Syllabus for CS 182 Artificial Intelligence

1 Overview

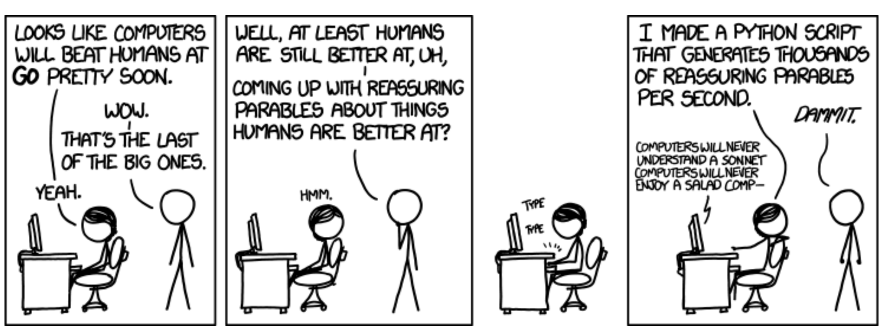
CS 182 is an introduction to the area of Artificial Intelligence a.k.a designing intelligent machines. Artificial intelligence aims to understand thinking and intelligence in ways that enable the construction of computer systems that are able to reason in uncertain environments. Work in AI has supported the development of driverless cars and house-cleaning robots as well as systems that have defeated world chess champions and planned space explorations.

The course has three core sections: search, representation, and uncertainty. In each section, it will provide a thorough understanding of major approaches, representational techniques and core algorithms. In particular we will focus on the trade-offs between the model structure of different frameworks and the algorithmic constraints that this structure implies. Central topics in **search** will include classical search algorithms, heuristics and relaxation, and adversarial game-playing. The **representation** section will cover constraint-satisfaction, logical formalisms for representing knowledge, efficient algorithms for logical inference, and an introduction to planning. The section on **uncertainty** will introduce probabilistic reasoning, the formalism of Markov decision processes, and conclude with an overview of Bayesian networks for modeling uncertainty.

Within each area, the course will also present practical AI algorithms being used behind the scenes every day and explore cutting edge research and philosophical foundations. The class will include lectures connecting the models we explore with application in natural language processing, vision, machine learning, and robotics.

In addition to introducing algorithms that every computer scientist should know, the course will provide a good foundation for topics covered in advanced AI courses (CS28x). CS 182 complements CS 181, which emphasizes machine learning. Students who take both CS 182 and CS 181, will have the background for understanding current artificial intelligence research and experience implementing algorithms and developing domain models in all 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, and conversational chat-bots. In this spirit, assignments will include programming an efficient Sudoku solver, an clever maze-solving robot, and a ghost avoiding agent for Pac-Man. There will also be much XKCD.



Objectives Students completing this course will have an in-depth understanding of three core areas of AI and the connections among them, and with such other key AI areas as machine learning, robotics, natural language processing and multi-agent systems. They 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, in writing and orally
- critically read papers on AI systems

2 Preliminaries

Prerequisites CS 51 (experience with systems building and familiarity with complexity). CS 121, CS 124, or CS 124 are recommend and may be taken concurrently. No previous exposure to AI is assumed. Talk to the instructor if you're concerned about your preparation. Programming assignments will use the language Python; an introduction to the language will be given in the first week.

Textbook The main textbook for the course is **Artificial Intelligence: A Modern Approach** (3rd edition) by Stuart Russell and Peter Norvig, a.k.a AIMA(3e). It is available in the COOP. In addition to the textbook, we will also read several research papers during the term. Finally, the course staff is always happy to recommend additional readings or other sources of information if you would like to explore a topic from the course in more depth.

Laptop Policy For the sake of cutting down on distraction and maintaining an academic atmosphere, phones and laptops will in general not be permitted during lecture. As we understand that some students prefer laptops for note-taking, we ask that you contact the course staff at the beginning of the semester if you require your laptop during class. We will also ask that students using laptops sit in a designated section so as not to distract other colleagues.

Support resources We will be using the Piazza for questions. Unless your question would reveal confidential information or give away answers to homework questions, please post there. We also encourage you to answer each others questions.

Office hours The staff office hours will be posted on the website. You are welcome to come with specific questions about the material, to discuss final project ideas, or just to chat about things you find interesting and want to explore further.

Email Staff emails are posted on the website. To avoid duplication of questions and keep the email load manageable, please use the forums if your question may be of interest to other students, and only use email for personal questions.

3 Provisional Schedule

This weekly schedule is provisional. It may be adjusted based on the observed pace of the course:

