CSC 696H: Advanced Topics in Artificial Intelligence

(Topic: Advanced Probabilistic Graphical Models)

Mon / Wed : 12:30pm – 1:45pm : Gould-Simpson, Rm 701

Description of Course

This seminar course will expand on the concepts introduced in CSC 535. The primary aim of this course is to explore advanced techniques in probabilistic graphical models (PGMs) and statistical machine learning (ML) more broadly. Students will develop the ability to apply these techniques to their own research. Students will learn to perform statistical inference and reasoning in complex probabilistic statistical models. The course will survey state-of-the-art ML research including: variational inference, advanced Markov chain Monte Carlo sampling, Bayesian nonparametrics, Bayesian optimization, and Bayesian Deep Learning. Upon conclusion of this course students will be capable of developing new methods and advancing the state-of-the-art in ML and PGM research.

Course Prerequisites

To successfully complete this course, students should have the following skills:

- Basic probability: distributions, marginalization, conditional probability, Bayes' rule
- Familiarity with probabilistic graphical models: Markov random fields, factor graphs, Bayes nets
- At least an undergraduate level understanding of linear algebra, calculus, and some familiarity with concepts in nonlinear and discrete optimization
- Advanced programming (to complete term project)

Instructor and Contact Information

Instructor:

Jason Pacheco, GS 724, Email: pachecoj@cs.arizona.edu

Office Hours: Thursday, 10:00-11:30am

Web Information:

Course Homepage: http://pachecoj.com/courses/csc696h_fall2022

D2L: https://d2l.arizona.edu/d2l/home/1205997

Piazza: https://piazza.com/arizona/fall2022/csc696h1

Instructor Homepage: http://pachecoj.com

Course Format and Teaching Methods

Each class will combine instructor lectures with student presentations of assigned readings. In addition, each student must present the results of a term project of their choosing during the final period.

Obtaining Help

- **Advising:** If you have questions about your academic progress this semester, or your chosen degree program, consider contacting your graduate program coordinator and faculty advisor. Your program coordinator, faculty advisor, and the Graduate Center can guide you toward university resources to help you succeed. **Computer Science students** are encouraged to email gradadvising@cs.arizona.edu for advising related questions.

- **Life challenges:** If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office can be reached at 520-621-2057 or DOS-deanofstudents@email.arizona.edu.
- **Physical and mental-health challenges**: If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care. For medical appointments, call (520-621-9202. For After Hours care, call (520) 570-7898. For the Counseling & Psych Services (CAPS) 24/7 hotline, call (520) 621-3334.

Class Recordings

For lecture recordings, which are used at the discretion of the instructor, students must access content in D2L only. Students may not modify content or re-use content for any purpose other than personal educational reasons. All recordings are subject to government and university regulations. Therefore, students accessing unauthorized recordings or using them in a manner inconsistent with UArizona values and educational policies (Code of Academic Integrity and the Student Code of Conduct) are also subject to civil action.

Course Objectives

The primary objective of this course is to provide students a deeper understanding and familiarity with advanced topics in PGMs and statistical ML, as well as recent research in these areas. Our primary focus will be algorithms for Bayesian posterior inference in hierarchical statistical models. Planned topics will include:

Introductory foundations
- Probability and Statistic Primer
- Bayesian Inference
- Probabilistic Graphical Models

Variational Inference
- Exponential families
- Mean field variational
- Stochastic variational
- Loopy Belief Propagation
- Expectation Propagation

Advanced Monte Carlo Methods
- Advanced Particle Filters
- Hamiltonian Markov chain Monte Carlo (MCMC)
- Reversible Jump Markov chain Monte Carlo (RJMCMC)

Gaussian Processes and Bayesian Optimization

Bayesian Deep Learning

Expected Learning Outcomes

Upon conclusion of this course, students will have learned to read, understand, and critique machine learning research articles. Students will demonstrate their understanding of articles through class presentations and critical summaries. Through assigned readings, students will be

familiar with state-of-the-art research in key areas of statistical machine learning and PGMs. Students will apply these techniques to their own research, which will be assessed through term projects.

Absence and Class Participation Policy

The UA's policy concerning Class Attendance, Participation, and Administrative Drops is available at https://catalog.arizona.edu/policy/class-attendance-and-participation

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable: http://policy.arizona.edu/human-resources/religious-accommodation-policy.

Absences pre-approved by the UA Dean of Students (or dean's designee) will be honored. See https://deanofstudents.arizona.edu/policies/attendance-policies-and-practices

Participating in the course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all lectures. Absences may affect a student's final course grade. If you anticipate being absent, are unexpectedly absent, or are unable to participate in class online activities, please contact me as soon as possible. To request a disability-related accommodation to this attendance policy, please contact the Disability Resource Center at (520) 621-3268 or drc-info@email.arizona.edu. If you are experiencing unexpected barriers to your success in your courses, the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office is located in the Robert L. Nugent Building, room 100, or call 520-621-7057.

