** *Large-scale Kernel Methods via Random Features*
  
  Raffay Hamid, Ying Xiao, Alex Gittens, and Dennis DeCoste. Compact Random Feature Maps. ICML 2014

- **Week 9** *Kernel Methods for Probability Structure Discovery*
  
  **Required reading**
  L. Song et al. Hilbert Space Embeddings of Conditional Distributions. ICML. 2009
  D. Lopez-Paz, P. Hennig and B. Schölkopf. The Randomized Dependence Coefficient. NIPS 2013
  A. Gretton, O. Bousquet, A. Smola, and B. Schölkopf. Measuring statistical dependence with Hilbert-Schmidt norms. ALT 2005

- **Week 10** *Shallow or Deep: kernel methods vs. Neural Networks*
  
  **Required reading**

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Andreas C. Damianou, Neil D. Lawrence. Deep Gaussian Processes. AISTATS 2014

- **Week 11** selected papers NIPS 2014 papers on Kernel Method
  **Required reading**
  Students are required to select 4 papers on kernel methods from NIPS 2014 to present. The IDs of the papers are to be approved by the instructor at Week 9.

**Module III: Monte Carlo Markov Chain (MCMC)**

- **Week 12** Introduction and Review of MCMC
  **Required reading**

- **Week 13** Slice sampling, HMC, etc
  **Required reading**
  R. Neal. MCMC using Hamiltonian dynamics. Handbook of Markov Chain Monte Carlo. 2011
  S. Sisson. Transdimensional Markov Chains: A Decade of Progress and Future Perspectives. JASA. 2005
  I, Murray, Z. Ghahramani and D. J. C. MacKay. MCMC for doubly-intractable distributions. UAI. 2012

- **Week 14** Large-scale MCMC
  T. Chen, E. Fox and C. Guestrin. Stochastic Gradient Hamiltonian Monte Carlo. ICML. 2014

- **Week 15** Selected papers in NIPS 2014 on MCMC
  **Required reading**
Students are required to select 4 papers on MCMC from NIPS 2014 to present. The IDs of the papers are to be approved by the instructor at Week 13.

**Statement for Encouraging All Students to Be Active Participants**  The diversity of the participants in this course is a valuable source of ideas, problem solving strategies, and engineering creativity. I encourage and support the efforts of all of our students to contribute freely and enthusiastically. We are members of an academic community where it is our shared responsibility to cultivate a climate where all students and individuals are valued and where both they and their ideas are treated with respect, regardless of their differences, visible or invisible.

**Statement on Academic Conduct**  Plagiarism—presenting someone else’s ideas as your own, either verbatim or recast in your own words—is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Section 11, Behavior Violating University Standards https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.  

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity http://equity.usc.edu or to the Department of Public Safety http://capsnet.usc.edu/department/public-safety/online-forms/contact-us. This is important for the safety of the whole USC community. Another member of the university community such as a friend, classmate, advisor, or faculty member can help initiate the report, or can initiate the report on behalf of another person. The Center for Women and Men http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage http://sarc.usc.edu describes reporting options and other resources.

**Statement on Support Systems**  A number of USC’s schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the American Language Institute http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students. The Office of Disability Services and Programs http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, USC Emergency Information http://emergency.usc.edu will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.