Artificial Intelligence

Berlin Chen 2005
Course Contents

• The theoretical and practical issues for all disciplines of Artificial Intelligence (AI) will be considered
  – AI is interdisciplinary!

• Foundational Topics to Covered
  – Intelligent Agents
  – Search, Advanced Search, Adversarial Search (Game Playing), Constraint Satisfaction Problems (CSP)
  – Propositional and Predicate Logic, Inference and Resolution
  – Rules and Expert Systems
  – Probabilistic Reasoning and Bayesian Belief Networks
  – Others (Hidden Markov Models, Graphical Models, Neural Networks, Genetic Algorithms, etc.)
Textbook and References

• Textbook:
    http://aima.cs.berkeley.edu/

• References:
  – B. Coppin. *Artificial Intelligence Illuminated*. Jones and Bartlett, 2004
Grading

• Midterm or Final: 30%
• Homework: 25%
• Project/Presentation: 30%
• Attendance/Other: 15%
Introduction

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Reference:
What is AI?

• “[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning…” (Bellman, 1978)

• “The exciting new effort to make computer think … machines with mind, in the full and literal sense.” (Haugeland, 1985)

• “The study of mental faculties through the use of computational models” (Charniak and McDermott, 1985)

• “The study of how to make computers do things at which, at the moment, people do better.” (Rich and Knight, 1991)
What is AI?

- The study of the computations that it possible to perceive, reason, and act.” (Winston, 1992)
- “AI…is concerned with intelligent behavior in artifacts.” (Nilsson, 1998)

**AI systemizes and automates intellectual tasks as well as any sphere of human intellectual activities.**
- Duplicate human facilities like creativity, self-improvement, and language use
- Function autonomously in complex and changing environments

**AI still has openings for several full-time Einsteins!**
Categorization of AI

<table>
<thead>
<tr>
<th>Thought/ reasoning</th>
<th>fidelity</th>
<th>rationality</th>
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<tr>
<td></td>
<td>Systems that <strong>think</strong> like humans</td>
<td>Systems that <strong>think</strong> rationally</td>
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<td>behavior</td>
<td>Systems that <strong>act</strong> like humans</td>
<td>Systems that <strong>act</strong> rationally</td>
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- Physical simulation of a person is unnecessary for intelligence?
  - Humans are not necessarily “rational”
Acting Humanly: The Turing Test

• Turing test: proposed by Alan Turing, 1950

- The test is for a program to have a conversation (via online typed messages) with an interrogator for 5 minutes
- The interrogator has to guess if the conversation is with a machine or a person
- The program passes the test if it fools the interrogator 30% of the time
Acting Humanly: The Turing Test

• Turing’s Conjecture
  – At the end of 20 century a machine with 10 gigabytes of memory would have 30% chance of fooling a human interrogator after 5 minutes of questions

• Problems with Turing test
  – The interrogator may be incompetent
  – The interrogator is too lazy to ask the questions
  – The human at the other hand may try to trick the interrogator
  – The program doesn’t have to think like a human
  – ....
Acting Humanly: The Turing Test

• The computer would possess the following capabilities to pass the Turing test
  • **Natural language** *(Speech processing?)*
  • Knowledge representation
  • Automated reasoning
  • Machine learning/adaptation
  • Computer vision
  • Robotics

Six disciplines compose most of AI

So-called "total Turing Test"

Imitate humans or learn something from humans?
Acting Humanly: The Turing Test

• However, scientists devoted much effort to studying the underlying principles of intelligence than passing Turing test!
  – E.g. Aircrafts vs. birds
  – E.g. Boats/submarines vs. fishes/dolphins/whales
  – E.g. Perception in speech/vision
Thinking Humanly: Cognitive Modeling

• Get inside the actual workings of human minds through
  – Introspection
  – Psychological experiments

• Once having a sufficiently precise theory of the mind, we can express the theory as a computer program!

• Cognitive science - interdisciplinary
  – Computer models from AI
  – Experimental techniques from psychology

An algorithm performs well \(\leftrightarrow\) A good model of human performance
Thinking Rationally: Laws of Thought

• Correct inference
  
  “Socrates is a man; all men are mortal; therefore, Socrates is mortal”
  
  – Correct premises yield correct conclusions

• Formal logic
  
  – Define a precise notion for statements all things and the relations among them
    
    • Knowledge encoded in logic forms
  
  – Main considerations
    
    • Not all things can be formally repressed in logic forms
    • Computation complexity is high
Acting Rationally: Rational Agents

- An agent is just something that perceives and acts
  - E.g., computer agents vs. computer programs
  - Autonomously, adaptively, goal-directly

- Acting rationally: doing the right thing
  - The right thing: that which is expected to maximize the goal achievement, given the available information
  - Don’t necessarily involve thinking/inference

- Rationality $\leftrightarrow$ Inference

- The study of AI as rational-agent design
Acting Rationally: Rational Agents

![Diagram showing the relationship between the environment, agent, sensors, percepts, actions, and actuators.]}
Foundations of AI

