Artificial Intelligence: Introduction

- Where is AI in Computer Science?
- What IS artificial intelligence?

Where is AI in Computer Science?

Computer Science: Problem solving using computers.

- Computer Architecture and System Software study how to build good computers.
- Computation Theory and Complexity Theory study what can be computed, what cannot be computed, i.e., the limits of different computing devices.
- Programming Languages study how use computers conveniently and efficiently.
- Algorithms and Data Structures study how to solve popular computation problems efficiently.
- **Artificial Intelligence**, Databases, Networking, Security, etc., study how to extend the use of computers.

Definitions of AI

- There are as many definitions as there are practitioners.
- How would you define it? What is important for a system to be intelligent?

Definition of AI:

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.

What is Intelligence then?

- Fast thinking?
- A lot of knowledge?
- to pass as a human?
- to reason logically?
- to learn?
- to perceive and act upon one's environment?
- to play chess at grand-master's level?
- ...

Dictionary: Intelligence

- The capacity to acquire and apply knowledge.
- The faculty of thought and reason.
- Superior powers of mind.
- An intelligent, incorporeal being, especially an angel.
- Information; news.
- Secret information, especially about an actual or potential enemy.
- Espionage agents, organizations, and activities considered as a group

Dictionary: Artificial Intelligence

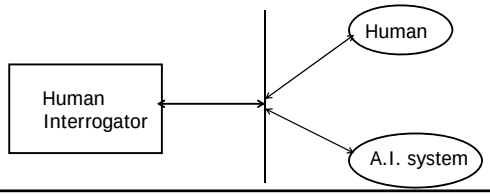
- Dictionary 1:
  - The ability of a computer or other machine to perform those activities that are normally thought to require intelligence.
  - The branch of computer science concerned with the development of machines having this ability.
- Dictionary 2: The subfield of computer science concerned with the concepts and methods of symbolic inference by computer and symbolic knowledge representation for use in making inferences. AI can be seen as an attempt to model aspects of human thought on computers. It is also sometimes defined as trying to solve by computer any problem that a human can solve faster.

Four main approaches to AI

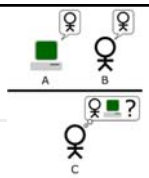
- Systems that *act* like *humans*
- Systems that *think* like *humans*
- Systems that *think rationally*
- Systems that *act rationally*

Approach #1: Acting Humanly

- AI is: "The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil)
- Ultimately to be tested by the Turing Test



The Turing Test



- Loebner God Medal
  - http://www.loebner.net/Prizef/loebner-prize.html
- 2014 University of Reading competition
  - On 7 June 2014 in a Turing test competition organized by Kevin Warwick to mark the 60th anniversary of Turing's death, was won by the Russian chatter bot Eugene Goostman. The bot, during a series of five-minute-long text conversations, convinced 33% of the contest's judges that it was human.

In practice

- Needs:
  - Natural language processing
  - Knowledge representation
  - Automated reasoning
  - Machine learning
- Too general a problem – unsolved in general case
- Intelligence takes many forms, which are not necessarily best tested this way
- Is it actually intelligent? (Chinese room thought experiment; Searle, 1980)

Approach #2: Thinking Humanly

- AI is: "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning..." (Bellman)
- Goal is to build systems that function *internally* in some way similar to human mind.

Workings of the human mind

- Traditional computer game players typically work much differently than human players
  - Massive look-ahead, minimal "experience"
- People think differently in experience, "big picture", etc.
- *Cognitive science* tries to model human mind based on experimentation
- Cognitive modeling approach tries to act intelligently while actually internally doing something similar to human mind

Approach #3: Thinking rationally

- AI is "The study of the computations that make it possible to perceive, reason, and act" (Winston)
- Approach firmly grounded in logic
- I.e., how can knowledge be represented logically, and how can a system draw deductions?
- Uncertain knowledge? Informal knowledge?
- *"I think I love you."*

Approach #4: Acting rationally

- AI is "The branch of computer science that is concerned with the automation of intelligent behavior" (Luger and Stubblefield)
- The intelligent agent approach
- An *agent* is a system that perceives and acts
- Emphasis is on behavior

Acting rationally: emphasis of this class (and most AI today)

