

# CS 581 – ADVANCED ARTIFICIAL INTELLIGENCE

TOPIC: SYLLABUS



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# INSTRUCTOR

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  - Director of MAS-AI
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# AGENDA

- Brief introduction to AI
- Course syllabus
- Course logistics
- Q&A
- Adjourn

# BRIEF INTRO TO AI

# WEAK AI IS UBIQUITOUS

- Speech recognition
  - Siri, Alexa, Google Assistant, Cortona, ...
  - Hidden Markov models, recurrent neural networks
- Email classification
  - Spam, important, social, promotion, ...
  - Text classification, probabilistic models
- Image classification
  - Face recognition, object classification, medical image analysis, ...
  - SIFT features, support vector machines, deep learning
- Game playing
  - Chess, Go, Poker, ...
  - Alpha-beta pruning, supervised learning, deep learning, reinforcement learning, Monte-Carlo tree search, ...

# SUBFIELDS

## ○ Search

- Pretty much everything in AI is powered by search
- Path finding, solving constraint satisfaction problems, parameter search for machine learning models, policy search for reinforcement learning, searching for moves in games, searching for most-probably translations, ...

## ○ Machine learning

- Rather than hardcoding the rules, learn them from history and experience
- Supervised learning, unsupervised learning, reinforcement learning

# SUBFIELDS

- Probabilistic reasoning
  - Represent an uncertain world and act under uncertainty
  - Pretty much all decisions are based on probabilistic inference
  - Medical diagnosis, automated driving, face recognition, ...
- Knowledge representation
  - Common sense reasoning
  - Planning
  - Long-term / sequential acting rather than episodic actions

# COURSE SYLLABUS



# COURSE DESCRIPTION

<http://bulletin.iit.edu/search/?search=cs+581>

Covers advanced topics in artificial intelligence. Topics include search and optimization, simulated annealing, evolutionary algorithms, gradient optimization, constraint optimization, A\* search, alpha-beta search, Monte Carlo tree search, probabilistic reasoning, Bayesian networks, hidden Markov models, Kalman filters, decision-making under uncertainty, influence diagrams, Markov decision processes, bandit problems, supervised learning, classification, deep learning, reinforcement learning, knowledge representation, propositional and first-order logic, ontological engineering, AI ethics and safety, privacy, bias and fairness in machine learning, and explainable AI.

# TEXTBOOK

- There is no required textbook for this course
- You might find the following textbook useful
  - Artificial Intelligence: A Modern Approach by Stuart Russell and Peter Norvig
  - <http://aima.cs.berkeley.edu/>

# WE'LL COVER

- Search and optimization
  - Hill climbing
  - Gradient ascent/descent
  - Coordinate descent
  - Constrained optimization
  - Genetic algorithms
  - Simulated annealing
  - Maximum likelihood estimation
  - Bayesian estimation
  - Expectation maximization
  - Specific algorithms
    - A-star
    - Alpha-beta search
    - Monte Carlo tree search
    - Backpropagation

# WE'LL COVER

- Probabilistic reasoning
  - Bayesian networks
  - Temporal models
  - Hidden Markov models
  - Kalman filters
- Decision-making under uncertainty
  - Influence diagrams
  - Value of information
  - Markov decision processes
  - Bandit problems

# WE'LL COVER

## ○ Learning

- Supervised learning
- Naive Bayes
- Logistic regression
- Support vector machines
- Deep learning
- Convolutional neural networks, recurrent neural networks
- Reinforcement learning
- Passive reinforcement learning, active reinforcement learning, temporal-difference learning, policy search

# WE'LL COVER

- Knowledge representation
  - Propositional logic
  - First-order logic
  - Conjunctive normal form
  - Resolution
  - Ontological engineering
- AI Safety and Ethics
  - AI safety
  - Privacy
  - Bias and fairness in machine learning
  - Explainable AI
- Other topics
  - Computer vision
  - Natural language processing

# POSSIBLE ORDER OF TOPICS

- Searching for solutions in a discrete world with discrete set of actions
  - Algorithms
    - Hill climbing, uniform cost search, best-first search, A\* search, simulated annealing, genetic algorithms
  - Examples
    - Route planning, N-queens, N-Puzzle, traveling salesman problems

# POSSIBLE ORDER OF TOPICS

- Probabilistic reasoning
  - Representation
    - Bayesian networks, hidden Markov models, Kalman filters
  - Parameter estimation
    - Maximum likelihood estimation, Bayesian estimation, expectation maximization



# POSSIBLE ORDER OF TOPICS

- Decision-making under uncertainty
  - Influence diagrams, Markov decision processes, bandit problems
  - Value of information, value iteration, policy iteration

# POSSIBLE ORDER OF TOPICS

## ○ Learning

- Naïve Bayes, logistic regression, support vector machines, neural networks, deep learning, reinforcement learning
- Gradient optimization, Lagrange optimization, backpropagation, temporal difference learning
- Computer vision and natural language processing applications of deep learning

