Artificial Intelligence

Introduction and History

Dr. Bilgin Avenoğlu

What is AI?

- **AI** is intelligence demonstrated by machines, as opposed to the **natural intelligence** displayed by animals and humans.
- AI research has been defined as the field of study of intelligent agents (IA).
- An **IA** is anything which perceives its environment, takes actions autonomously in order to achieve goals, and may improve its performance with learning or may use knowledge.
- They may be simple or complex
  - a thermostat
  - a human being

What is AI?

- AI as a field of study
  - Computer Science
  - Cognitive Science
  - Psychology
  - Philosophy
  - Linguistics
  - Neuroscience
- AI is part science, part engineering
- AI often must study other domains in order to implement systems
  - e.g., medicine and medical practices for a medical diagnostic system, engineering and chemistry to monitor a chemical processing plant
- AI is a belief that the brain is a form of biological computer and that the mind is computational

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.

- John McCarthy, 2004

What is Intelligence?

- Is there a "holistic" definition for intelligence?
- Here are some definitions:
  - *the ability to comprehend; to understand and profit from experience*
  - *a general mental capability that involves the ability to reason, plan, solve problems, think abstractly, comprehend ideas and language, and learn*
  - *effectively perceiving, interpreting and responding to the environment*
- None of these tells us what intelligence is, so instead, maybe we can enumerate a list of elements that an intelligence must be able to perform:
  - perceive, reason and infer, solve problems, learn and adapt, apply common sense, apply analogy, recall, apply intuition, reach emotional states, achieve self-awareness
- Which of these are necessary for intelligence? Which are sufficient?
- Artificial Intelligence – should we define this in terms of human intelligence?
  - does AI have to really be intelligent?
  - what is the difference between being intelligent and demonstrating intelligent behavior?

Isn’t AI about simulating human intelligence?

- Sometimes but not always or even usually.
- On the one hand, we can learn something about how to make machines solve problems by observing other people or just by observing our own methods.
- On the other hand, most work in AI involves studying the problems the world presents to intelligence rather than studying people or animals.
- AI researchers are free to use methods that are not observed in people or that involve much more computing than people can do.

- John McCarthy, 2004

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.

- John McCarthy, 2004

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.

- John McCarthy, 2004

Are computers the right kind of machine to be made intelligent?

- Computers can be programmed to simulate any kind of machine.
- Many researchers invented non-computer machines, hoping that they would be intelligent in different ways than the computer programs could be.
  - See Braitenberg Vehicles http://users.sussex.ac.uk/~christ/crs/kr-ist/lecx1a.html
- However, they usually simulate their invented machines on a computer and come to doubt that the new machine is worth building.

- John McCarthy, 2004

What about making a “child machine” that could improve by reading and by learning from experience?

- This idea has been proposed many times, starting in the 1940s.
- Eventually, it will be made to work.
- However, AI programs haven’t yet reached the level of being able to learn much of what a child learns from physical experience.
- Nor do present programs understand language well enough to learn much by reading.

- John McCarthy, 2004

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 (Chinese room argument).
- 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 artificial intelligence hasn’t reached human level by now, it must be impossible.

