Artificial Intelligence Programming

Introduction

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Course Mechanics

- Requirements: CS 245 or equivalent.
  - You should be comfortable writing medium-sized programs
  - We'll primarily program in Python.
  - We'll also use some pre-existing tools
- Grading:
  - 9 assignments, each of which will take 1-2 weeks (65%)
  - Two midterms, plus a final (30%)
  - The dreaded "class participation" component (5%)
- Attendance is required.

Course Mechanics

- Text: AIMA, 2nd edition
- Late Policy
- Collaboration

Topics

- Topics we'll cover:
  - Uninformed Search
  - Heuristic Search
  - Genetic Algorithms and Simulated Annealing
  - Knowledge Representation
  - Logic and Inference
  - Ontologies
  - Probabilistic Reasoning
  - Machine Learning

non-AI topics

- Along the way, you'll also get exposed to some non-AI topics:
  - HTTP
  - HTML, XML
  - Semantic Web
  - Text classification
  - Python
  - and more!

Topics we won't get to ...

- Stuff we probably won't have time for:
  - Robotics
  - Vision
  - Natural Language

AI as a research field

- Ordinary folks typically think that AI is all about building the Terminator, or Data, or other “human-level” AI.
- AI research is typically **much** more narrowly focused.
  - Why is that?
- AI also has a perception of being a “failed research area”
  - Again, this hinges on how you define the field.
- It’s important to carefully define the problems you want to solve.

What is AI?

- ‘concerned with intelligent behavior in artifacts’ - Nilsson
- ‘study of the design of intelligent agents’ - Poole
- ‘Creating machines that perform functions that require intelligence when performed by people.’ - Kurzweil
- ‘The automation of activities we associate with human thinking, such as decision-making, problem-solving, learning’ - Bellman
- ‘The study of the computations that make it possible to perceive, reason, and act’ - Winston

Reducing this ...

- “Intelligence” is a hard thing to quantify. Let’s make the question simpler.
- Can machines think?
- Let’s break this down further:
  - *Can* - is it possible to build a machine that thinks?
  - Searle: Thought is a byproduct of human makeup - nothing less complex than a human can actually think.
    - “Brains cause minds” - we are intelligent because we have evolved to function in a very complex, spatially rich world.
    - Being completely embedded in the world is necessary for intelligence.

Reducing this ...

- *Can* machines think?
- Newell and Simon: Physical Symbol System Hypothesis
- A physical symbol system has the *necessary* and *sufficient* means for general intelligent action.
- Symbols: letters, numbers, words, variables, etc.
- A symbol system is a collection of symbols, plus the rules or means to combine them into new symbols.
  - e.g. A CPU or a Turing machine
- Symbols are used to construct a *language* or *representation*

PSS Hypothesis

- necessary: symbol manipulation is required for intelligence.
  - This is controversial; some folks feel that intelligence can be achieved purely through subsymbolic manipulation of signals.
  - For example, recognizing someone’s face is not a symbolic task.
- Sufficient - no other system or capability is required for intelligence if one has a PSS.
  - Also controversial - some people argue that the agent must be grounded in a sufficiently rich world.

Reducing this ...

- Can machines think?
- *machines* - What is a machine?
- We typically look at Turing-equivalent machines.
- Perhaps other types of machines can be intelligent.
- Cells can be programmed using DNA
- We can argue that the human body is just a very complex machine.
- We’ll worry about standard stored-program computers in this class.

Reducing this ...

- Can machines think?
- *think* - This is the hardest one yet.
  - What does it mean for a machine (or a person) to think?
  - How can we as scientists say that some external thing is thinking?
  - How can we say that it is intelligent?
  - How do I know that other humans are thinking? Maybe they're just cleverly programmed automata.

Thinking

- "A system is intelligent if it acts like a human"
- I assume people are intelligent because they act appropriately.
- Can we apply this metric to a computer?
- Turing test
  - Talk with a human and a computer about any topic over an IM-style interface.
  - If a questioner cannot tell which is which, the computer must be intelligent.

Problems with the Turing Test

- Sufficient, but not necessary.
- Only measures language and conversation.
  - What about learning, problem solving, vision, etc ...
- Test is subjective; depends on the questions asked.
- Do we really want an intelligent machine to be indistinguishable from a human?
  - Can't do square roots, gets tired, can't remember lists, etc.
- What about complicated mimicry programs? Do they count?
- Searle's Chinese Room

Thinking

- "A system is intelligent if it *thinks* like a human"
- If a system uses the same reasoning processes as a human, then it is intelligent.
- How do humans think? This is an ongoing research problem.
- Researchers in cognitive science and psychology construct computational models of human problem solving.
  - Gives a way to 'look inside' a model of the human brain
  - Goal: better understand the human brain/mind.
- Again, do we really want a machine to think 'like a human'? Make logical errors, misestimate distances and probabilities, draw faulty conclusions, etc.

Thinking

- "A system is intelligent if it thinks *rationally*"
- An intelligent system is one that follows sound reasoning processes that always lead to correct outcomes.
- This leads to the study of logic and formal reasoning
- This used to be the dominant approach in AI.
- However, logic has its problems.
  - Formalizing common-sense knowledge
  - Dealing with uncertainty
  - Computational issues

Thinking

- "A system is intelligent if it *acts* rationally"
- Currently the most popular definition.
- Sidesteps all the sticky questions.
- A rational agent is one that acts so as to achieve the best possible (expected) outcome, given its knowledge and ability.
- Not omnipotent or omniscient
- This lets us work on smaller problems that require 'intelligence'
- We can build agents that do cetain tasks intelligently without having human-level intelligence.

AI as an engineering problem

- We'll focus on the engineering and design problems in AI
  - How do we build a program that can learn to do a task?
  - What sorts of knowledge is needed for a program to solve a word problem?
- Less emphasis on cognitive and philosophical issues.

Successes of AI

- A common criticism of AI is that it's a failure.
- Early AI researchers were overly optimistic.
  - Solutions to simple problems didn't scale up.
- "As soon as something works, it's no longer AI."
  - Voice recognition
  - Face recognition
  - Optimal scheduling
  - Automated translation
  - Factory robots
  - Object-oriented programming

Successes of AI

- Some successful AI programs:
  - Deep Blue
  - Chinook
  - TD-Gammon
  - Remote Agent
  - Expert systems (Dendral, MYCIN)
  - DARPA Grand Challenge
  - Soar
  - Logistics planning

Current AI Applications

- Information Processing
- Expert Systems
- Space exploration
- Automated factories
- Robotic search-and-rescue
- Games and immersive environments
- Electronic Commerce
- Financial Management
- Tutoring systems
- and many others ...