# POSSIBLE ORDER OF TOPICS

- Game playing
  - Minimax, alpha-beta search, Monte-Carlo tree search
  - Supervised learning
  - Reinforcement learning

# POSSIBLE ORDER OF TOPICS

- Knowledge representation
  - Propositional logic, first-order logic, ontological engineering
  - Resolution

# POSSIBLE ORDER OF TOPICS

- AI Safety and Ethics
  - AI safety
  - Privacy
  - Bias and fairness in machine learning
  - Explainable AI

# WHAT THIS COURSE IS NOT

- Not a machine learning course
- Not a deep learning course
- Not a gaming course
- Not an applications course

# RELATED CS COURSES

- <http://bulletin.iit.edu/courses/cs/>
- 400-level
  - CS 422, CS 429, CS 480, CS 481, CS 482, CS 484
- 500-level
  - CS 512, CS 522, CS 529, CS 577, CS 578, CS 579, CS 580, CS 582, CS 583, CS 584, CS 585
- Some courses are offered more frequently than others
  - <https://docs.google.com/document/d/1kiI3FAEZFC4C1wilkYMJF-KHy-m4BG2jL-pbZNiXehI/edit>

# COURSE OBJECTIVES AND OUTCOMES

- Implement and evaluate search and optimization algorithms for various AI problems both in discrete and continuous spaces
- Carry out probabilistic inference for both episodic and sequential tasks
- Compute value of information using probabilistic reasoning and influence diagrams
- Design and implement an agent that can learn from feedback using reinforcement learning
- Develop and evaluate deep learning models of image and text classification
- Apply the resolution algorithm to answer logical entailment queries
- Summarize and critique bias and fairness definitions and solutions



# COURSE LOGISTICS

# ONLINE, IN-PERSON, SYNCHRONOUS, ...?

- Fully online the first two weeks
- Synchronous online lectures
  - Tuesdays/Thursdays 10am-11:15am (US Central)
  - “Zoom Meetings” on BB
- Recording
  - Lectures will be recorded and made available on BB

# WEBSITES

- Blackboard
  - Assignments, lecture videos, calendar
  - <https://blackboard.iit.edu/>
- GitHub
  - Slides, notebooks
  - <https://github.com/CS581/CS581-S22>
- Piazza
  - Questions & answers
  - <https://piazza.com/iit/spring2022/cs581/home>
- OneNote
  - Instructor's handwritten notes
  - See BB for the link

# GRADING

Assignments	30%
Midterm Exam	30%
Final Exam	40%

# ASSIGNMENTS (30%)

- Written assignments
  - Tracing algorithms, calculating probabilities, logical reasoning, essay questions, ...
- Discussions
  - Read and discuss a paper
- Programming assignments
  - Python 3.x
  - Implement and apply an algorithm to a toy/real problem

# LATE SUBMISSION POLICY

- 5-minute grace period, without any penalty
- After that, every late minute will cost
  - $\frac{100}{48 \times 60} \cong 0.03472$  points per minute

# EXAMS

- A midterm (30%) and a final (40%)
- Like written assignments
- Most likely via Blackboard
- Midterm exam date
  - Thursday, March 3<sup>rd</sup>
- Final exam date
  - May 2 – 7
  - Exact date is TBD by the university

# ACADEMIC HONESTY

- If you violate the academic honesty (such as unauthorized/undocumented collaboration, cheating, etc.), then depending on the severity of the violation, it can result in
  - zero points on the respective assignment,
  - E in the course,
  - suspension of your enrollment at the university,
  - expulsion from the university.
- Full guidelines are available at:  
<https://web.iit.edu/student-affairs/handbook/fine-print/code-academic-honesty>



# TITLE IX

- Illinois Tech prohibits all sexual harassment, sexual misconduct, and gender discrimination by any member of our community. This includes harassment among students, staff, or faculty.
- Illinois Tech encourages anyone experiencing sexual harassment or sexual misconduct to speak with the Office of Title IX Compliance for information on support options and the resolution process.
- You can report sexual harassment electronically at [iit.edu/incidentreport](https://iit.edu/incidentreport), which may be completed anonymously. You may additionally report by contacting the Title IX Coordinator, Virginia Foster at [foster@iit.edu](mailto:foster@iit.edu) or the Deputy Title IX Coordinator at [eespeland@iit.edu](mailto:eespeland@iit.edu).
- For confidential support, you may reach Illinois Tech's Confidential Advisor at (773) 907-1062. You can also contact a licensed practitioner in Illinois Tech's Student Health and Wellness Center at [student.health@iit.edu](mailto:student.health@iit.edu) or (312)567-7550
- For a comprehensive list of resources regarding counseling services, medical assistance, legal assistance and visa and immigration services, you can visit the Office of Title IX Compliance website at <https://www.iit.edu/title-ix/resources>.

# AMERICANS WITH DISABILITIES ACT (ADA) POLICY

- Reasonable accommodations will be made for students with documented disabilities. In order to receive accommodations, students must obtain a letter of accommodation from the Center for Disability Resources
- <https://web.iit.edu/cdr>

# QUESTIONS?