CPS 570

Artificial Intelligence
(emanating planning and sensing)

Introduction
Ron Parr

Who is Ron?

• Professor of Computer Science
• 14th year at Duke
• A.B. in Philosophy (thought I don’t use that much)
• Interests:
  – Robotics
  – MDPs & Reinforcement learning
  – Game theory
  – Sensing

More AI at Duke

• In CS: Vince Conitzer (Computational Economics), Bruce Donald & Alex Hartemink (Computational Biology), Carlo Tomasi (vision),
• In Engineering: Larry Carin (Machine Learning), Silvia Ferrari (Intelligent Control), Guillermo Sapiro (Vision)
• In Statistics: Katherine Heller & Sayan Mukherjee (Machine Learning)
• In Math: Mauro Maggioni (Machine Learning)
• In Biostatistics: Barbara Engelhardt & Raluca Gordan (Computational Biology)
• (With apologies to those I left out...)

What is AI?

• For centuries, perhaps longer, people have wondered how to reproduce the smarts that people have...
• Even though we really have no idea how to define such things
• The task of defining intelligence has, itself, been a career long endeavor for many scholars
Machine Intelligence

- For as long as people have made machines, they have wondered if these machines could exhibit human-like intelligence
- von Kempelen’s (fraudulent) Turk (1700s), Babbage’s analytical and difference engines (1800s), Turing’s Turing machine (1900s)

AI after Turing

- Modern AI is ~55 years old
- “AI” term proposed at the famous “Dartmouth Conference” in 1957, when computers were slow, room-sized monstrosities
- Has been a subject of intense study since then
  - Most CS departments have at least one AI expert
  - Defense department, national science foundation, industry invest heavily in AI every year
  - Google, amazon, etc. all have robust AI groups – often machine learning

Exhibit at the Computer History Museum in Santa Clara

Are We Making Progress? (AI in your life)

- Game playing - chess, jeopardy
- Voice recognition – siri
- Recommendation systems – netflix, amazon
- Handwriting recognition
- Automated logistics – UPS, US military
- Space exploration
But Where’s the General Intelligence?

- AI didn’t get traction until it focused on more specific problems
- Hard to provide “general intelligence” if you don’t know what it is
- Are we mimicking intelligence or getting closer to it by focusing on specific problems?

What This Class Is Not

- A Balanced Introduction to AI
- Easy

How This Differs from Undergraduate AI

- Undergrad AI:
  - Covers most of AI
  - Covers things at a shallow level
  - Uses an encyclopedic textbook
  - Emphasizes programming, basic algorithms
- This course:
  - Focuses on a few topics
  - Goes into depth
  - Uses no textbook – lectures and papers
  - Emphasizes theory, discussion of papers

How This Differs From The Old 270

- Grad AI (270) was undergrad AI (170) with harder questions
- 270 was taken by many grad students for the sole purpose of fulfilling distribution requirements = many students who were not very interested
Why We’re Changing Graduate AI

• Graduate students now encouraged to pass qualifying exams to demonstrate undergraduate-level mastery of breadth topics

• Graduate AI should:
  – be a more exciting class for people who are genuinely interested in more advanced material
  – prepare students for further study in AI
  – help students become effective researchers/computer scientists

• Desire to align graduate AI with the WlSeNet program

The Major Problem We’re fixing

• Students could pass graduate AI but still have no clue about how to start doing AI research

• There needs to be a transitional course from undergraduate problem solving to graduate research

Another Issue We’re Exploring

• What is the evolving role of the lecture?

• As lectures become commoditized (coursera, udacity, etc.), should class time:
  – Reproduce what is already available on the web
  – Augment what is available?
    • Make the most of in-person, real time interactions
    • Teach skills that aren’t easily addressed through lectures?

Learning Objectives

• Teach students to think outside the textbook

• Teach students to teach themselves:
  – Reading papers in the field
  – Discussing papers with peers

• Expose students to classic topics in AI as well as leading edge research
**What If I’m not an AI student?**

- AI papers tend to mix theory and application
- AI has been a source of interesting questions for theoreticians
- AI has useful applications across CS, engineering, biology, etc.

- Learning to read AI papers will help develop useful skills that transfer to other disciplines

**What if I’m a WISENet student?**

- Sensing is central to sensor networks
- Sensing without planning is foolish
- Sensing is expensive
- No such thing as a “free” sensor reading
  - Cost of moving a resource to acquire data
  - Direct cost of acquiring data (power, time)
  - Cost of transmitting data
  - Cost of processing data

**What if I’m not a Graduate Student?**

- Hopefully you will be one some day

- Even if you don’t go to graduate school:
  - There is no textbook for the real world
  - Much of what is in your textbooks now will be outdated in a few years

- Make sure you’ve got enough background:
  We assume you know a lot of basic CS

**Requirements**

- Familiarity with programming
- Ability to do short proofs
- Basic probability concepts
- Basic algorithmic concepts
  - Complexity - O()
  - Analysis of algorithms
- Math
  - Basic calculus (partial derivatives)
  - Basic linear algebra
Major Topics Covered

- NP-hardness and satisfiability
  - Review of NP-hardness, fast SAT solvers, phase transition effects, approximation
- Planning (and hierarchical planning)
  - Classical planning, robot motion planning
- Reasoning under uncertainty
  - Probability, Bayes nets, Markov Random Fields, HMMs
- Reinforcement learning (and hierarchical methods)
  - MDPs, POMDPs, reinforcement learning
- Game Theory and linear programming
- Sensing applications
  - Value of information, observation planning in HMMs, observation planning with POMDPs, observation planning using game theory, stereo vision

Major Topics Not Covered

- Search – single player and games
- Constraint Satisfaction
- Natural Language – written, spoken language
- Logic and Knowledge Representation
- Machine Learning – clustering, supervised learning
- Vision – object and activity recognition

Class Mechanics

- No Textbook!:
  - Lectures will cover basic background material with pointers to optional readings in textbooks
  - Papers will be downloadable from the web
- Homework: 30%
  - Mix of short problems on basic concepts and questions about readings
- Class Participation: 10% (more on next slide)
- Mini project: 10%
  - Critical evaluation of a paper of your choosing (approved by me)
- Midterm 20%
  - Closed book, in class, no collaboration
- Final: 30%
  - Closed book, finals week, no collaboration
- Why exams count 50%: This is a requirement for classes that give quals credit in CS (sorry!)

Papers

- Lectures will be intended to provide sufficient background to read the papers
- Discussions will begin with a brief overview from me
  - Provide additional context
  - Clarify any issues that come up from student questions before class
  - Class will break up into two groups
  - Groups will produce PowerPoint slides that address questions about the reading
  - Class ends with groups presenting their findings
- Discussion will be guided by questions from me but, hopefully, will be driven by student interest
**Academic Honesty**

- You are encouraged to discuss papers and high level concepts with your friends
- Specific answers to questions must be your own
- You may **not**
  - ask your friends for specific answers to questions
  - use code from other sources without permission
  - search the internet for answers to questions
- Don’t push it; we take these things seriously here.
- More details in a separate presentation

**Grading**

- This is a graduate course
- Grades are typically A’s and B’s
- Lower grades are rare, but they do occur
- If you are a young Ph.D. student, you probably need to **rethink the importance of grades in your life**

**Things that Might go Wrong**

- Sometimes papers will be confusing
  - This may be the fault of the authors
  - This may be because the paper assumes something you don’t know yet

- Discussions may work well sometimes and may fall flat at other times
- We will be experimenting with ways to make discussion stimulating and rewarding