22c:145 Artificial Intelligence
Fall 2005

Introduction

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The University of Iowa

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Class Web Site:  
www.cs.uiowa.edu/~tinelli/145

*Check the class web site daily!*

Some slides and most of the figures are from our textbook.
## Other AI texts

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Publisher</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI: A New Synthesis</td>
<td>Nilsson</td>
<td>Morgan Kaufmann</td>
<td>1998</td>
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<tr>
<td>Computational Intelligence</td>
<td>Poole, Mackworth, Goebel</td>
<td>Oxford</td>
<td>1998</td>
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<tr>
<td>Artificial Intelligence (3rd ed.)</td>
<td>Winston</td>
<td>Addison-Wesley</td>
<td>1992</td>
</tr>
<tr>
<td>AI: Theory and Practice</td>
<td>Dean, Allen, Aloimonos</td>
<td>Benjamin Cummings</td>
<td>1995</td>
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<tr>
<td>Mathematical Methods in AI</td>
<td>Bender</td>
<td>IEEE Comp. Press</td>
<td>1996</td>
</tr>
<tr>
<td>Logical Foundations of AI</td>
<td>Genesereth, Nilsson</td>
<td>Morgan Kaufmann</td>
<td>1987</td>
</tr>
</tbody>
</table>
# Course Overview

<table>
<thead>
<tr>
<th>Topic</th>
<th>Chapters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intelligent Agents</td>
<td>1, 2</td>
</tr>
<tr>
<td>Programming in OCaml</td>
<td></td>
</tr>
<tr>
<td>Problem Solving and Search</td>
<td>3, 4</td>
</tr>
<tr>
<td>Constraint Satisfaction</td>
<td>5</td>
</tr>
<tr>
<td>Knowledge Representation and Reasoning</td>
<td>7, 8</td>
</tr>
<tr>
<td>Logical Inference</td>
<td>9</td>
</tr>
<tr>
<td>Planning</td>
<td>11, 12</td>
</tr>
<tr>
<td>Uncertain Knowledge and Reasoning</td>
<td>13, 14</td>
</tr>
<tr>
<td>Machine Learning</td>
<td>18, 19, 20</td>
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</tbody>
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Prerequisites

- The course will be self-contained, but an elementary background in CS and Math is required.

- Expect the class material to become a little technical at times.

- You will implement some of the techniques seen in class. Programming assignments will be mostly in OCaml.
Readings for This Lecture

- Chap. 1 of [Russell and Norvig, 2003]
What is Artificial Intelligence?

A scientific and engineering discipline devoted to:

- understanding principles that make intelligent behavior possible in natural or artificial systems;

- developing methods for the design and implementation of useful, intelligent artifacts. [Poole, Mackworth, Goebel]
What is intelligence then?
What is intelligence then?

- Fast thinking?
- Knowledge?
- Ability to pass as a human?
- Ability to reason logically?
- Ability to learn?
- Ability to perceive and act upon one’s environment?
- Ability to play chess at grand-master’s level?
- ...
Acting Humanly: The Turing test

Turing (1950) “Computing machinery and intelligence”:

![Diagram](image-url)
Acting Humanly: The Turing test

- “Can machines think?” → “Can machines behave intelligently?”
- Operational test for intelligent behavior: the Imitation Game
- Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes
- Anticipated all major arguments against AI in following 50 years
- Suggested major components of AI: knowledge, reasoning, language understanding, learning

**Problem**: Turing test is not *reproducible*, *constructive*, or amenable to *mathematical analysis*.
1960s “cognitive revolution”: information-processing psychology replaced prevailing orthodoxy of behaviorism

Require scientific theories of internal activities of the brain
- What level of abstraction? “Knowledge” or “circuits”?
- How to validate? It requires
  1. Predicting and testing behavior of human subjects (top-down, Cognitive Science)
  2. Direct identification from neurological data (bottom-up, Cognitive Neuroscience)
Several Greek schools at the time of Aristotle developed various forms of logic:

- **Notation and rules of derivation** for thoughts. They may or may not have proceeded to the idea of mechanization.
- **Direct line through mathematics and philosophy to modern AI**.
- **Problems:**
  1. Not all intelligent behavior is mediated by logical deliberation.
  2. What is the purpose of thinking? What thoughts **should** I have?
Acting Rationally

- **Rational** behavior: doing the right thing, that which is expected to maximize goal achievement, given the available information

- Doesn’t necessarily involve thinking—e.g., blinking reflex—but thinking should be in the service of rational action

- Aristotle:
  
  *Every art and every inquiry, and similarly every action and pursuit, is thought to aim at some good*
Rational Agents

- An *agent* is an entity that perceives and acts
- This course is about designing *rational agents*
- Abstractly, an agent is a function from percept histories to actions:
  \[ f : P^* \rightarrow A \]