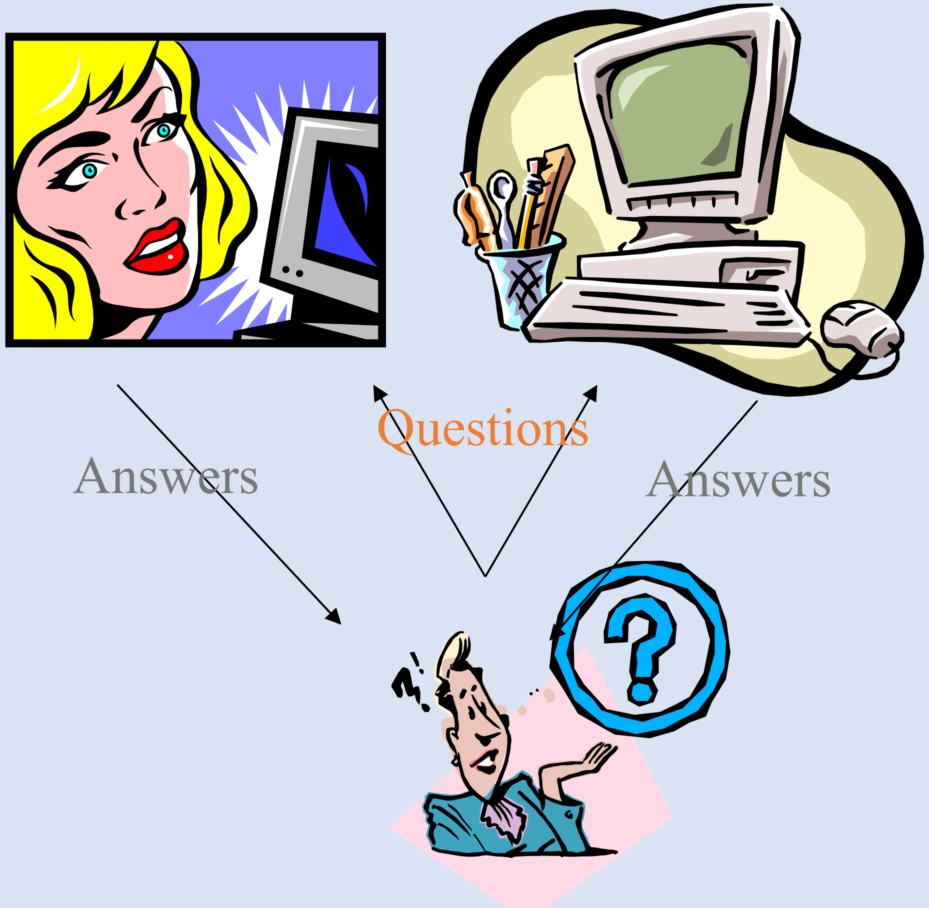
- John McCarthy, 2004

AI Spring - 1940s and 1950s

- Alan Turing developed a code breaking machine called The Bombe for deciphering the Enigma code.
- In 1950, he published "Computing Machinery and Intelligence" describing how to create intelligent machines and test their intelligence.
- The term "Artificial Intelligence" was coined in 1956 at "Dartmouth Summer Research Project" hosted by Marvin Minsky and John McCarthy.

