CS 3011: Artificial Intelligence

Introduction

Instructors: Dr. Durgesh Singh

CSE Discipline, PDPM IIITDM, Jabalpur -482005

Introduction

- **Intelligence** is so important to humans, and we have been tried to understand '*how we think and act* ' for thousands of years.
- Currently, we do not completely understand '*how we think and act*'

  — that is, how our brain can perceive, understand, predict, and manipulate a world far larger and more complicated than itself.
- The field of **artificial intelligence, or AI**, is concerned with not just understanding but also building intelligent entities.
- AI currently encompasses a huge variety of subfields, ranging from the general (learning, reasoning, perception, and so on) to the specific, such as playing chess, proving mathematical theorems, writing poetry, driving a car, or diagnosing diseases.
- AI is relevant to any intellectual task, and it is truly a universal field.

Some Definition of Artificial Intelligence (AI)

- Artificial intelligence leverages computers and machines to mimic the problem-solving and decision-making capabilities of the human mind.
- Artificial intelligence (AI) makes it possible for machines to learn from experience, adjust to new inputs and perform human-like tasks.
- Most AI examples that you hear about today – from chess-playing computers to self-driving cars – rely heavily on deep learning and natural language processing.
  - Using these technologies, computers can be trained to accomplish specific tasks by processing large amounts of data and recognizing patterns in the data.

Note: Machine learning is a subfield of AI that studies the ability to improve performance based on experience. Some AI systems use machine learning methods to achieve competence, but some do not.

What is AI?

- Historically, researchers have pursued several different versions of AI.
- Some have defined intelligence in terms of fidelity to human performance, while others prefer an abstract, formal definition of intelligence called rationality "loosely speaking, doing the "right thing".
- The subject matter itself also varies some consider intelligence to be a property of internal **thought processes** and **reasoning**, while others focus on intelligent **behavior**, an external characterization.
- From these two dimensions--human vs. rational and thought vs. behavior --there are four possible combinations.

What is AI?

- The human-centered approach must be an empirical science related to psychology, involving observations and hypotheses about actual human behavior and thought processes.
- A rationalist approach involves a combination of mathematics and engineering.
- Following four approaches of AI has been followed:
  - Systems that think like humans
  - Systems that act like humans
  - Systems that think rationally
  - Systems that act rationally

What is AI? : Four main views/approaches

Systems that think like humans: "[automation of] activities that we associate with human thinking, activities such as decision making, problem solving, learning…" (Bellman 1978)	**Systems that think rationally:** "The study of mental faculties through the use of computational models" (Charniak & McDertmott 1985)
Systems that act like humans: "The study of how to make computers to things at which, at the moment, people are better" (Rich & Knight 1991)	**Systems that act rationally:** "Computational Intelligence is the study of design of intelligent agents." (Poole et al., 1998)

Acting Humanly: The Turing Test Approach

- AI means acting humanely i.e., acting like a person
- The classic example of this is the “Turing Test”.
- Turing Test was proposed by Alan Turing (1950).
- Turing =“If any machine pass Turing test, then it will have intelligence”.
- In the basic Turing Test, there are three terminals. Two of the terminals are operated by humans, and the third terminal is operated by a computer.
- Each terminal is physically separated from the other two.

Acting Humanly: The Turing Test Approach…

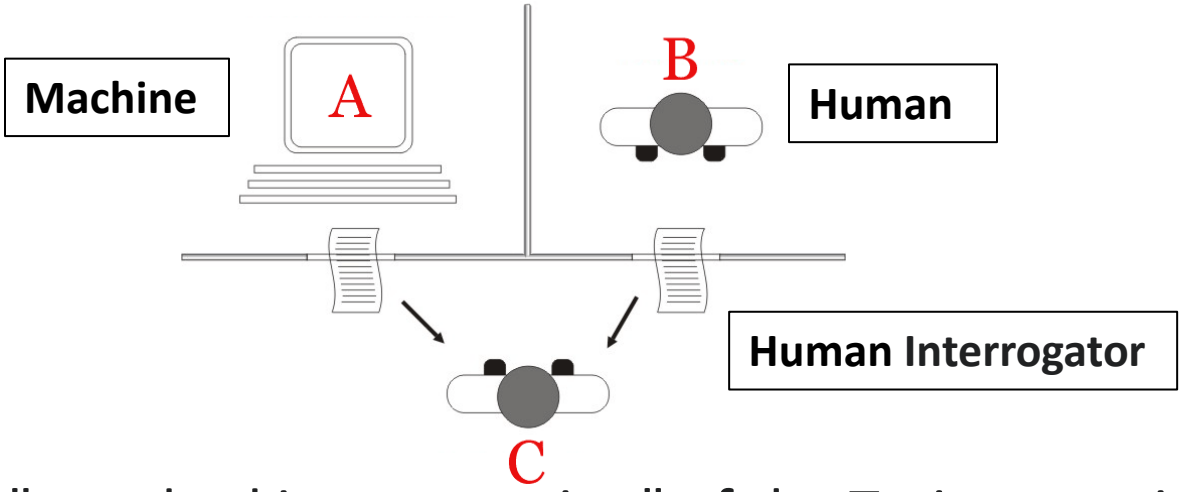


Fig. The "standard interpretation" of the Turing test, in which player C, the interrogator, is given the task of trying to determine which player – A or B – is a computer and which is a human. The interrogator is limited to using the responses to written questions to make the determination.

