**Welcome to Artificial Intelligence!**

In this course, you will learn the fundamental concepts of Artificial Intelligence (AI) and apply them to the design and implementation of intelligent agents that solve real-world AI problems, including problems in search, games, machine learning, logic, and constraint satisfaction.

We will provide a broad understanding of the basic techniques for building intelligent computer systems.  Topics include the history of AI, intelligent agents, state-space problem representations, uninformed and heuristic search, game playing and adversarial search, logical agents, constraint satisfaction problems, along with techniques in machine learning and other applications of AI, such as natural language processing (NLP).

**Please read the full syllabus carefully.**

**Time:** Mondays and Wednesdays  1:00pm-4:10pm **Location:** 451 Computer Science Building

**Piazza**: [https://piazza.com/class/jtz26ov9rnqtj (Links to an external site.)Links to an external site.](https://piazza.com/class/jtz26ov9rnqtj)

**Instructor: Ansaf Salleb-Aouissi**[**ansaf@cs.columbia.edu**](mailto:ansaf@cs.columbia.edu)

**Instructor office hours:** Wednesdays 10:30-12:30 in 702 CEPSR starting  May 29 (Except June 26 which is moved to Monday June 24 same time)

**TA Office Hours (held in the TA room in Mudd 122A):**

Nicole Mbithe  HEAD TA Sundays 3 pm - 5 pm

Pranav Shrestha Thursday 11am - 1pm

Sharon Jin Sundays 5 pm - 7 pm (temporary)

**Course Level**

Expect to spend at least several hours to complete the assignments, although the exact amount of time will depend on your background and proficiency with coding.

**Prerequisites**

You will need some basics in Linear algebra (vectors, matrices, derivatives), Calculus, Probability theory.

You will need to be fluent in programming in Python programming (2 or 3) and know data structures.

**Assignments**

There will be three to four homework assignments, each consisting of a conceptual and programming portion. Students will have two to three weeks to complete each assignment.

**Grading:  *Assignments:* 50%,  FINAL 50%.**

**Academic Honesty Policy**

Please familiarize yourself with the honesty, integrity, and [cheating policies of the University and the Department of Computer Science](http://www.cs.columbia.edu/education/honesty). Ignorance of these policies will not be considered as an acceptable reason for violating the policies. It is your responsibility to be aware of the policies. Each student is sole owner of his own code and work and**must NOT**:

* + Submit work that is not original.
  + Publish code or solutions online.
  + Post the course questions on forums including stack overflow.
  + Submit someone else’s work, or a modification of that work, with or without that person’s knowledge.
  + Allow someone else to submit his/her work, or a modification of that work.
  + Solve as a group a quiz or project. **All coursework is to be done by the student working alone.**
  + Contract course work out to others.
  + Plan or execute with another student a cooperative subterfuge during an exam.
  + Make use of unauthorized material during an exam.

Project assignments will be checked with plagiarism detection software.

Thank you for abiding by these rules. Doing so will ensure the experience is fair to everyone taking this class or the future sessions of this class.

**Textbook:**Artificial Intelligence, A Modern Approach. Stuart Russell and Peter Norvig. Third Edition. Pearson Education. Check out the book resources: [http://aima.cs.berkeley.edu/ (Links to an external site.)Links to an external site.](http://aima.cs.berkeley.edu/)

**Late Policy:**Homework must be submitted by the deadline**.**

**Exceptions There will be no make-up exams. In case you must miss an exam or a homework for a valid medical/family emergency, your exam grade composition will be adjusted.**

To be considered for an exception to the above policies you must furnish ***both***a letter from your physician (doctor) describing a medically-necessary delay in your studies **and** a letter sent directly to your instructor from your academic dean. There is no make-up exam.

