Artificial Intelligence

What is AI?
Some Definitions of AI

• “The scientific understanding of the mechanisms underlying thought and intelligent behavior and their embodiment in machines”
  – American Association of Artificial Intelligence (AAAI)

• “Artificial Intelligence is the branch of computer science that is concerned with the automation of intelligent behavior”
  – Luger and Stubblefield

• “AI strives to understand and build intelligent entities (also helps us to learn more about ourselves)”
  – Russell and Norvig

Definitions of AI

• Based on theoretical and applied principles of CS
  – Data structures for knowledge representation
  – Algorithms needed to apply that knowledge
  – Languages and programming techniques used for implementation
Why is AI difficult?

(or is it easy?)

Intelligence

- AI definitions suffer from fact that intelligence itself is not very well defined or understood
  - Though study of intelligence is over 2000 yrs old (philosophers)
- However, it is easy to recognize intelligent behavior when we see it
  - Though “beauty is in the eye of the beholder”
- Difficult to define intelligence specific enough to evaluate a supposedly intelligent computer program
  - More on this later…
How Can it be?

• How can a slow and tiny brain (biological, technological)
  – Perceive
  – Understand
  – Predict
  – Manipulate
  a world far more complicated than itself???
• How can we build something with these properties?

Sub-Fields of AI

• Many sub-fields
  – Knowledge
  – Reasoning
  – Machine learning
  – Language
  – Robotics
  – Vision
  – …
Four Categories of AI

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<tr>
<th>Thinking humanly</th>
<th>Thinking rationally*</th>
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* Rational system “does the right thing”  
(People make mistakes)

Thinking Humanly  
Cognitive (Neuro)Science

- “[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning…” (Bellman, 1978)
- Get inside the actual workings of human minds  
  – Introspection  
  – Psychological experiments
- Cognitive modeling
- Requires scientific theories of brain  
  – Behavior of human subjects (top-down)  
  – Neurological data (bottom-up)
Thinking Rationally

- “The study of the computations that make it possible to perceive, reason, and act” (Winston, 1992)
- “The study of mental faculties through the use of computational models” (Charniak and McDermott, 1985)
- Laws of thought
  - Aristotle: What are correct reasoning processes?
    - Syllogism: Socrates is a man; all men are mortal; therefore Socrates is mortal
- Initiated the field of Logic
- Hard to put “uncertain” knowledge in logic terms

Acting Humanly

- “The art of creating machines that perform functions that require intelligence when performed by people” (Kurzweill, 1990)
- Turing Test (Alan Turing, 1950)
  - Operational definition of intelligence
  - Human-level performance in cognitive tasks and is sufficient to fool an interrogator
  - Imitation game
    - Computer interrogated by human via keyboard
    - Test if interrogator cannot tell if computer or human
  - Not easily amenable to mathematical analysis
- Computers need several capabilities
  - Language processing, reasoning, learning, knowledge
Acting Humanly

• “Total” Turing Test
  – Includes video signal of interrogator
    • Test subject’s (machine’s) perceptual ability
  – Includes portal for interrogator to pass objects to the subject (machine)
  – Need
    • Computer vision to perceive objects
    • Robotics to manipulate objects
Acting Humanly

Acting Rationally

• Rational behavior = doing the right thing
  – The right thing maximizes some goal achievement, given available information
  – Correct inferences
• Rational behavior does not necessarily involve thinking (not inference)
  – Reflexes (e.g., pulling hand away from hot stove)
Rational Agents

- An **AGENT** is an entity that **perceives** and **acts**
  - Also a definition of a ROBOT
- Abstractly, agent is a function from percept histories to actions
  \[ f : P^* \rightarrow A \]
- Computational limitations in complicated environments make perfect rationality unachievable
  - Design best program for given machine resources

Foundations of AI

- AI itself is a new discipline (started in 1956), but many other disciplines have contributed ideas, viewpoints, and techniques to AI
- Philosophy
  - Going back to 400 B.C. (Aristotle)
  - Considered ideas that the mind is in some ways like a machine
    - Operated on knowledge
    - Thought/knowledge and goals used to decide right actions
  - Hume’s principle of induction (1700’s)
    - General rules are acquired by exposure to repeated associations
Foundations of AI