Illnesses and Emergencies

- If you feel sick, or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel.
- Notify your instructor(s) if you will be missing up to one week of course meetings and/or assignment deadlines.
- If you must miss the equivalent of more than one week of class and have an emergency, the Dean of Students is the proper office to contact (DOS-deanofstudents@email.arizona.edu). The Dean of Students considers the following as qualified emergencies: the birth of a child, mental health hospitalization, domestic violence matter, house fire, hospitalization for physical health (concussion/emergency surgery/coma/COVID-19 complications/ICU), death of immediate family, Title IX matters, etc.
- Please understand that there is no guarantee of an extension when you are absent from class and/or miss a deadline.

Statement on compliance with COVID-19 mitigation guidelines: As we enter the semester, your and my health and safety remain the university's highest priority. To protect the health of everyone in this class, students are required to follow the university guidelines on COVID-19 mitigation. Please visit www.covid19.arizona.edu.

Makeup Policy for Students Who Register Late

Late registrants are required to complete all reading assignments that were missed. They will be required to submit reading summaries of the assignments and to view lecture recordings for the aforementioned topics.

Course Communications

Online communication will be conducted via Piazza. Grade feedback will be provided via D2L.

Required Texts and Materials

Required readings will be made available electronically, and on a weekly basis, as the course progresses.

Scheduled Topics/Activities

Week 1: Introduction + Course Mechanics
Week 2: Probability Primer
Week 3: Exponential Families
Week 4: Variational Inference (Mean Field)
Week 5: Variational Inference (Stochastic Variational)
Week 6: Variational Inference (Loopy Belief Propagation)
Week 7: Variational Inference (Expectation Propagation)
Week 8: Monte Carlo Methods
Week 9: Advanced Particle Filters
Week 10: Hamiltonian Monte Carlo / No U-Turn Sampler
Week 11: Gaussian Processes
Week 12: Bayesian Optimization
Week 13: Bayesian Deep Learning
Week 14: Variational Autoencoder
Week 15: Dropout Monte Carlo
Week 16: Wrapup and Project Presentations

Final Examination or Project

The course will not have a final exam, but will instead have a semester project. The final project report will be due on the scheduled exam date Wed ,12/14.

Grading Scale and Policies

Students shall submit a critical summary for each assigned reading. To receive full credit, summaries must demonstrate that the student has adequately read and critiqued the material. Each student will additionally select among assigned papers and prepare two separate 1hr presentations to the class in which they explain key technical details of the reading. To receive full credit for class participation, students must attend and participate in the discussion of all classes. Students should contact the instructor regarding absences for make-up. Finally, term project grading will be assessed based on how well the idea is conceived, planned, executed, and presented.

Grading Breakdown

Attendance / participation:	10%
Paper presentation:	20%
Critical reading summaries:	20%
Term project proposal:	10%
Term project (presentation and writeup):	40%

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete and http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal, respectively.

All grade items will receive grades and feedback within one week of their due date. Any due dates will be provided in the syllabus and on the course webpage. Any deviation from the planned schedule or grading delays will be announced in class and on Piazza.

Dispute of Grade Policy: The student is required to notify the instructor of any grading dispute within 1 week of receiving the grade.

Department of Computer Science Code of Conduct

The Department of Computer Science is committed to providing and maintaining a supportive educational environment for all. We strive to be welcoming and inclusive, respect privacy and confidentiality, behave respectfully and courteously, and practice intellectual honesty. Disruptive behaviors (such as physical or emotional harassment, dismissive attitudes, and abuse of department resources) will not be tolerated. The complete Code of Conduct is available on our department web site. We expect that you will adhere to this code, as well as the UA Student Code of Conduct, while you are a member of this class.

Classroom Behavior Policy

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Students are asked to refrain from disruptive conversations with people sitting around them during lecture. Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

Threatening Behavior Policy

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students.

Accessibility and Accommodations

At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience barriers based on disability or pregnancy, please contact the Disability Resource Center (520-621-3268, https://drc.arizona.edu/) to establish reasonable accommodations.

Code of Academic Integrity

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See https://deanofstudents.arizona.edu/student-rights-responsibilities/academic-integrity .

