CS 4710 Artificial Intelligence
Spring 2020

1 Basic Information

Lecture: Tue/Thur, 9:30 am to 10:45 am, Rice Hall 130

Instructor: Haifeng Xu

- **Email**: hx4ad AT virginia.edu
- **Office** : Rice Hall 522
- **Office hours**: Mon 4 - 5 pm, Thur 11 - 12 pm

TAs:

- Minbiao Han, Email: mh2ye AT virginia.edu; Office hour: Wed 10 - 12 Rice 422
- Liuwang Kang, Email: lk2sa AT virginia.edu; Office hour: Tue/Thur 5 - 6 pm, Rice 220
- Quinlan Dawkins, Email: qed4wg AT virginia.edu; Office hour: Wed 3:30 - 5 pm; Fri 12 - 1:30 pm, Rice 422
- Chenghan Zhou, Email: cz4gr AT virginia.edu; Office hour: Mon/Tue 11-12pm, Rice 422
- Matt Lee, Email: jl4wq AT virginia.edu; Office hour: Mon 7 - 8 pm, Rice 422

Course Material:

- Artificial Intelligence: A Modern Approach (AIMA), the main textbook
- Reinforcement Learning: An Introduction (S&B) by Sutton and Barto
- Multi-Agent Systems (MAS)

Prerequistes: This course has substantial elements of both programming and mathematics. You should have taken the following classes or their equivalence:

- Discrete Mathematics
- Probability
- Program and Data Representation

You should be prepared to review basic probability and mathematics on your own if it is not fresh in your head. You should also be very comfortable with Python.

2 Overview

Artificial Intelligence (AI) is an exciting field that has enabled a wide range of cutting-edge technology, from driverless cars to grandmaster-beating Go programs. The goal of this course is to introduce the basic ideas and techniques underlying the design of intelligent computer systems. Topics covered in this course are broadly be divided into 1) planning and search algorithms, 2) probabilistic reasoning and representations, 3) machine learning, and 4) multi-agent systems (although, as you will see, it is impossible to separate these ideas so neatly). Within each area, the course will also present practical AI algorithms being used in the wild and, in some cases, explore the relationship to state-of-the-art techniques. The class will include lectures connecting the models and algorithms we discuss to applications in robotics, computer vision, online platforms, and related domains.

The course will provide a good foundation for topics covered in advanced AI courses. CS 4710 complements CS 4774. In particular, CS 4774 emphasizes *machine learning*, which is part (though probably the most hot part currently) of AI, whereas CS 4710 provides a *more comprehensive overview of the whole AI landscape*. Students who take both CS 4710 and CS 4774 will have a solid background for understanding and contextualizing modern AI research and experience implementing algorithms in several key areas of the field.

Finally, in spite of its practical usefulness this course is also quite fun. AI also has a long history of research into topics like puzzle-solving, game-playing, robotics, and conversational chat-bots. In this spirit, problem sets will include programming intelligent robot/game agents.

List of Topics and Tentative Length

- Introduction to AI
- Agent and Search, A* Search and Heuristics, Adversarial Search ($\sim$2 weeks)
- Constraints Satisfaction Problems ($\sim$1 weeks)
- Markov Decision Processes ($\sim$1 weeks)
- Reinforcement Learning ($\sim$1 weeks)
- Markov Models, HMMs, POMDPs ($\sim$1 weeks)
- Bayes' Nets ($\sim$1 weeks)
- Basic Machine Learning Algorithms ($\sim$2 weeks)
- Optimization, Linear Program, Mixed Integer Linear Program ($\sim$1 week)
- Multi-Agent Systems, Game Theory, Mechanism Design ($\sim$2 weeks)

Learning Outcomes Students completing this course should be able to:

- choose the appropriate representation for an AI problem or domain model, and construct domain models in that representation,

- choose the appropriate algorithm for reasoning within an AI problem domain,
- implement and debug core AI algorithms in a clean and structured manner,
- design and analyze the performance of an AI system or component,
- describe AI algorithms and representations and explain their performance,
- and critically read papers on AI systems.