**Topics**

1. Introduction to AI, history of AI, course logistics, and roadmap
2. Intelligent agents, uninformed search
3. Heuristic search, greedy search, A\* algorithm, stochastic search
4. Adversarial search, game playing
5. Machine Learning: basic concepts, linear models, K nearest neighbors, overfitting
6. Machine Learning: perceptrons, neural networks, naive Bayes, decision trees, ensemble, logistic regression, and unsupervised learning
7. Constraint satisfaction problems
8. Reinforcement learning.
9. Logical agents, propositional logic and first order logic
10. AI applications to natural language processing (NLP)
11. Review and conclusion

**Tentative Schedule:  SUBJECT TO CHANGE. PLEASE CONSULT REGULARLY FOR HW DEADLINES.**

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**Week 1**

**HW1 released (June 2)**

Introduction: history of AI. A quick tour of AI, course overview, logistics  ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4831471)).

Intelligent agents ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4827548))

Search Algorithms: search agents ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4827547))

**Reading/notes:**

Chapter 1, 2, 3

[Computing Machinery and  Intelligence by Alan Turing (1950)](https://courseworks2.columbia.edu/courses/82461/files/folder/READING?preview=2224975)

President Obama’s [Preparing for the Future of Artificial Intelligence. (Links to an external site.)Links to an external site.](https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf)

[Artificial Intelligence and Life in  (Links to an external site.)Links to an external site.](https://ai100.stanford.edu/sites/default/files/ai_100_report_0831fnl.pdf)2030

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**Week 2**

Search Algorithms:

Search Algorithms: search agents CONTINUED ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4827547))

Uninformed search ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4827629))

Class notes on Korf paper ([notes](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4827625))

Informed search ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4827545))

Stochastic/Local search ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4846831&sort=modified_at&order=desc))

Application of search to Association Rules ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4827623))  **(OUT OF THE SCOPE OF FINAL EXAM)**

Adversarial search. Stochastic games ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4854220))

Reading/notes:

Chapter 3, 4, 5

[A formal basis for the heuristic determination of minimum cost paths](https://courseworks2.columbia.edu/courses/82461/files/folder/READING?preview=2364309)Hart et al. 1968.

[An overview of Genetic Algorithms Part I](https://courseworks2.columbia.edu/courses/82461/files/folder/READING?preview=4056991)

[An overview of Genetic Algorithms Part II](https://courseworks2.columbia.edu/courses/82461/files/folder/READING?preview=4056985)

[Programing a computer for playing Chess](https://courseworks2.columbia.edu/courses/82461/files/folder/READING?preview=2224973). Claude Shannon 1950

[Checkers is solved. Schaeffer, 2007](https://courseworks2.columbia.edu/courses/82461/files/folder/READING?preview=2224961)

[Depth-First Iterative Deepening Korf 1985](https://courseworks2.columbia.edu/courses/82461/files/folder/READING?preview=2364236)

Demo: [Alpha-Beta pruning (Links to an external site.)Links to an external site.](http://inst.eecs.berkeley.edu/~cs61b/fa14/ta-materials/apps/ab_tree_practice/)

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**Week 3**

**HW1 due June 11**

**HW2 released  June 12**

Adversarial search (continued). Stochastic games ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4854220))

Machine Learning: Basic Concepts, KNN. ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4859454&sort=modified_at&order=desc))

Machine Learning: Linear regression ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4859457&sort=modified_at&order=desc))

Machine Learning: Naive Bayes ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4827614))

**Reading/notes:**

[Programing a computer for playing Chess](https://courseworks2.columbia.edu/courses/82461/files/folder/READING?preview=2224973). Claude Shannon 1950

[Checkers is solved. Schaeffer, 2007](https://courseworks2.columbia.edu/courses/82461/files/folder/READING?preview=2224961)

Demo: [Alpha-Beta pruning (Links to an external site.)Links to an external site.](http://inst.eecs.berkeley.edu/~cs61b/fa14/ta-materials/apps/ab_tree_practice/)

Chapter 18

[*A Course in Machine Learning (Links to an external site.)Links to an external site.*](http://ciml.info/)by Hal Daumé III

[Deep Learning (Links to an external site.)Links to an external site.](http://www.deeplearningbook.org/)by Goodfellow, Bengio and Courville. The book includes a review of  Linear Algebra and Probability and Information Theory

[Are ML and Statistics Complementary?](https://courseworks2.columbia.edu/courses/82461/files/folder/READING?preview=2224977)

