THE UNIVERSITY OF VERMONT
COMPUTER SCIENCE

CS 2990 / Introduction to Artificial Intelligence / 2025 Spring

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Instructor: Clayton Cafiero
Email: cbcafier@uvm.edu
Office: Innovation E309
Office hours: Drop in T 3:00–4:00 PM, Th 10:00–11:30 AM, F 8:30–9:30 AM, or by appointment
Website: https://www.uvm.edu/~cbcafier

TA: Alden Hinkel
Email: alden.hinkel@uvm.edu
Office hours: By appointment

Class meetings: M/W/F 2:20–3:10 PM
Location: Lafayette L411

Welcome to the course!

Overview and topics: This course will introduce you to the foundations of artificial intelligence: its history and selected methods. Topics include: logic- and rule-based approaches, knowledge representation, heuristic search, A*, IDA*, alpha/beta pruning, minimax, expectiminimax, Markov models and Markov decision models, decision tree, ensemble learning / random forest, the neural model and simple multi-layer perceptrons. Other topics, if any, TBD.

Prerequisites: CS2240 with grade of C- or better.

Learning objectives: Through lecture, in-class active learning exercises, and homework, students will be able to:

- describe in general terms the history and development of the field of artificial intelligence;
- use Prolog to develop small scale knowledge-bases of facts and rules, and then use queries and helper functions to produce inferences / predictions (including application of recursive rules);
- construct and evaluate simple knowledge representations, and be able to identify how a knowledge representation determines what inferences are sanctioned;

- identify common biases in knowledge representations;
- understand how heuristic search can outperform naive search in many instances;
- implement and use A* and IDA* in code;
- choose or design an appropriate heuristic for use with A* and IDA* algorithms (also ensuring the heuristicsis admissible, and if possible, consistent);
- apply alpha/beta pruning to heuristic search, understand the benefits of doing so, and, given small problem instances, identify subtrees which can be pruned;
- compute best moves / actions, using minimax or expectiminimax, given a game tree for evaluation;
- implement at least one fully-observable, two-player, turn-taking, deterministic game using minimax;
- compute a stochastic matrix (Markov model) from a set of observations and use the resulting model to make single- and multi-time step predictions;
- understand the basics of Markov decision processes (MDPs) and how policies are devised to maximize gain, given a particular environment with rewards and actions;
- apply the Bellman equation in the context of MDPs;
- construct decision trees using ID3 and/or CART algorithms and produce classification predictions using such trees;
- understand how entropy and information gain are used in constructing decision trees, and perform such computations by hand or in code;
- implement random forest in code and compare results with individual decision trees;
- understand and compute metrics commonly used to evaluate model performance (*e.g.*, precision, recall, accuracy, F-measure, *etc.*);
- understand how simple neurons (units) aggregate inputs and produce output via various activation functions, and perform simple computations on small problem instances (for example, applying the perceptron learning rule);
- perform experiments to test how hidden layers, non-linear activation functions, and learning rate affect model performance and training time; and
- describe the concepts behind backpropagation without detailed or rigorous mathematical treatment.

Course materials: Textbook (optional): Ertel, Wolfgang, *Introduction to Artificial Intelligence*, third edition, Springer, 2025. An ebook is available directly from the publisher at https://link.springer.com/book/10.1007/978-3-658-43102-0.

Other materials including lecture notes will be circulated via Brightspace.

Software: You should have a working installation of Python (Python 3.10 or higher is recommended). We will use Scikit-Learn, TensorFlow 2 or PyTorch, and Matplotlib. All of these are `pip`-installable (instructions will be circulated via Brightspace).[1] With these installed, Numpy, Scipy, and many other packages will be installed as dependencies. I *strongly* recommend creating a new virtual environment for this course, to isolate requirements.

We will do some programming in Prolog. Installation will vary from machine to machine, from OS to OS, so I cannot provide a universal recipe. See SWI Prolog: https://www.swi-prolog.org/. Your best bet on systems with package managers (Linux, macOS) is to use the package manager (*e.g.*, Apt, Aptitude, dpkg, Homebrew, MacPorts, *etc*.) If installation is problematic, you can run Prolog programs in the SWISH web interface at: https://swish.swi-prolog.org/.

Correspondence: Please use email for electronic correspondence (and not MS Teams). As I teach multiple courses please indicate the course in which you are enrolled in the subject line. Please use your UVM email for all correspondence.