The Turing Test

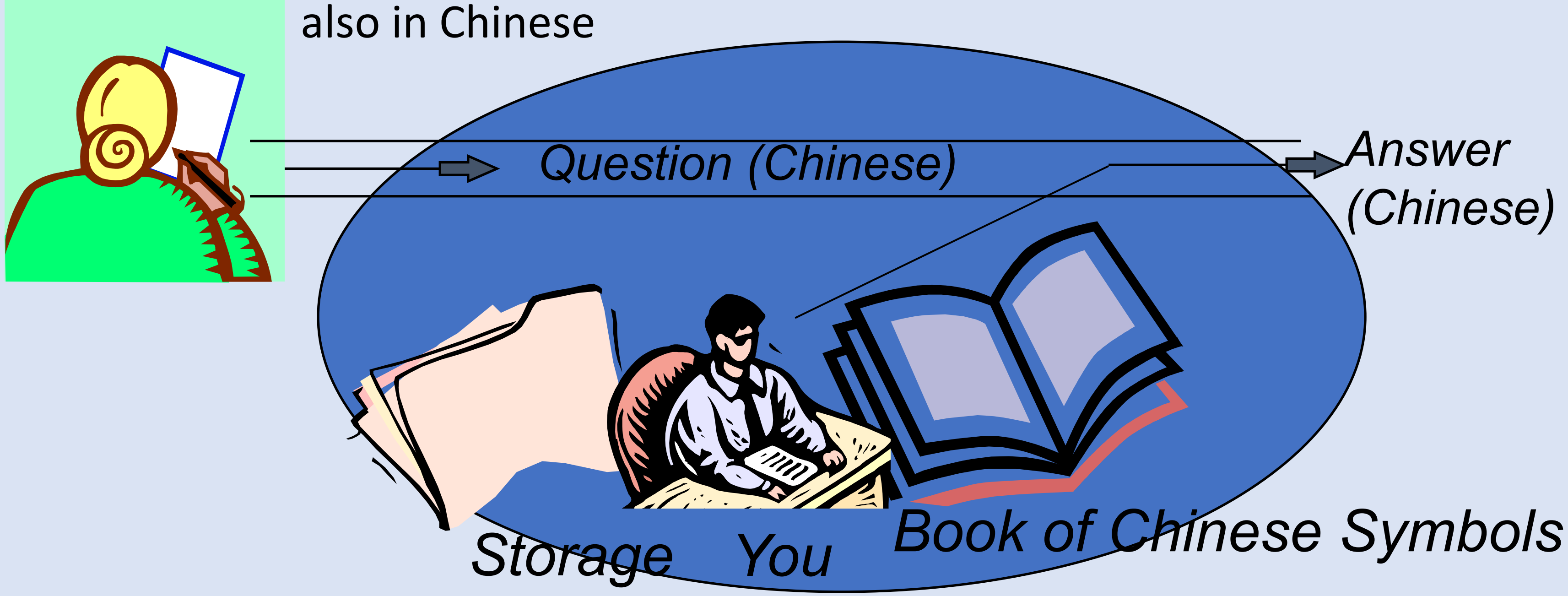
- 1950 - Alan Turing devised a test for intelligence called the Imitation Game
  - Ask questions of two entities, receive answers from both
  - If you can't tell which of the entities is human and which is a computer program, then you are fooled and we should therefore consider the computer to be intelligent



Which is the person?
Which is the computer?

