CSC 696H

Seminar on advanced topics in artificial intelligence

Optimization and sampling for computational intelligence research

Fall 2020, MW 12:30-1:45 MST, ONLINE

Description of the Course

Overview. Most problems in AI involve representing one's problem mathematically as function over quantities or values of interest so that high (or low) values of this *objective* function occur for good solutions. Finding a good solution amounts to maximizing or minimizing this function. Alternatively, we might seek to characterize the space of solutions with respect to that function, which is usually addressed by sampling methods for intractable problems in AI. We further break the function of interest into two cases: 1) when the parameters are about multiple instances (learning); and 2) when the parameters are about a single instance (fitting). Doing this optimization in most real problems is intractable, and most effort is expended in those cases, but PhD students should also know some of the theoretical aspects that help one recognize when a problem is in fact tractable, or is likely have to a good approximation.

Implementation. This course will combine basic readings and lectures about important optimization methods with presentations, and discussions on more in-depth and current research-oriented papers on optimization, estimation, and sampling. The final topic areas will be decided based on the makeup of the class, but is expected to include most, if not all of the following.

- Basic preparation and building blocks including least squares, Lagrange multipliers, conjugate gradient descent.
- Convex optimization for continuous values
- Neural network training (e.g., stochastic gradient descent and alternatives).
- Integer programming
- Convex optimization for discrete variables
- EM and related methods
- Basic MCMC methods.
- Variational methods
- Advanced MCMC methods

In addition, students will implement optimization and/or estimation and/or sampling methods as part of three technical projects. Students will be encouraged to be creative regarding project domains, and, in particular, will be encouraged to make project work relevant to their research. In addition, this course will have significant components of research methods, presentation, and writing.

Course Prerequisites or Co-requisites

MATH 223 and MATH 313 or equivalent math background. MATH 464 or alternative courses that covers basic discrete and continuous probability. CSC 345 or equivalent preparation in algorithms, data structures, and programming.

Instructor and Contact Information

Instructor:

Kobus Barnard, kobus@cs.arizona.edu

Office Hours: By appointment

Web information:

Course home page: http://vision.cs.arizona.edu/teaching/cs696H/fall20

Instructor home page: http://kobus.ca

We will use D2L and Piazza for this course

CSC COVID 19 Policy:

All Fall 2020 CSC courses, whether In-Person, In-Person Flex, or Live Online, will provide recorded lectures for students along with office hour accommodations via Zoom. Additionally, In-Person and In-Person Flex courses will accommodate students who cannot attend class to take midterm exams and attendance will not be factored into final grades.

Course Format and Teaching Methods

Seminar format. This entails some lectures by the instructor, some lectures and presentations by the students, and open discussion. There will be significant project work, and projects will be presented and formally written up.

This class is scheduled to be taught in the LIVE ONLINE modality.

Meeting Times: The class will meet MW from 12:30 to 1:45 (MST) via Zoom. Our synchronous meetings will give us the opportunity to present to an audience and engage in extensive discussion. In addition to discussion of the content, we will budget time to provide live feedback to student presenters, with follow-up email feedback.

All meetings will be recorded and made available. If you are not able to attend a synchronous meeting, you will be expected to provide some feedback via email regarding any student presentations that are not able to join in person. If you are not able to attend a synchronous meeting when you are scheduled to present, you will be responsible for providing a recording of your presentation, which those attending will watch and comment on.

Class attendance: As above, this is a synchronous on-line course, where attendance at the prescribed time will not factor into grades.

Pandemic-Related Information for All Modalities

- **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.

- **Exams**: As this is a seminar class, there will be no formal exams.
- **Equipment and software requirements**: For this class you will need daily access to the following hardware: computer or web-enabled device with webcam and microphone; regular access to reliable internet signal; ability to download and run the following software: web browser, Adobe Acrobat, a programming environment (e.g., Matlab, Python, C), and a method to create reports and provide them in PDF format (e.g., Latex or Microsoft word; if you use word, it is recommended (but not required) that you consider the Mathtype equation editor).
- **Staying current:** You are required to complete the readings, email feedbacks, topic, paper, and project presentations, and project work and written reports of them on your own time to achieve the broad course objectives listed below.
  Class Recordings: For lecture recordings, 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 are subject to suspension or civil action.

Course Objectives and Expected Learning Outcomes

The broad objectives are this course are to develop a solid fundamental understanding of optimization and sampling as used in computational intelligence and to learn how to apply them to diverse problems. In addition, this course will have components on research methods, presentation, and writing. In summary, the course objectives are:

- become knowledgeable about a wide range of optimization and sampling methods
- become fluent in key related concepts such as local and global optima, gradients, constraints, convexity, sub-modularity, samples from a distribution, and risk functions
- understand setting up objective functions and the critical role that optimization of them has in computational intelligence
- learn technical aspects of least squares methods, (stochastic) coordinate descent, Lagrange multipliers, expectation maximization, Metropolis-Hastings (MH), reversible jump MH, Hamiltonian Monte Carlo (HMC), variational methods
- develop critical reading and thinking skills
- develop technical implementation skills for high performance computing for optimization
- develop writing and presentation skills

Absence and Class Participation Policy

Attendance at the prescribed time will not factor into grades. Nor will live participation in discussion. However, written feedback on readings and student presentations is required.