Weekly schedule of topics
(tentative and subject to change):

Week	Topic
1	Introduction; history of AI; complexity; logic foundations
2	Logic programming with Prolog
3	Logic programming with Prolog; knowledge representation and ontologies
4	Expert systems; uninformed search
5	Heuristic search, permissible heuristics, A*
6	More on heuristic search, IDDFS and IDA*
7	Adversarial games, minimax and alpha-beta pruning
8	Midterm exam; additional topics in search and adversarial games
9	Non-deterministic games: expectiminimax, quiescence and null move search
10	Markov models and decision processes
11	Decision tree; random forest / ensemble learning
12	The neural model; McCulloch-Pitts
13	Multi-layer perceptron networks
14	Add'l topics TBD; review and discussion
15	Add'l topics TBD; review and discussion

In addition to the above, we'll read a few papers and set aside some class time for (hopefully lively) discussion.

Scribing: In most weeks a group of two or three students, working independently, are expected to take notes in class and write them up in electronic form for distribution to the rest of the students in the course. Since I'm sure you're all taking notes anyway, I don't think you'll find this too onerous. Notes are to be prepared in Markdown format, with inline LaTeX as needed for equations and mathematical notation. Instructions and guidelines will be posted on Brightspace, and notes will be submitted via Brightspace.

[1] You may wish to use Anaconda, but I find this has an unnecessarily large footprint.

I will assign groups at random, and you should inform me as soon as possible if you have a conflict and we'll see what we can do to swap assignments for a given week. Scribing will commence in week two, and will not take place in weeks in which we have an in-class exam. Look on Brightspace for your scribing assignment.

If you have a documented accommodation which entitles you to a peer note taker (through the ACCESS office), you are exempt from scribing, but I will give you a small supplemental assignment you can do on your own instead.

In the event we have a need for a peer note taker (for the ACCESS office), anyone who volunteers and serves as a peer note taker will be exempt from other scribing duties and will receive full credit.

Grading:

Weight	Assessment
10%	in-class discussion and active learning
45%	homework and mini-projects
10%	quizzes (11, drop one)
10%	midterm exam
5%	scribing
20%	final exam
100%	TOTAL

Grades will be assigned using a conventional scale: $\geq 98 =$ A+, $\geq 93 =$ A, $\geq 90 =$ A-, $\geq 87 =$ B+, $\geq 83 =$ B, $\geq 80 =$ B-, $\geq 77 =$ C+, $\geq 73 =$ C, $\geq 70 =$ C-, $\geq 67 =$ D+, $\geq 63 =$ D, $\geq 60 =$ D-, and $< 60 =$ F. Any grade appeal (assignment, quiz, lab, exam, *etc.*) must be directed to your grader within one week of the grade being posted. The secret word is "melismatic." If grading is done on Gradescope, there's a *regrade request* feature which should be used for grade appeals.

Academic integrity: The Department of Computer Science enforces UVM's Code of Academic Integrity. Any suspected violation of this policy will be referred immediately to UVM's Center for Student Conduct (https://www.uvm.edu/sconduct). Sanctions for a violation may include a grade of XF in the course. Additional violations can result in dismissal from the university. In a word: *Don't*. All students should read and understand this policy. See: https://go.uvm.edu/cai.

Collaboration on quizzes and exams is strictly prohibited. Use of online services as a source of solutions is strictly prohibited. Using generative AI such as ChatGPT or Claude, or websites such as Chegg or Course Hero to complete coursework is a form of academic dishonesty. Work you submit for an individual grade must be your own. Any work not produced by you must be cited. For certain assignments, students may collaborate on homework (typically limited to teams of two). If you collaborate with another student on an assignment, be sure to indicate team members as specified. If you have any questions ask!

Any attempt to tamper with or defeat any autograder is a form of academic dishonesty. This applies wherever autograders are in use, for example on Brightspace or Gradescope.

All code submitted by students is subject to code similarity review.

Exams, quizzes, homework assignments, answer keys and solutions, presentations or lecture notes, specifications and rubrics are copyright protected works, unless clearly and explicitly indicated otherwise. Any unauthorized copying or distribution of protected works is a violation of federal law and may result in disciplinary action. This includes submission of protected works as prompts to generative AI.

Sharing of course materials without the specific, express approval of the instructor may be a violation of the University's Code of Academic Integrity and an act of academic dishonesty, which could result in disciplinary action. Violations will be handled under UVM's Intellectual Property Policy and Code of Academic Integrity, as appropriate. See: https://go.uvm.edu/ipp and https://go.uvm.edu/cai.

Late policy / extensions: Each homework assignment has a specific due date / time. You may submit work up to 24 hours after the due date / time, however, late submissions will be penalized 20%. Submissions that are more than 24 hours late will not be accepted unless an extension has been granted. We will consider reasonable requests for extensions when extenuating circumstances arise. (It can't hurt to ask.) However, extensions will not be granted if the request for extension is made within 24 hours of the time an assignment is due, except in the most extraordinary circumstances. So if you wish to request an extension, *do so early*! If an extension is granted, you must submit your work by the agreed-upon extension date.