• Mathematics
  – What things can be computed
    • Intractability and exponential growth
  – Tools for formal logic
  – Probabilistic manipulation with uncertain information

• Economics
  – Decision theory (probability with utility)
  – Make decisions that maximize payoff
  – Handling situation when payoff is far in future

• Neuroscience
  – Examines how the brain processes information
  – Neural networks
  – Study EEG, fMRI

Foundations of AI

• Psychology
  – Cognitive psychology
    • View brain as information-processing device
      – Humans (and animals) are information processing machines
    • “A cognitive theory should be like a computer program” (Anderson 1980)

• Computer science and engineering
  – Efficient computational systems
  – Make AI applications possible
    • Hardware and software
Foundations of AI

• Control Theory and Cybernetics
  – Viewed purposive behavior as arising from regulatory mechanism trying to minimize “error” between current state and goal state
    • Maximize some mathematical objective function over time
    • AI: Design systems that behave optimally

• Computational linguistics
  – Natural language processing
  – Understanding language also needs understanding of subject matter and context (not just syntax)
  – Relate language to thought

Early History of AI

• 1943  McCulloch & Pitts: Boolean circuit model of brain
  – Artificial neurons, Neural Networks
• 1950  Turing’s “Computing Machinery and Intelligence”
• 1952-69  “A machine can never do X” period
• 1950’s  Early AI programs
  – Newell & Simon’s Logic Theorist: proved theorem in fewer steps, paper with LT as author (rejected)
• *1956*  Dartmouth workshop: “Artificial Intelligence” coined
• 1958  Machine evolution (genetic algorithms)
• 1960’s  Microworld domains (blocks world)
• 1962  Rosenblatt’s perceptron learning (simple NN)
• 1969  Perceptrons by Minsky and Papert
• 1970’s  Knowledge-based systems
• 1980’s  Expert systems

Now:  Deep Learning, Autonomous systems, robotics, machine learning
What is Artificial Intelligence?

Basic questions answered by
John McCarthy

http://www-formal.stanford.edu/jmc/whatisai/whatisai.html

Q: What is Artificial Intelligence?

- It is the science and engineering of making intelligent machines, especially intelligent computer programs.
- It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.
Q: Yes, but what is intelligence?

- Intelligence is the computational part of the ability to achieve goals in the world.
- Varying kinds and degrees of intelligence occur in people, many animals, and some machines.

Q: Don’t some people say that AI is a bad idea?

- The philosopher John Searle says that the idea of a non-biological machine being intelligent is incoherent.
- The philosopher Hubert Dreyfus says that AI is impossible.
- The computer scientist Joseph Weizenbaum says the idea is obscene, anti-human, and immoral.
- Various people have said that since AI hasn’t reached human level by now, it must be impossible.
- Still other people are disappointed that companies they invested in went bankrupt.
Q: Does AI aim to put the human mind into the computer?

- Some researchers say they have that objective, but maybe they are using the phrase metaphorically.
- The human mind has a lot of peculiarities, and I’m not sure anyone is serious about imitating all of them.

Note: Strong AI view = build a mind in a computer
Weak AI view = not a mind, but good intelligent process

What do you think?

Does AI aim at human-level intelligence?

- Yes.
- The ultimate effort is to make computer programs that can solve problems and achieve goals in the world as well as humans.
- However, many people involved in particular research areas are much less ambitious.
Major AI Outlets

- Societies
  - American Association of Artificial Intelligence (AAAI)
    - Check out www.aaai.org
- Conferences
  - International Joint Conference on AI (IJCAI)
  - National Conference on AI (AAAI)
- Journals
  - *Artificial Intelligence*
  - *Computational Intelligence*
  - *IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)*
  - *Journal of Artificial Intelligence Research*
  - *Neural Information Processing Systems (NIPS)*

AI in OSU CSE Dept.

- Core AI research group
- AI meetings/talks/seminars