The following UA policies still apply when appropriate.

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

Participating in the course and attending lectures and other course events are vital to the learning process. 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.

Makeup Policy for Students Who Register Late

In consultation with the instructor, students who register late can makeup for requirements that are past their due date.

Course Communications

Online communication will be conducted using D2L, Piazza, and, where applicable, official UA e-mail addresses.

Required Texts or Readings

This class will be based on material available on-line. There is no required physical text book.

Required or Special Materials

For this class you will need daily access to the following hardware: computer or web-enabled device with webcam and microphone; regular access to reliable internet signal; ability to download and run the following software: web browser, Adobe Acrobat, programming environments (*) Matlab, Python, C, and a method to create reports and provide them in PDF format (e.g., Latex or Microsoft word; if you use word, it is recommended (but not required) that you consider the Mathtype equation editor).

(*) It is likely that Matlab will be helpful, and students wishing to use Matlab on a personal computer can download and install it through the U. Arizona web pages (http://softwarelicense.arizona.edu/mathworks-matlab). Python and C are both freely available on all common computer programs.

Required Extracurricular Activities

None.

Course structure

There are 16 weeks in the semester, and we will lose a Monday and a Wednesday due to holidays. To manage having all assigned work completed by Dec 10 (university policy), I have set aside the last week for integrative activities related to our topics that do not entail extra deliverables.

We will divide the first 15 weeks into three 5-week periods. Each of those periods will be associated with a project. In week 3 there will be a small deliverable for the project. The last week of the five-week block will be used for project presentations. The project reports will be due the next week so that students can incorporate feedback from the instructor and their peers.

The first four weeks of each 5-week period will focus on content. Most content presentation will be of two types --- basic or tutorial, and in-depth follow-ups or research papers. The operational difference is that some of the readings will be associated with short written feedback in the form of a few questions or comments that are due a few days in advance of the presentation. Each student will present one of each type of content, but adjustments based on the number of students will likely be necessary. Hence group presentations, or two presentations of the same type, might occur. For the first three lectures the instructor will present introductory material.

This overall design entails the following schedule.

Course schedule/due dates

TT == tutorial topic; RP == research paper

		Class activity	Available	Due
1	Mon: 08/24	Introduction (instructor)		
	Wed:08/26	TT1 (instructor)	RP1	
2	Sun: 08/30			RP1 feedback
	Mon:08/31	TT2 (instructor)		
	Wed:09/02	RP1	RP2	
	Fri: 09/04			Presentation feedback
3	Sun: 09/06			RP2 feedback
	Mon:09/07	None (Labor Day)	TT3	
	Wed:09/09	RP2	RP3	Project update
	Fri: 09/11			Presentation feedback
4	Sun: 09/13			RP3 feedback
	Mon: 09/14	TT3		
	Wed: 09/16	RP3		
	Fri: 09/18			Presentation feedback
5	Sun: 09/20			
	Mon: 09/21	Project presentations	TT4	
	Wed: 09/23	Project presentations	RP4	
	Fri: 09/25			Presentation feedback
6	Sun: 09/27			RP4 feedback
	Mon: 09/28	TT4	TT5	
	Wed: 09/30	RP4	RP5	Project reports
	Fri: 10/02			Presentation feedback
7	Sun: 10/04			RP5 feedback
	Mon: 10/05	TT5	TT6	
	Wed: 10/07	RP5	RP6	
	Fri: 10/09			Presentation feedback
8	Sun: 10/11			RP6 feedback
	Mon: 10/12	TT6	TT7	
	Wed: 10/14	RP6	RP7	Project update
	Fri: 10/16			Presentation feedback
9	Sun: 10/18			RP7 feedback
	Mon: 10/19	TT7	TT8	
	Wed: 10/21	RP7	RP8	
	Fri: 10/23			Presentation feedback

Course schedule/due dates (continued)