3 Course Requirements

The course has several components:

- Two in-class midterm exams (40%)
- 5 or 6 problem sets (optionally done in pairs); each will have a programming part and written/analytical part (40%)
- A mini course project (done in groups of 2-4) (20%)

Final grades take into account each component. You must achieve a passing grade in all components to pass this course. Although we won't publish hard grade cutoffs, just note that to receive an "A" you must have high performance is all categories.

Readings Each class meeting is preceded by a reading assignment, which will be assumed during the lecture and discussion in class. You should set aside 2 hours to compete each reading. We do not expect you to fully understand everything before coming to class, but the goal is to prepare for class, familiarize yourself with new terminology and definitions, and to determine which part of the subject you want to hear more about. We encourage you to bring questions to class about material that is confusing. Other students might share your confusion.

Problem Sets The problem sets will be published on UVA Collab. Most problem sets have two components: programming and written. The problem sets can be done in pairs *or* individually. The written part will focus more on conceptual/analysis questions and must be done individually. Computational assignments will ask you to develop implementations of algorithms discussed in class. We expect that all code will run, be well-written and be commented appropriately. All problem sets will be submitted through Collab.

Collaboration Policy Each assignment will include a programming component and a written component. HW0 (more of an entrance test) must be done individually. *The remaining HWs can done and submitted in pairs*. This implies writing the code and homework together and both submitting the same HW and receiving the same grade. You will need to mention the name of your partner on the homework, and you can work with different partners for different HWs. Note that we will treat pairs/non-pairs the same from a grading perspective. We expect you and your partner to implement and write the solutions together. You may also consult with your classmates in other groups as you work on the problem, but you should not talk in terms of pseudocode or real

code, and you should not share answers. In addition, you must cite any books, articles, websites, lectures, etc. that have helped you with your work. If you are doing the HW individually, then the same rules apply: talking is ok, sharing answers is not. Note that understanding the concepts in HWs is important for the exams.

Late days Each student is allotted a total of **five** late days for use on problem sets. A late day extends the due date by **24 hours** and a **maximum of 2 late days** can be used towards any individual assignment. Weekends are not counted as late days. If you have used up your 5 late days, you will be penalized 25% per day, up to two days max, with no credit after two days.

In cases of medical or other emergencies which interfere with your work, have your Resident Dean contact the instructor. Any grading disputes on written assignments must be submitted as Piazza private messages ***within one week of the grades being posted*** after which the grade is final. Except in extraordinary circumstances, ***no regrades will be accepted on programming assignments***. The work in question will be fully regraded and the grade may go up or down as a result. Programs will be graded based on correctness, performance and documentation. Written components will be graded based on correctness, depth of analysis, and clarity.

Late days *cannot* be used on any of the components of the course project.

Exams There are two in-class midterm exams (closed book, no notes), one covering the first half of the course material and the second covering the second half of the course material. See the schedule for dates and topics covered. The exams are in-class because we want to leave sufficient time for you to complete the final project during the examination period, described as follows.

Mini Course Project Close to the end of the course students will design and carry out a course project in groups of 2 - 4. The goal of the project is for you to use techniques learned from class or outside the class to solve an AI problem of your interest. In the project, you will need to: (1) identify an AI problem of your interest; (2) implement algorithms or techniques, covered in class or learned by your own after class, to solve the problem. You are expected to identify the right approach to solve the problem though innovation in the techniques is not required (i.e., you do not need to design new techniques). This is to give you an opportunity to try something "real". The project is expected to *not* take too much of your time and thus is called a "mini" project.