Psychology
Linguistics
Neuroscience
Economics
Philosophy
Computer Engineering
Control Theory
AI
Foundations of AI

• **Philosophy**: (428 B.C. - present)
  
  Logic, methods of reasoning
  
  – A set of rules that can describe the formal/rational parts of mind
  
  – Mind as a physical system / computation process
  
  – Knowledge acquired from experiences and encoded in mind, and used to choose right actions
  
  – Learning, language, rationality
Foundations of AI

• **Mathematics** (C. 800 - present)
  
  Formal representation and proof
  
  – Tools to manipulate logical/probabilistic statements
  – Groundwork for computation and algorithms

  Three main contributions:
  - (decidability of) logic, (tractability of) computation, and probability (for uncertain reasoning)
Foundations of AI

• **Economics** (1776 - present)
  
  Formal theory for the problem of making decisions
  – Utility: the preferred outcomes
  – Decision theory
  – Game theory (賽局)
  – Operations research
    • Payoffs from actions may be far in the future
Foundations of AI

• **Neuroscience** (1861- present)
  
  Brains cause minds
  
  - The mapping between areas of the brain and the parts of body they control or from which they receive sensory input

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Ramón y Cajal (拉蒙卡哈)
Foundations of AI

- **Psychology** *(1879- present)*
  Brains as information-processing devices
  - Knowledge-based agent
    - Stimulus translated into an internal representation
    - Cognitive process derive new international representations from it
    - These representations are in turn retranslated back into action

- **Computer engineer** *(1940- present)*
  Artifacts for implementing AI ideas/computation
  - (Software) programming languages
  - The increase in speed and memory
Foundations of AI

• **Control theory** (1948- present)
  Maximizing an objective function over time
  – Minimize the different between current and goal states

• **Linguistics** (1957- present)
  How does language relate to thought?
  – Languages fit information processing model
  – Understanding languages requires an understanding of subject matter and context
History of AI

• 1943-55  Gestation of Artificial Intelligence  
  McCulloch & Pitt: Boolean circuit model of neurons  
  Turing’s “Computing Machinery and Intelligence”

• 1956       The birth of Artificial Intelligence  
  Dartmouth meeting: “Artificial Intelligence” adopted  
  (McCarthy, Minsky, Shannon, …)

• 1966-85  Neural network research almost disappears  
  No efficient Training Algorithms for Layered networks

• 1969-79  Knowledge-based systems

• 1980-88  Expert system industry booms  
  A million dollars to billions of dollars

• 1986-  Neural networks return to popularity

• 1988-93  Expert system industry busts: “AI winter”

• 1995-  Agents everywhere …
Advances in AI

- **Search Algorithms** like genetic algorithms
  
- Machine Learning
  - Hidden Markov Models
  - Neural Networks
  - Bayesian Networks
  - Support Vector Machines

- Data Mining
Research Prototypes

- MIT Microworlds: “analogy problems” (1968)

- MIT Microworlds: “blocks world” (1972)
Research Prototypes

• ELIZA: A simple natural-language understanding program (1966)
  
  User1: Men are all alike.
  ELIZA1: IN WHAT WAY
  User2: They’re always bugging us about something or other.
  ELIZA2: CAN YOU THINK OF A SPECIAL EXAMPLE
  User3: Well, my boyfriend made me come here.
  ELIZA3: YOUR BOYFRIEND MADE YOU COME HERE
  User4: He says I’m depressed much of the time.
  ELIZA4: I AM SORRY TO HERE YOU ARE DEPRESSED

s/.*/ all .*/IN WHAT WAY/
s/.*/ always .*/CAN YOU THINK OF A SPECIFIC EXAMPLE/
s/.*/ I’m (depressed|sad) .*/I AM SORRY TO HEAR YOU ARE \1/
Research Prototypes

- CMU ALVIN project, 1989 ( Autonomous Land Vehicle In a Neural Network)
  - 1200 computer-generated images as training examples
    - Half-hour training
    - The salient features have been directly acquired by the network itself

An additional information from previous image indicating the darkness or lightness of the road
Research Prototypes

• IBM Deep Blue (1997)

– Let IBM’s stock increase by $18 billion at that year
Research Prototypes
Research Prototypes

• Sony AIBO robot
  – Available on June 1, 1999
  – Weight: 1.6 KG
  – Adaptive learning and growth capabilities
  – Simulate emotion such as happiness and anger
Research Prototypes

• Honda ASIMO (Advanced Step in Innovate MObility)
  – Born on 31 October, 2001
  – Height: 120 CM, Weight: 52 KG
Research Prototypes

• MIT CSAIL (電腦科學與人工智慧)
Research Prototypes

- MIT Oxygen Project: Spoken Interface (CMU, Delta)

  ubiquitous

- Speech recognition/synthesis
- Natural language understanding/generation
- Machine translation
SR & AI?

From Prof. Chin-Hui Lee
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