TT == tutorial topic; RP == research paper

		Class activity	Available	Due
10	Sun: 10/26			
	Mon: 10/27	Project presentations	TT9	
	Wed: 10/28	Project presentations	RP9	
	Fri: 10/30			Presentation feedback
11	Sun: 11/01			RP4 feedback
	Mon: 11/02	TT9	TT10	
	Wed: 11/04	RP9		Project reports
	Fri: 11/06			Presentation feedback
12	Sun: 11/08			RP5 feedback
	Mon: 11/09	TT10	TT11	
	Wed: 11/11	None (Veterans day)	RP10	
	Fri: 11/13			Presentation feedback
13	Sun: 11/15			RP6 feedback
	Mon: 11/16	TT11	TT12	
	Wed: 11/18	RP10	RP11	Project update
	Fri: 11/20			Presentation feedback
14	Sun: 11/22			RP7 feedback
	Mon: 11/23	TT12	TT13	
	Wed: 11/25	RP11	RP12	
	Fri: 11/27			Presentation feedback
15	Sun: 11/29			
	Mon: 11/30	Project presentations		
	Wed: 12/02	Project presentations		
	Fri: 12/04			Presentation feedback
16	Mon: 12/07	Integration event one		
	Wed: 12/09	Integration event two		Project reports

Final Examination or Project

As a seminar course, this course has no exams.

Grading Scale and Policies

Project report grading. Project report deliverables will generally consist of two parts: 1) all code developed in response to the assignments; and 2) a report, in PDF format explaining what has done, what the results were, commenting on the results, and answering any questions posed in the assignment. The instructor will provide a document that details the expectations of the report. Assignments will be graded with respect to four criteria: 1) reproducibility (the ease by which the grader can run the code to get the reported results); 2) completeness (the extent that the work done and sufficient effort was applied); 3) correctness; and 4) the exposition (clarity, insight, and conformance to the guidelines provided). The weight of these four criteria will vary among the assignments, but students are advised that the fourth criterion will generally have substantive weight.

Grading breakdown.

Research papers feedback:	10%
Project presentations feedback:	10%
Tutorial presentation:	10%
Research paper presentation:	10%
Project presentations:	15%
Project reports:	45%

90% guarantees an A, 80% guarantees a B, 70% a C, and 60% a D.

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.

Dispute of Grade Policy. Students wishing to dispute a grade on an assignment or exam should contact the instructor within two weeks of the date that the assignment or exam was returned to the students.

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.).

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 http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity.

The University Libraries have some excellent tips for avoiding plagiarism, available at http://www.library.arizona.edu/help/tutorials/plagiarism/index.html.

Sharing solution keys with others (e.g., students who might take the class in a future term, or who are taking the class in a future term) is considered by the instructor to be a serious violation of academic integrity.

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.

UA Nondiscrimination and Anti-harassment Policy

The University is committed to creating and maintaining an environment free of discrimination; 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

Student Assistance and Advocacy information is available at http://deanofstudents.arizona.edu/student-assistance/students/student-assistance

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.

Title IX

The University of Arizona is committed to removing educational barriers created by sex discrimination and sexual harassment. Sex discrimination under Title IX can include acts of violence based on sex, such as sexual assault, domestic violence, dating violence, and stalking. If you (or someone you know) has experienced or experiences any of these incidents, you have options for help at the University. The University of Arizona has staff members trained to support you in navigating campus life, accessing health and counseling services, providing academic and housing accommodations, helping with legal protective orders, and more.

Please be aware that UA faculty and instructors who work with students are required to report allegations of sex discrimination to the Title IX Office. This means that if you tell me about a situation involving sexual harassment, sexual assault, dating violence, domestic violence, or stalking that involves another student or employee, or that happens on campus or in a UA program, I **must** share that information with the Title IX Coordinator. Although I have to make that notification, you will have choices regarding whether or not you want to pursue a formal complaint against anyone on campus. Our goal is to make sure you are aware of the range of options available to you and have access to the resources you need.

If you wish to speak to someone privately, you can contact any of the following on-campus resources:

- Counseling & Psych Services (CAPS), https://health.arizona.edu/counseling-psych-services, 520-621-6490, 520-570-7898 (after hours)
- Oasis Sexual Assault, Relationship Violence, and Trauma Services, https://health.arizona.edu/counseling-oasis (same phone as CAPS)
- Campus Health, https://health.arizona.edu/home, (520) 621-6490
- University of Arizona Ombuds, https://ombuds.arizona.edu/, (520)-626-5589
- Title IX section on sexual assault support & resources (https://titleix.arizona.edu/title-ix/sexual-harassment-violence) has more information, as well as a link explaining options if you have a concern, need assistance/support, or would like to file a complaint.

Preferred Gender Pronoun

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 preferred gender 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/.

Confidentiality of Student Records

Please refer to:

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

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.

Land Acknowledgement Statement

The University of Arizona sits on the original homelands of indigenous peoples who have stewarded this land since time immemorial. Aligning with the university's core value of a diverse and inclusive community, it is an institutional responsibility to recognize and acknowledge the people, culture, and history that make up the Wildcat community. At the institutional level, it is important to be proactive in broadening awareness throughout campus to ensure our students feel represented and valued.