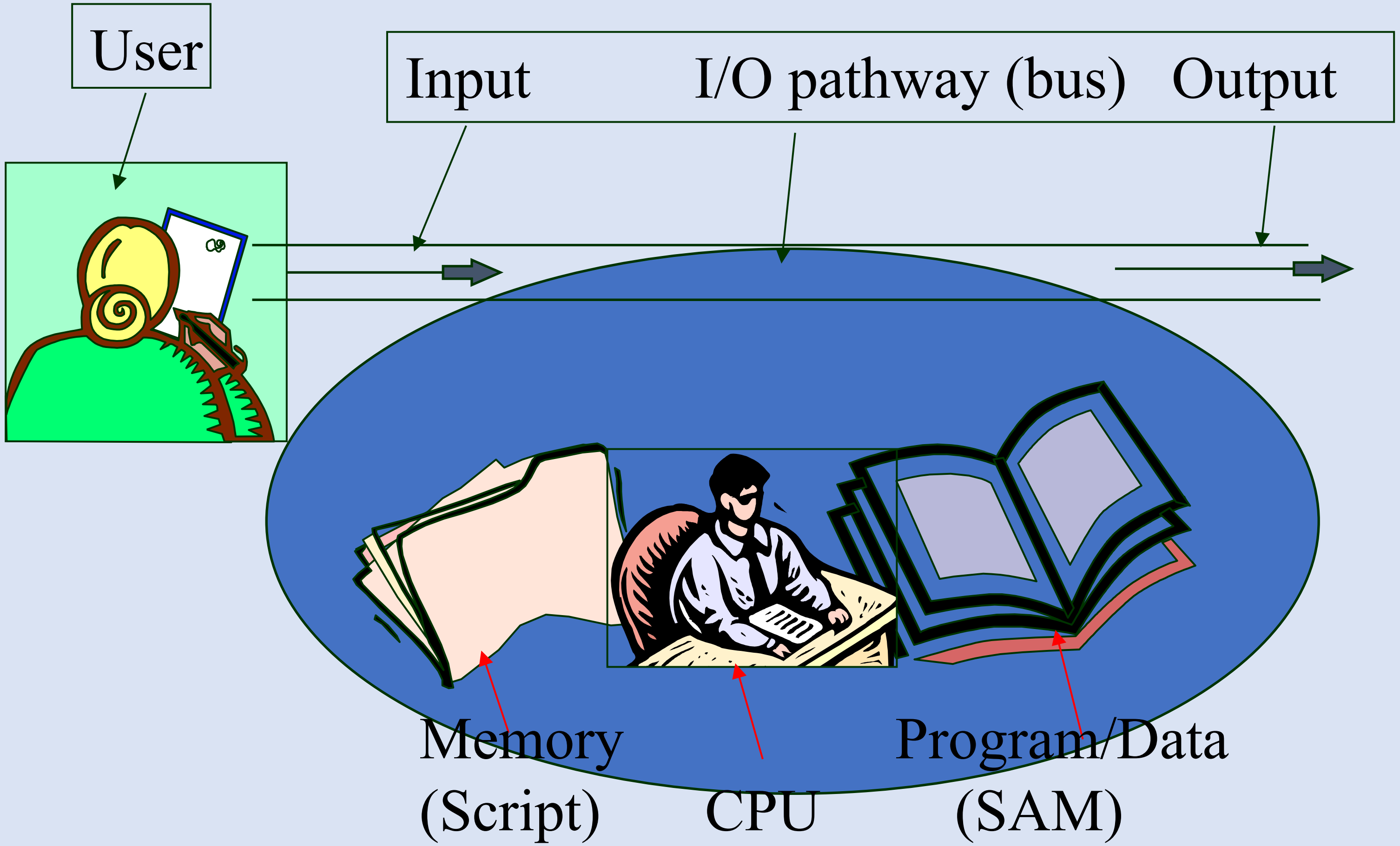
The Chinese Room Problem

- From John Searle, Philosopher, in an attempt to demonstrate that computers cannot be intelligent
  - The room consists of you, a book, a storage area (optional), and a mechanism for moving information to and from the room to the outside
    - a Chinese speaking individual provides a question for you in writing
    - you are able to find a matching set of symbols in the book (and storage) and write a response, also in Chinese



Chinese Room: An Analogy for a Computer

- Note: Searle's original Chinese Room actually was based on a Script that was implemented in Chinese, our version is just a variation on the same theme



Searle’s Question

- You were able to solve the problem of communicating with the person/user and thus you/the room passes the Turing Test
- But did you understand the Chinese messages being communicated?
  - since you do not speak Chinese, you did not understand the symbols in the question, the answer, or the storage
  - can we say that you actually *used* any intelligence?
- By analogy, since you did not understand the symbols that you interacted with, neither does the computer understand the symbols that it interacts with (input, output, program code, data)
- Searle concludes that the computer is not intelligent, it has no “semantics” but instead is merely a symbol manipulating device
  - the computer operates solely on syntax, not semantics
- He defines to categories of AI:
  - strong AI – the pursuit of machine intelligence
  - weak AI – the pursuit of machines solving problems in an intelligent way

Two AI Assumptions

- We can understand and model cognition without understanding the underlying mechanism
  - model of cognition that is important not the physical mechanism that implements it
  - we should be able to create cognition (mind) out of a computer or a brain or even other entities that can compute such as a mechanical device
    - This is the assumption made by symbolic AI researchers
- Cognition will emerge from the proper mechanism
  - the right device, fed with the right inputs, can learn and perform the problem solving that we call intelligence
  - cognition will arise as the result of the hardware
    - This is the assumption made by connectionist AI researchers
- While the two assumptions differ, neither is necessarily mutually exclusive and both support the idea that cognition is *computational*