Student course evaluations: Students are warmly encouraged to complete an evaluation of the course at its conclusion. Evaluations are anonymous and confidential, and the information gained, including constructive criticisms, will be used to improve the course.

Accommodations: In keeping with UVM policy, if you have a documented disability and are interested in utilizing ADA accommodations, you should contact Student Accessibility Services (SAS), the office of Disability Services on campus for students. SAS works with students and faculty in an interactive process to explore reasonable and appropriate accommodations, which are communicated to faculty in an accommodation letter.

Contact SAS: A170 Living/Learning Center; +1 802 656 7753; access@uvm.edu; or visit https://www.uvm.edu/access.

If you are entitled to use the Exam Proctoring Center, please book reservations at least four days in advance.

Class participation: You are expected to be an active participant in class. The more engaged you are, the more you will learn—and the more fun you'll have. This includes being prepared and attentive, responding when called on, participating in group discussion, and asking questions as appropriate. When it comes to asking questions, *please don't be shy!* There's no such thing as a "dumb" or "silly" question. If there's something you don't understand—*ask*! Asking questions helps you understand the material presented in the course. Asking questions is good for your classmates. It's almost certain that if you need clarification on some point, that there's at least one other student in the class with the same question. So help each other out—*ask*! Finally, when you ask a question you help the instructor to do a better job of explaining. If someone explains something, and you still don't quite grasp it, it's not unlikely that the explanation could be improved or clarified.

Diversity, equity, and inclusion: UVM is a place where you should be treated with respect and kindness. We welcome individuals of all ages, backgrounds, beliefs, interests, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability, and other visible and non-visible differences. All students are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the community. If you ever feel that you have been unfairly treated or judged by an instructor, a mentor, another student, or another member of the community, please let someone know. Your instructors and advisors in the CEMS Office of Student Services are available to discuss any concerns, or you can report an incident of bias through the bias report program (https://go.uvm.edu/brp).

Conduct: Be kind to one another and to yourself. Be respectful of yourself, others, and the institution. Please arrive on time. Please, no food in class. Please, no cell phones in class (except for using the iClicker app when requested). You may use a laptop or tablet, but only for active learning sessions, pair programming, taking notes, or assistive technologies.

For other policies on classroom conduct, please see: https://go.uvm.edu/srr and https://go.uvm.edu/csc.

Promoting health and safety: If you are concerned about a UVM community member or are concerned about a specific event, we encourage you to contact the Dean of Students Office (+1 802 656 3380). If you would like to remain anonymous, you can report your concerns online by visiting the Dean of Students website at https://www.uvm.edu/deanofstudents.

Wellbeing resources:

- Center for Health and Wellbeing: https://www.uvm.edu/health/services
- Counseling and Psychiatry Services (CAPS): +1 802 656 3340
- Food Insecurity Assistance: https://www.uvm.edu/health/food-insecurity-uvm

Student advocacy: https://www.uvm.edu/deanofstudents/student_advocacy

Your identity at UVM: Students at UVM can specify the first name and pronoun they want used on campus. For information on how to update your preferred name and personal pronouns as well as keeping your legal name private, and UVM policy on lived name and pronouns, see: https://go.uvm.edu/lnpr.

Religious holidays: Students have the right to practice the religion of their choice. In order to receive extensions or excused absences, you should submit via email your documented religious holiday schedule for within the first week of the course. Reasonable extensions will be granted where assignment deadlines conflict with religious holidays.

Student athletes: In order to receive extensions or excused absences, you should submit via email appropriate documentation as soon as possible, preferably within the first week of the course. Reasonable extensions will be granted where assignment deadlines conflict with team events or team travel.

Statement on alcohol and other drugs: We want you to get the most you can out of this course. Therefore, you are expected to familiarize yourself and abide by the University's policies with regard to alcohol, cannabis, tobacco, and other drug use. See: https://go.uvm.edu/actd. Please do everything you can to optimize your learning and to participate fully in this course.

Class format changes: The University of Vermont reserves the right to make changes in the course offerings, mode of delivery, degree requirements, charges, regulations, and procedures contained herein as educational, financial, and health, safety, and welfare considerations require, or as necessary to be compliant with governmental, accreditation, or public health directives.

Changes to this document: This document is subject to change. Any such change will be communicated via an announcement on Brightspace. The latest version of the syllabus will always be available on Brightspace.