Date	Topic	Readings	Assignment
Sept. 3	Artificial Intelligence	AIMA3e 1	HW 0
Sept. 8	Search 1: Formalism	AIMA3e 3.1-3.4	HW 1
Sept. 10	Search 2: Uninformed Search	AIMA3e 3.5,3.6	
Sept. 15	Search 3: A* and Heuristics		HW 2
Sept. 17	Adversarial Search	AIMA3e 5	
Sept. 22	Constraint Satisfaction	AIMA3e 6.1-6.3	
Sept. 25	CSP, Local Search, and Optimization	AIMA3e 4.1, 6.4	HW 3
Sept. 29	Propositional Logic and Satisfiability	AIMA3e 7	
Oct. 1	Propositional Logic For Planning	AIMA3e 10	
Oct. 6	Applications in NLP/Vision/Robotics #1		
Oct. 8	Paper Discussion #1		
Oct. 13	Midterm #1 (Search, CSP, Logic)		
Oct. 15	Probability	AIMA3e 13	HW 4
Oct. 20	Markov Decision Processes 1	AIMA3e 17.1-17.3	
Oct. 22	Markov Decision Processes 2		
Oct. 27	Paper Discussion #2		
Oct. 29	Baysian Networks: Representation	AIMA3e 14	HW 5
Nov. 3	Baysian Networks: Independence		
Nov. 5	Baysian Networks: Inference		
Nov. 10	Hidden Markov Models 1	AIMA3e 15.1-15.3	
Nov. 12	Hidden Markov Models 2		
Nov. 17	Applications in NLP/Vision/Robotics #2		
Nov. 19	Midterm #2 (MDPs, Bayes Nets, HMMs)		
Nov. 24	Guest Lecture		Project Update
Dec. 1	Paper Discussion #3		
Dec. 3	Final Project Presentations		
Dec. 8	Final Project Presentations		
Dec. 10	Final Project Due		

4 Course Requirements

The course has several components:

- Six assignments; each will have a computational part and written part (50%)
- Two in-class exams (October 13 and November 19) (25%)
- A final project (done in pairs) (20%)
- Paper reviews and discussion (5%)

Final grades take into account each component. You must achieve a passing grade in all components to pass this course. To receive an A you must have high performance is all categories.

Assignments The 6 assignments (HW 0 - HW 5) will be published on the course webpage. Also see the collaboration policy below.

Most assignments have two components: computational and written. The computational part can be done in pairs or individually and will require programming and experimentation. The written part will be submitted individually and will include analysis of the results. Computational assignments will ask you to develop implementations of algorithms for search, game-solving, constraint satisfaction, knowledge representation and reasoning, and planning, to apply them to different real-world problems, and to analyze the performance. We expect that all code will run, be well-written and be commented appropriately; the course staff is always happy to help explain style and conventions. The written components ask you questions about the concepts and methods that you have learned and to reflect on the performance of your implementations.

Late days As students tend to be over-committed, each student is allotted **five** late days which may be applied to any of the assignments. You must **email** the TF for a late day to apply. A late day extends the due date by 24 hours. No more than two late days may be used on any one assignment. In cases of medical or other emergencies which interfere with your work, have your senior tutor contact the instructor.

Grading Assignments will be due at **5pm** on the day scheduled. 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. We will only give extensions for emergencies, and you will need a note from either a doctor or your Resident Dean. Any grading disputes, aside from arithmetic errors, will go to the head TF, and the work in question will be fully regraded; the grade may go up or down as a result. Computational components will be graded based on correctness, performance and documentation. Written components will be graded based on correctness, depth of analysis, and clarity.

Readings Each class meeting is preceded by a reading assignment. It is important to keep on top of the reading, 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.

In addition, we will have three paper discussion sessions. You are expected to read the paper before class and should post a question in the forum that is designated for discussion of that paper. The post should contain a thought provoking question about the assigned paper and is due no later than midnight of the night before the class meeting.

Extra Credit We will offer two sources of additional extra credit in the class. First for students who go out of their way to provide additional support in the Piazza forums, and second for students who find bugs or errata in the course lecture notes or homeworks. For the second, please email the professor with the subject `CS182 Bugs` in the subject line.

In-class Exams In addition to homework assignments, there are two in-class 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 sections preceding the class days will be exam reviews.

Final Project During the second half of the course students will design and carry out a final project, working in pairs. The final project is of your choosing: it can describe a system you have built or discuss more theoretical issues or even survey cutting edge work in an active area of AI research. We will provide a list of potential topics and an opportunity to get feedback before starting. Most people who have taken the course consider this one of the most fun and rewarding parts of the course, and we hope you'll have fun with it too. The final presentation and paper (by the group) are due at the end of reading period, and attendance at the final presentation sessions is mandatory.

The project grade is based three aspects:

1. project concepts and results
2. presentation quality
3. final paper quality

Collaboration Policy Each assignment will include a computational component and a written component.

HW 0 must be done individually. The computational component of assignments 1-5 can done and submitted in pairs. In pairs implies designing and writing the code together and submitting a single assignment and receiving the same grade. Note that we will treat pairs/non-pairs the same from a grading perspective. We expect you and your partner to design and implement 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. Similarly, you must list the names of students from other groups with whom your group has collaborated. If you are doing the computational assignment individually, then the same rules apply for collaboration as for the written assignments: talking is ok, sharing code is not.

The written component of all assignments must be done individually, and each person must submit her/his own written assignment. You are encouraged to consult with your classmates as you work on the problems for the written assignments. However, you should not share answers. After discussions with your peers, make sure that you can work through the problem yourself and ensure that any answers you submit for evaluation are the result of your own efforts. In addition, you must cite any books, articles, websites, lectures, etc. that have helped you with your work. Similarly, you must list the names of students with who you have collaborated. Note that understanding the concepts in the written assignments is important both for the computational components and the exams. Final projects must be done in pairs. You are encouraged to discuss your project ideas with your peers.

For any questions not covered in this document, email the course staff for clarification.