Grading of the project is based on how interesting/difficult is your problem, how solid are your solutions, and how good are your results. Each project group will need to:

1. Submit a one-page proposal, describing your team, what problem you propose to tackle, and proposed approaches (3 points)
2. A short presentation ($\sim$ 5 mins) at the end of semester to present your solution and results you obtained (7 points)
3. A short report ($\leq$ 3 pages), together with your code if applicable, to describe your project problem, approaches and results you get (10 points)

Note: All group members will receive the *same score* for a project. Thus it is your responsibility to find collaborative partners to work together on the project. In the past, we have received complaints about some group members not doing the work. You should try to *figure out this as early as possible and, if necessary, re-organize the group*. For such situations, we cannot do much from our side unfortunately, especially when it comes close to the end of the semester.

4 Other Related Statements

Diversity and Inclusion In an ideal world, science would be objective. However, much of science is subjective and is historically built on a small subset of privileged voices. We acknowledge that it is possible that there may be both overt and covert biases in the material due to the lens with which it was written, even though the material is primarily of a scientific nature. Since integrating a diverse set of experiences is important for a more comprehensive understanding of science please contact the course staff (in person or electronically) or submit anonymous feedback if you have any suggestions to improve the quality of the course materials.

We would like to create a learning environment that supports diversity of thoughts, perspectives, and experiences, and honors your identities. If you have a name and/or set of pronouns that differ from those that appear in your official records, please let us know! If you feel like your performance in the class is being impacted by your experiences outside of class, please don't hesitate to contact us.

Honor code (Adapted from Honor Syllabus Example Statement of UVa) I trust every student in this course to fully comply with all of the provisions of the University's Honor Code. By enrolling in this course, you have agreed to abide by and uphold the Honor System of the University of Virginia, as well as the policies specific to this course. All suspected violations will be forwarded to the Honor Committee, and you may, at my discretion, receive an immediate zero on that assignment regardless of any action taken by the Honor Committee.

Please let me know if you have any questions regarding the course honor policy. If you believe you may have committed an Honor Offense, you may wish to file a Conscientious Retraction by calling the Honor Offices at (434) 924-7602. For your retraction to be considered valid, it must, among other things, be filed with the Honor Committee before you are aware that the act in question has come under suspicion by anyone. More information can be found at here.

Students with disabilities or learning needs We thrive to create a learning experience that is as accessible as possible. If you anticipate any issues related to the format, materials, or requirements of this course, please meet with me outside of class so we can explore potential options. Students with disabilities may also wish to work with the Student Disability Access Center to discuss a range of options to removing barriers in this course, including official accommodations. Please visit their website for information on this process and to apply for services online: sdac.studenthealth.virginia.edu. If you have already been approved for accommodations through SDAC, please send me your accommodation letter and meet with me so we can develop an implementation plan together.

Discrimination and power-based violence The University of Virginia is dedicated to providing a safe and equitable learning environment for all students. To that end, it is vital that you know two values that I and the University hold as critically important:

- Power-based personal violence will not be tolerated.
- Everyone has a responsibility to do their part to maintain a safe community on Grounds.

If you or someone you know has been affected by power-based personal violence, more information can be found on the UVA Sexual Violence website that describes reporting options and resources available - https://eocr.virginia.edu/

As your professor and as a human, I care about you and your well-being and stand ready to provide support and resources as I can. As a faculty member, I am required by University policy and federal law to report what you tell me to the University's Title IX Coordinator. The Title IX Coordinator's job is to ensure that the reporting student receives the resources and support that they need, while also reviewing the information presented to determine whether further action is necessary to ensure survivor safety and the safety of the University community. If you wish to report something that you have seen, you can do so at the Just Report It portal. The worst possible situation would be for you or your friend to remain silent when there are so many here willing and able to help.

Religious accommodations It is the University's long-standing policy and practice to reasonably accommodate students so that they do not experience an adverse academic consequence when sincerely held religious beliefs or observances conflict with academic requirements.

Students who wish to request academic accommodation for a religious observance should submit their request in writing directly to me via Email as far in advance as possible. Students who have questions or concerns about academic accommodations for religious observance or religious beliefs may contact the University's Office for Equal Opportunity and Civil Rights (EOCR) at UVAEOCR@virginia.edu or 434-924-3200.