[Data Mining and statistics: what's the connection?](https://courseworks2.columbia.edu/courses/82461/files/folder/READING?preview=2224962)

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**Week 4**

**HW2 due June 23**

**HW3 released  June 23**

Perceptrons, Neural networks ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4456478))

Perceptron: Proof of convergence ([notes](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4056950))

Machine Learning:  Decision trees ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4349159))

Reading/notes:

[An Empirical Comparison of Supervised Learning Algorithms Rich Caruana and Alexandru Niculescu-Mizil. ICML 2006](https://courseworks2.columbia.edu/courses/82461/files/folder/READING?preview=2224960)

[The Elements of Statistical Learning (Links to an external site.)Links to an external site.](http://web.stanford.edu/~hastie/ElemStatLearn/) by Hastie, Tibshirani and Friedman

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**Week 5**

Ensemble methods ([slides](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4513032)) and [Condorcet jury theorem](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4057015)

[Clustering](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4541870)

[Constraint Satisfaction problems](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4056966)

**FRIDAY JUNE 28 MAKE UP MEMORIAL DAY @10am-1pm. Same Room. Will be recorded. Recitation/lecture.**

**Reading/notes:**

[(Links to an external site.)Links to an external site.](http://www.deeplearningbook.org/)[Updated Chapter 6 CSP (Links to an external site.)Links to an external site.](http://aima.cs.berkeley.edu/2nd-ed/newchap05.pdf)[(Links to an external site.)Links to an external site.](http://www.deeplearningbook.org/)

[Deep Learning (Links to an external site.)Links to an external site.](http://www.deeplearningbook.org/) by Goodfellow, Bengio and Courville

[Tensorflow playground (Links to an external site.)Links to an external site.](http://playground.tensorflow.org/)

[Some visualizations of NN  (Links to an external site.)Links to an external site.](http://colah.github.io/posts/2014-03-NN-Manifolds-Topology/)

[https://www.naftaliharris.com/blog/visualizing-dbscan-clustering/ (Links to an external site.)Links to an external site.](https://www.naftaliharris.com/blog/visualizing-dbscan-clustering/)

[https://www.naftaliharris.com/blog/visualizing-k-means-clustering/ (Links to an external site.)Links to an external site.](https://www.naftaliharris.com/blog/visualizing-k-means-clustering/)

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**Week 6**

[Logical Agents](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4057001).

[Introduction to NLP](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4644604)

**Conclusion: Curse of dimensionality, AI and ethics, AI and Inclusion (**[**Slides)**](https://courseworks2.columbia.edu/courses/82461/files/folder/LECTURES?preview=4719795)

**EXAM  JULY 3rd.**

**Two cheat sheets, both sides.**

**Topics that are out of the scope:**

**1- Association rules.**

**2- Curse of dimensionality**

**3- ... Check again here...**

**Reading/notes:**

Chapter 7, 8, 10

McCarthy: [programs with common sense](https://courseworks2.columbia.edu/courses/82461/files/folder/READING?preview=2224968)

Chapter 22

"AI’s Language Problem", by [Will KnightLinks to an external site.](https://www.technologyreview.com/profile/will-knight/),  
MIT Technology Review, August 9, 2016.

[https://www.technologyreview.com/s/602094/ais-language-problem/Links to an external site.](https://www.technologyreview.com/s/602094/ais-language-problem/)

[Artificial intelligence: How to avoid racist algorithms (Links to an external site.)Links to an external site.](http://www.bbc.com/news/technology-39533308)

*Joy Buolamwini*[How I'm fighting bias in algorithms (Links to an external site.)Links to an external site.](https://www.ted.com/talks/joy_buolamwini_how_i_m_fighting_bias_in_algorithms)

[David Lee: Why jobs of the future won't feel like work (Links to an external site.)Links to an external site.](https://www.ted.com/talks/david_lee_why_jobs_of_the_future_won_t_feel_like_work)

[When is the NN meaningful?](https://courseworks2.columbia.edu/courses/82461/files/folder/READING?preview=4723857)

**HW3 due July 1**

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Additional material:

**Reinforcement Learning:** Markov Decision Processes, Bellman equations, Optimal policy, policy/value iteration