For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance

- Caveat: *computational limitations make perfect rationality unachievable*
- Approach: design best *program* for given machine resources
## Summary of Experts’ View of AI

<table>
<thead>
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<tbody>
<tr>
<td>“The exciting new effort to make computers think ... <em>machines with minds</em>, in the full and literal sense” (Haugeland, 1985)</td>
<td>“The study of mental faculties through the use of computational models” (Charniak and McDermott, 1985)</td>
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<td>“[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning ...” (Bellman, 1978)</td>
<td>“The study of the computations that make it possible to perceive, reason, and act” (Winston, 1992)</td>
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<td>“The art of creating machines that perform functions that require intelligence when performed by people” (Kurzweil, 1990)</td>
<td>“A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes” (Schalkoff, 1990)</td>
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<td>“The study of how to make computers do things at which, at the moment, people are better” (Rich and Knight, 1991)</td>
<td>“The branch of computer science that is concerned with the automation of intelligent behavior” (Luger and Stubblefield, 1993)</td>
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<thead>
<tr>
<th>Systems that <em>think</em> like humans</th>
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</tbody>
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Operational Definition of AI

Systems that *act* like humans
Turing test.

Systems that *think* like humans
Cognitive Science

Systems that *think* rationally
Logic-based AI

Systems that *act* rationally
Rational Agents
AI’s Foundations

- Philosophy: logic, methods of reasoning, mind as physical system, foundations of learning, language, rationality,
- Mathematics: formal representation and proof, algorithms, computation, (un)decidability, (in)tractability, probability,
- Psychology: adaptation, perception and motor control, experimental techniques,
- Economics: formal theory of rational decisions,
- Linguistics: knowledge representation, grammar,
- Neuroscience: plastic physical substrate for mental activity,
- Control theory: homeostatic systems, stability, simple optimal agent designs.
1943  McCulloch & Pitts: Boolean circuit model of brain
1950  Turing’s “Computing Machinery and Intelligence”
1950s  Early AI programs, including Samuel’s checkers program, Newell & Simon’s Logic Theorist, Gelernter’s Geometry Engine
1956  Dartmouth meeting: “Artificial Intelligence” adopted
1965  Robinson’s complete algorithm for logical reasoning
1966–74  AI discovers computational complexity
          Neural network research almost disappears
1969–79  Early development of knowledge-based systems
1980–88  Expert systems industry booms
1985–95  Neural networks return to popularity
1988–  Resurgence of probability; general increase in technical depth
          “Nouvelle AI”: ALife, GAs, soft computing
1995–  Agents agents everywhere . . .
State of the art

Which of the following can be done at present?

♦ Play a decent game of table tennis
♦ Drive along a curving mountain road
♦ Drive in the center of Cairo
♦ Buy a week’s worth of groceries at Berkeley Bowl
♦ Buy a week’s worth of groceries on the web
♦ Play a decent game of bridge
♦ Discover and prove a new mathematical theorem
♦ Write an intentionally funny story
♦ Give competent legal advice in a specialized area of law
♦ Translate spoken English into spoken Swedish in real time
♦ Perform a complex surgical operation
Why Study AI?

AI helps

- computer scientists and engineers build more useful and user-friendly computers,
- psychologists, linguists, and philosophers understand the principles that constitute what we call intelligence.

AI is an interdisciplinary field of study.

Many ideas and techniques now standard in CS (symbolic computation, time sharing, objects, declarative programming, . . . ) were pioneered by AI-related research.
Recent applications using AI techniques:

- **Sony Aibo**
  Entertainment robot with pet-like behaviour
  ([http://www.us.aibo.com](http://www.us.aibo.com))

- **Dragon Naturally Speaking**
  (Dictation and voice recognition software)
  ([http://www.dragonsys.com/naturallyspeaking](http://www.dragonsys.com/naturallyspeaking))

- **Ananova**
  Virtual newscaster on the web
  ([http://www.ananova.com/video](http://www.ananova.com/video))

- **Honda Humanoid Robot**
  Demo walking robot ([http://www.honda.co.jp/robot](http://www.honda.co.jp/robot))
AI is among us!

More applications using AI techniques:

- Deep Blue
  Chess program that beat chess grand-grand-master Kasparov
  (http://researchweb.watson.ibm.com/deepblue)

- Mars Pathfinder
  Autonomous land vehicle sent to Mars
  (http://mars.jpl.nasa.gov/MPF)

- Aaron The Robot as an Artist
  http://www.scinetphotos.com/aaron.html

- Astronomy and Space Exploration

- and many more!
AI is pretty hard stuff

I went to the grocery store, I saw the milk on the shelf and I bought it.

What did I buy?

- The milk?
- The shelf?
- The store?

An awful lot of knowledge of the world is needed to answer simple questions like this one.