AI Summer

- The Dartmouth Conference was followed by a period of nearly two decades that saw significant success in the field of AI.
- An early example is the famous ELIZA computer program, created between 1964 and 1966 by Joseph Weizenbaum at MIT.
  - ELIZA was a natural language processing tool able to simulate a conversation with a human and one of the first programs capable of attempting to pass the Turing Test.
- General Problem Solver program - Herbert Simon, Cliff Shaw and Allen Newell
  - that was able to automatically solve certain kind of simple problems, such as the Towers of Hanoi

AI Summer

- Marvin Minsky, interview in Life Magazine, 1970
- “a machine with the general intelligence of an average human being could be developed within three to eight years”

AI Winter

- In 1973, the U.S. Congress started to strongly criticize the high spending on AI research.
- In the same year, the British mathematician James Lighthill questioned the optimistic outlook given by AI researchers.
  - "machines would only ever reach the level of an "experienced amateur" in games such as chess and that common-sense reasoning would always be beyond their abilities."

AI Fall

- ELIZA, General Problem Solver etc.
  - they were all Expert Systems, collections of rules which assume that human intelligence can be formalized and reconstructed in a top-down approach as a series of “if-then” statements.
  - these systems were successful for example in Chess – Deep Blue
- Expert Systems perform poorly in areas that do not lend themselves to such formalization.
  - An Expert System cannot be easily trained to recognize faces or even to distinguish between a picture showing a muffin and one showing a Chihuahua
- Statistical methods for achieving true AI have been discussed as early as the 1940s when the Canadian psychologist Donald Hebb developed a theory of learning known as Hebbian Learning that replicates the process of neurons in the human brain.
  - This led to the creation of research on Artificial Neural Networks.

AI Fall

- Artificial neural networks made a comeback in the form of Deep Learning when in 2015 AlphaGo, a program developed by Google, was able to beat the world champion in the board game Go.
- This harvest of the fruits of past statistical advances is the period of AI Fall, which we find ourselves in today.

Branches of AI

- Logical AI
  - What a program knows about the world in general the facts of the specific situation in which it must act, and its goals are all represented by sentences of some mathematical logical language.
  - The program decides what to do by inferring that certain actions are appropriate for achieving its goals.
- Search
  - AI programs often examine large numbers of possibilities, e.g. moves in a chess game or inferences by a theorem proving program.
  - Discoveries are continually made about how to do this more efficiently in various domains.

Branches of AI

- Pattern recognition
  - When a program makes observations of some kind, it is often programmed to compare what it sees with a pattern.
  - For example, a vision program may try to match a pattern of eyes and a nose in a scene in order to find a face.
- Representation
  - Facts about the world have to be represented in some way.
  - Usually languages of mathematical logic are used.
- Inference
  - From some facts, others can be inferred.
  - Mathematical logical deduction

Branches of AI

- Common sense knowledge and reasoning
  - This is the area in which AI is farthest from human-level, in spite of the fact that it has been an active research area since the 1950s.
- Learning from experience
  - The approaches to AI based on connectionism and neural nets specialize in that.
  - There is also learning of laws expressed in logic.
  - Machine learning. Programs can only learn what facts or behaviors their formalisms can represent, and unfortunately learning systems are almost all based on very limited abilities to represent information.

Branches of AI

- Planning
  - Planning programs start with general facts about the world, facts about the particular situation and a statement of a goal.
  - From these, they generate a strategy for achieving the goal.
  - In the most common cases, the strategy is just a sequence of actions.
- Ontology
  - Ontology is the study of the kinds of things that exist.
  - In AI, the programs and sentences deal with various kinds of objects, and we study what these kinds are and what their basic properties are.

Branches of AI

- Heuristics
  - A heuristic is a way of trying to discover something or an idea imbedded in a program.
  - Heuristic functions are used in some approaches to search to measure how far a node in a search tree seems to be from a goal.
- Genetic programming
  - Genetic programming is a technique for getting programs to solve a task by mating random Lisp programs and selecting fittest in millions of generations.

Applications of AI

- game playing
- speech recognition
- understanding natural language
- computer vision
- expert systems
- robotics
- autonomous cars
- …………

The End!