

# CS 581 – ADVANCED ARTIFICIAL INTELLIGENCE

TOPIC: SYLLABUS



**Mustafa Bilgic**



<http://www.cs.iit.edu/~mbilgic>



<https://twitter.com/bilgicm>

# INSTRUCTOR

- Dr. Mustafa Bilgic
  - Associate Professor in CS
  - Director of Masters in AI
  - Director of the Machine Learning Laboratory
- Office hours
  - See Blackboard

# TEACHING ASSISTANT

- Ruo Yang
  - PhD student at the Machine Learning Laboratory
- See Blackboard for office hours

# 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, ...
- Text classification
  - Spam, topic, sentiment, ...
- Image classification
  - Face recognition, object classification, medical image analysis, ...
- Game playing
  - Chess, Go, Poker, ...
- In-class examples
  - Anyone?

# SUBFIELDS OF AI

## ○ 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-probable translations, ...

## ○ Machine learning

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

# SUBFIELDS OF AI

## ○ Probabilistic reasoning

- Represent an uncertain world and act under uncertainty
- Most decisions are based on probabilistic inference
- Medical diagnosis, automated driving, ...

## ○ Knowledge representation

- Common sense reasoning
- Planning
- Long-term / sequential acting rather than episodic actions



# COURSE SYLLABUS

# COURSE DESCRIPTION

<https://bulletin.iit.edu/search/?P=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

- Textbook is not required
- You might find the following book useful
  - Artificial Intelligence: A Modern Approach by Stuart Russell and Peter Norvig
  - <http://aima.cs.berkeley.edu/>

# POTENTIAL TOPICS

- Search and optimization
  - Hill climbing
  - Gradient ascent/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

# POTENTIAL TOPICS

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

# POTENTIAL TOPICS

- Learning
  - Supervised learning
    - Naive Bayes, logistic regression, deep learning, convolutional neural networks, recurrent neural networks
  - Reinforcement learning
    - Passive reinforcement learning, active reinforcement learning, temporal-difference learning, policy search

# POTENTIAL TOPICS

- Knowledge representation (if there is time)
  - 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

- Search
  - Hill climbing, uniform cost search, best-first search, A\* search, simulated annealing, genetic algorithms, minimax, alpha-beta pruning, Monte-Carlo tree search
- Probability theory
  - Background, maximum likelihood estimation, Bayesian estimation
- Classification
  - Naïve Bayes, logistic regression
- Deep learning
  - Backpropagation, convolutional neural networks, recurrent neural networks
- Probabilistic decision making
  - Maximum expected utility, value of information, Bandit problems, Markov decision processes, value iteration, policy iteration
- Reinforcement learning
  - Temporal difference learning, Q-learning
- AI safety and ethics
  - Privacy, fairness, accountability, transparency



# WHAT THIS COURSE IS NOT

- Not a machine learning course
- Not a deep learning course
- Not a gaming course
- Not a specific-application 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
  - [http://www.cs.iit.edu/past\\_courses.html](http://www.cs.iit.edu/past_courses.html)

# 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

# IN-PERSON, ONLINE, BEACON

- Live lectures (Section 01)
  - Tuesdays/Thursdays 10am-11:15am (US Central)
- Recordings (Sections 02 and 03)
  - Recorded lectures will be available on BB

# WEBSITES

- Blackboard
  - Assignments, lecture videos, calendar
  - <https://blackboard.iit.edu/>
- GitHub
  - Slides, notebooks
  - <https://github.com/CS581/CS581-S23>
- Piazza
  - Questions & answers
  - <https://piazza.com/iit/spring2023/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 test an AI algorithm



# POSSIBLE ASSIGNMENTS

- Search for traveling from a city to another; manual/no coding
  - A\*, uniform cost search, greedy search
- Simulated annealing; Python
  - Toy problem
  - Traveling salesman
- Monte Carlo tree search; Python
  - A simple game
- Naïve Bayes, Logistic regression; Python
  - Explainable text classification
- Deep learning; Python
  - Image classification
  - A game board
- Reinforcement learning; Python
  - Toy problem
  - Game playing (Monte-Carlo tree search, deep learning, reinforcement learning); AlphaGo

# LATE SUBMISSION POLICY FOR ASSIGNMENTS

- 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
- Extensions for medical reasons: medical documentation is required

# EXAMS

- A midterm (30%) and a final (%40)
- Like written assignments
- Most likely via Blackboard
- Midterm exam date
  - Thursday, March 2<sup>nd</sup>
- Final exam date
  - May 1 – 6
  - The date is TBD by the university; per academic calendar (<https://www.iit.edu/registrar/academic-calendar>), the final exam date will be announced on March 8<sup>th</sup>

# ACADEMIC HONESTY

- <https://www.iit.edu/student-affairs/student-handbook/fine-print/code-academic-honesty>
- Violations
  - The misrepresentation of any work submitted for credit or otherwise as other than the product of a student's sole independent effort
  - The use of any unauthorized assistance in taking quizzes, tests or examinations
- Sanctions
  - Reduction in grade
  - Expulsion from the course with a grade of E
- Appeals
  - An appeal of a decision regarding academic honesty must be submitted in writing to the Dean of Students (dos@iit.edu)

# TITLE IX

- <https://www.iit.edu/title-ix>
- Illinois Tech prohibits all sexual harassment, sexual misconduct, and gender discrimination by any member of our community.
- 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.
- For resources, including counseling and legal assistance, please visit <https://www.iit.edu/title-ix/resources>

# ACCOMMODATIONS

- Reasonable accommodations will be made for students with documented disabilities.
- Reasonable accommodations include
  - Note taking, sign language interpretation, speech-to-text services, testing accommodations (e.g., large print, a reduced-distraction area), and housing accommodations
  - <https://www.iit.edu/cdr/services/reasonable-accommodations>
- To receive accommodations, students must obtain a letter of accommodation from the Center for Disability Resources
  - <https://www.iit.edu/cdr>
- All accommodations must be requested in advance

## RELIGIOUS/CULTURAL/NATIONAL HOLIDAYS

- If you observe a holiday on which you cannot submit an assignment or take an exam, please let me know as soon as possible but no later than January 28<sup>th</sup>
- I will do my best to schedule the midterm and the assignment due dates accordingly (the final exam date is set by the university)
- Requests made after January 28<sup>th</sup> will not be accommodated

# QUESTIONS?