CS 581 – ADVANCED ARTIFICIAL INTELLIGENCE

TOPIC: SYLLABUS

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COURSE

- CS 581
- Advanced Artificial Intelligence

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INSTRUCTOR

- Dr. Mustafa Bilgic
  - Associate Professor in CS
  - Director of the BS-AI and MAS-AI programs
  - Director of the Machine Learning Laboratory

Agenda

- Brief introduction to AI
- Course syllabus
- Course logistics
- Pick an office hour that works for most students
- Answer your questions
- Adjourn

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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

CS 581 – Advanced Artificial Intelligence – Illinois Institute of Technology

Course Syllabus

COURSE DESCRIPTION (OLD)

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

Covers various advanced topics in AI, including both theory and practice. Content may vary by instructor. Possible topics include: Planning: STRIPs planning; Partial-order planning; Situation calculus; Theorem proving; GraphPlan/SatPlan; Transformational planning; Simulated annealing; Motion planning; Case-based reasoning; Multi-agent coordination; Negotiation planning; Representation and Reasoning: Logical representation; Frame problem; Probabilistic reasoning; Bayesian networks; Game Playing: Minimax search; Evaluation functions; Learning evaluation functions; Markov Decision Processes; Reinforcement learning for games; Developing AI agents; Multi-agent planning.

COURSE DESCRIPTION (NEW)

https://github.com/CS581/CS581-S21

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 (2 weeks)
  - 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 (2 weeks)
  - Bayesian networks
  - Temporal models
  - Hidden Markov models
  - Kalman filters
- Decision-making under uncertainty (3 weeks)
  - Influence diagrams
  - Value of information
  - Markov decision processes
  - Bandit problems

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WE'LL COVER

- Learning (3 weeks)
  - 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 (2 weeks)
  - Propositional logic
  - First-order logic
  - Conjunctive normal form
  - Resolution
  - Ontological engineering
- AI Safety and Ethics (1.5 weeks)
  - AI safety
  - Privacy
  - Bias and fairness in machine learning
  - Explainable AI
- Other topics (1.5 weeks)
  - Computer vision
  - Natural language processing

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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, 8 queens, traveling salesman problems

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POSSIBLE ORDER OF TOPICS

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

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POSSIBLE ORDER OF TOPICS

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

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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

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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

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COURSE LOGISTICS

ONLINE, IN-PERSON, SYNCHRONOUS, …?

- Fully online

- Synchronous online lectures
  - Tuesdays/Thursdays 9:40am-10:55am (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
  - https://github.com/CS581/CS581-S21

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GRADING

Assignments	30%
Midterm Exam	30%
Final Exam	40%

ASSIGNMENTS (30%)

- Written assignments
  - Tracing algorithms, calculating probabilities, logical reasoning, essay questions, …

- 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 11th
- Final exam date
  - May 10 – 14
  - Exact date is TBD by the university

OFFICE (VIRTUAL) HOUR

- Survey to pick an hour that works for most

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, which may be completed anonymously. You may additionally report by contacting the Title IX Coordinator, Virginia Foster at foster@iit.edu or the Deputy Title IX Coordinator at 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 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.

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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?

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