- Why?
- In solving actual problems, it's what really matters
- Behavior is more scientifically testable than thought
- More general: rather than imitating humans trying to solve hard problems, just try to solve hard problems

Recap on the difference in approaches

- Thought vs. behavior
- Human vs. rational

History of AI

- It's in text and very cool, read it
- Sections 1.2-1.3

What we'll be doing

- Search methods, including game playing (e.g. chess)
- Constraint satisfaction
- Logic and reasoning
  - Propositional logic
  - First-order logic
  - Prolog (Program in Logic)

What we'll be doing

- Uncertain knowledge and reasoning
  - Probability, Bayes rule
- Machine learning
  - Neural networks, decision trees, computationally learning theory, reinforcement learning

What we won't be doing in class

- Sensors
- Robotics
- Natural language processing

Foundations of AI

- Foundation of AI is based on
  - Computer Science
  - Engineering
  - Mathematics
  - Neuroscience
  - Control Theory
  - Linguistics

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Foundations - Mathematics

- Formal logical methods
  - Boolean logic
  - Fuzzy logic
- Uncertainty
  - The basis for most modern approaches to handle uncertainty in AI applications can be handled by
    - Probability theory
    - Modal and Temporal logics

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Foundations - Neuroscience

- How do the brain works?
  - Early studies (1824) relied on injured and abnormal people to understand what parts of brain work
  - More recent studies use accurate sensors to correlate brain activity to human thought
    - By monitoring individual neurons, monkeys can now control a computer mouse using thought alone
  - Moore's law states that computers will have as many gates as humans have neurons in 2020
  - How close are we to have a mechanical brain?
    - Parallel computation, remapping, interconnections,....

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Foundations – Control Theory

- Machines can modify their behavior in response to the environment (sense/action loop)
  - Water-flow regulator, steam engine governor, thermostat
- Theory of stable feedback systems (1894)
  - Build systems that transition from initial state to goal state with minimum energy
  - In 1950, control theory could only describe linear systems and AI largely rose as a response to this shortcoming

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Foundations - Linguistics

- Speech demonstrates so much of human intelligence
  - Analysis of human language reveals thought taking place in ways not understood in other settings
    - Children can create sentences they have never heard before
    - Language and thought are believed to be tightly intertwined

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Cool Stuff in AI

- Game playing agents
- Machine learning
- Speech
- Language
- Vision
- Data Mining
- Web agents .....

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Useful Stuff

- Medical Diagnosis
- Fraud Detection
- Object Identification
- Space Shuttle Scheduling
- Information Retrieval ....

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AI Techniques

- Search
- Knowledge Representation
- Formal Logics
- Neural Networks
- Genetic Algorithms

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Components of AI Program

- AI techniques must be independent of the problem domain as far as possible.
- AI program should have
  - knowledge base
  - navigational capability
  - inferencing

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Knowledge Base

- AI programs should be learning in nature and update its knowledge accordingly.
- Knowledge base consists of facts and rules.
- Characteristics of Knowledge:
  - It is voluminous in nature and requires proper structuring
  - It may be incomplete and imprecise
  - It may keep on changing (dynamic)

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Navigational Capability

- Navigational capability contains various control strategies
- Control Strategy
  - determines the rule to be applied
  - some heuristics (thump rule) may be applied

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Inferencing

- Inferencing requires
  - search through knowledge base and
  - derive new knowledge

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Sub-areas of AI

- Sub areas of AI are:
  - Knowledge representation
  - Theorem proving
  - Game playing
  - Common sense reasoning dealing with uncertainty and decision making
  - Learning models, inference techniques, pattern recognition, search and matching etc.
  - Logic (fuzzy, temporal, modal) in AI
  - Planning and scheduling

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Sub-areas of AI – Contd..

- Natural language understanding
- Computer vision
- Understanding spoken utterances
- Intelligent tutoring systems
- Robotics
- Machine translation systems
- Expert problem solving
- Neural Networks, AI tools etc

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Applications

- **Business :** Financial strategies, give advice
- **Engineering:** check design, offer suggestions to create new product
- **Manufacturing:** Assembly, inspection, maintenance
- **Mining:** used when conditions are dangerous
- **Hospital :** monitoring, diagnosing & prescribing
- **Education :** In teaching
- **household :** Advice on cooking, shopping etc.
- **farming :** prune trees & selectively harvest mixed crops.

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