Uploading material from this course to a website other than D2L (or the class piazza) is strictly prohibited and will be considered a violation of the course policy and a violation of the code of academic integrity. Obtaining material associated with this course (or previous offerings of this course) on a site other than D2L (or the class piazza), such as Chegg, Course Hero, etc. or

accessing these sites during a quiz or exam is a violation of the code of academic integrity. Any student determined to have uploaded or accessed material in an unauthorized manner will be reported to the Dean of Students for a Code of Academic Integrity violation, with a recommended sanction of a failing grade in the course.

The University Libraries have some excellent tips for avoiding plagiarism, available at https://new.library.arizona.edu/research/citing/plagiarism.

Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

Nondiscrimination and Anti-harassment Policy

The University of Arizona is committed to creating and maintaining an environment free of discrimination. In support of this commitment, the University prohibits discrimination, including harassment and retaliation, based on a protected classification, including race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, or genetic information. For more information, including how to report a concern, please see http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

Additional Resources for Students

UA Academic policies and procedures are available at http://catalog.arizona.edu/policies
Visit the UArizona COVID-19 page for regular updates.

Campus Health
http://www.health.arizona.edu/
Campus Health provides quality medical and mental health care services through virtual and in-person care. Voluntary, free, and convenient COVID-19 testing is available for students on Main Campus. COVID-19 vaccine is available for all students at Campus Health.
Phone: 520-621-9202

Counseling and Psych Services (CAPS)
https://health.arizona.edu/counseling-psych-services
CAPS provides mental health care, including short-term counseling services.
Phone: 520-621-3334

The Dean of Students Office's Student Assistance Program
https://deanofstudents.arizona.edu/support/student-assistance
Student Assistance helps students manage crises, life traumas, and other barriers that impede success. The staff addresses the needs of students who experience issues related to social adjustment, academic challenges, psychological health, physical health, victimization, and relationship issues, through a variety of interventions, referrals, and follow up services.
Email: DOS-deanofstudents@email.arizona.edu
Phone: 520-621-7057

Survivor Advocacy Program

https://survivoradvocacy.arizona.edu/
The Survivor Advocacy Program provides confidential support and advocacy services to student survivors of sexual and gender-based violence. The Program can also advise students about relevant non-UA resources available within the local community for support.
Email: survivoradvocacy@email.arizona.edu
Phone: 520-621-5767

Campus Pantry

Any student who has difficulty affording groceries or accessing sufficient food to eat every day, or who lacks a safe and stable place to live and believes this may affect their performance in the course, is urged to contact the Dean of Students for support. In addition, the University of Arizona Campus Pantry is open for students to receive supplemental groceries at no cost. Please see their website at: *campuspantry.arizona.edu* for open times.

Furthermore, please notify me if you are comfortable in doing so. This will enable me to provide any resources that I may possess.

Pronouns and Preferred Names

This course affirms people of all gender expressions and gender identities. If you prefer to be called a different name than what is on the class roster, please let me know. Feel free to correct instructors on your pronoun. If you have any questions or concerns, please do not hesitate to contact me directly in class or via email (instructor email). If you wish to change your preferred name or pronoun in the UAccess system, please use the following guidelines:

Preferred name: University of Arizona students may choose to identify themselves within the University community using a preferred first name that differs from their official/legal name. A student's preferred name will appear instead of the person's official/legal first name in select University-related systems and documents, provided that the name is not being used for the purpose of misrepresentation. Students are able to update their preferred names in UAccess.

Pronouns: Students may designate pronouns they use to identify themselves. Instructors and staff are encouraged to use pronouns for people that they use for themselves as a sign of respect and inclusion. Students are able to update and edit their pronouns in UAccess.

More information on updating your preferred name and pronouns is available on the Office of the Registrar site at https://www.registrar.arizona.edu/.

Safety on Campus and in the Classroom

Familiarize yourself with the UA Critical Incident Response Team plans:
https://cirt.arizona.edu/

Department of Computer Science Evacuation Plan for Gould-Simpson:
https://drive.google.com/file/d/1iR1IcGcV_BgbGnEFBzZ2-do0FbLC3cvo/view?usp=sharing

Also watch the video available at https://ua-saem-aiss.narrasys.com/#/story/university-of-arizona-cert/active-shooter

Confidentiality of Student Records

http://www.registrar.arizona.edu/personal-information/family-educational-rights-and-privacy-act-1974-ferpa?topic=ferpa

Land Acknowledgement Statement

We respectfully acknowledge the University of Arizona is on the land and territories of Indigenous peoples. Today, Arizona is home to 22 federally recognized tribes, with Tucson being home to the O'odham and the Yaqui. Committed to diversity and inclusion, the University strives to build sustainable relationships with sovereign Native Nations and Indigenous communities through education offerings, partnerships, and community service.

Subject to Change Statement

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.