Requirements for Machine To Pass Turing Test

The computer need to process the following capabilities in order to pass the Turing Test:

- **Natural Language Processing:** to communicate successfully in a human language such as English.
- **Knowledge Representation:** to store what it knows or hears;
- **Machine Learning:** to adapt to new circumstances and to detect and extrapolate patterns.
- **Automated Reasoning:** to use stored information to answer questions and to draw new conclusions.

Full Turing Test

- Turing test does not allow physical interaction between the interrogator and the computer as it assumes that physical simulation is not necessary for intelligence.
- The Total Turing Test includes a video signal so that the interrogator can test the subject's perceptual abilities and the ability for the interrogator to pass physical simulations.
- In order to pass the total Turing test, a machine also requires:
  - **Computer Vision and speech recognition:** to perceive objects.
  - **Robotics:** to manipulate and move objects.

Thinking Humanly: Cognitive Modeling Approach

- AI means think like a human brain.
- The field of Cognitive science delves into this topic, trying to model ‘how humans think’.
- The difference between “acting humanly” and “thinking humanly” is that the first is only concerned with the actions, outcome or product of the human thinking process; whereas the later is concerned with modeling human thinking processes.

Thinking Humanly: Cognitive Modeling Approach…

- To say that a program thinks like a human, we need to determine how humans think.
  - We need to get inside the actual working of human minds
- There are three ways we can understand how we think:
  - **Through introspection**—trying to catch our own thoughts as they go by
  - **Through psychological experiments**—observing a person in action
  - **Through brain imaging**—observing the brain in action.

Thinking Humanly: Cognitive Modeling Approach…

- Once we have a sufficiently precise theory of the mind, it becomes possible to express the theory as a computer program.
- The field of cognitive science brings together computer models from AI and experimental techniques from psychology to construct precise and testable theories of the human mind.
- Recently, the combination of neuroimaging methods combined with machine learning techniques for analyzing such data has led to the beginnings of a capability to “read minds”.

Thinking Rationally: The “laws of thought” approach

- Thinking rationally, i.e., modeling thinking as a logical process, where conclusions are drawn based on some type of symbolic logic.
- The Greek Philosopher Aristotle was the first to attempt “the right thinking” approach for reasoning process.
- He devised syllogisms approach i.e., form of reasoning in which a conclusion is drawn from two or more given or assumed propositions.
- For example, John is a man. All men are mortal. Therefore, John is mortal

Thinking Rationally: The “laws of thought” approach.

- These laws of thought were supposed to govern the operation of mind and their study initiated the field called logic.
- Logicians in the 19th century developed a precise notation for statements about objects in the world and the relations among them.
- By 1965, programs could, in principle, solve any solvable problem described in logical notation.
- The logistic tradition within AI build programs to create human intelligence.

Thinking Rationally: The “laws of thought” approach.

- Two obstacles with the approach of defining AI as building thinking agents:
  1. **Not easy to state informal knowledge in logical notation.**
     - When knowledge is not 100% certain, it is not easy to take informal knowledge and state it in the formal terms required by logical notation. ----The theory of probability fills this gap, allowing rigorous reasoning with uncertain information
  2. **Big difference between solving a problem "in principle" and solving it “in practice”**
     - Even problems with just a few hundred facts can exhaust the computational resources of any computer unless if has some guidance as to which reasoning steps to try first.

Acting Rationally: The rational agent approach

- Rational behavior: doing the right thing
- **The right thing:** the optimal (best) thing that is expected to maximize the chances of achieving a set of goals, in a given situation.
- Acting rationally i.e., performing actions that increase the value of the state of the agent or environment in which the agent is acting. For example, an agent that is playing a game will act rationally if it tries to win the game.

Acting Rationally: The rational agent approach…

- The “laws of thought” approach to AI, the emphasis was on correct inferences and making correct inferences is sometimes part of being a rational agent
  - Because one way to act rationally is to deduce that a given action is best and then to act on that conclusion
- However, ‘correct inference’ is NOT ALL of rationality
  - In some situation there is no provably correct thing to do, but something must still be done
- Example of an activity that is acting rational but not thinking rationally:
  - recoiling from a hot stove is a reflex action that is usually more successful than a slower action taken after careful deliberation.

Acting Rationally: The rational agent approach

- The rational-agent approach has following advantages over other:
  1. It is more general than “laws of thought” approach because correct inference is just one of several possible mechanisms for achieving rationality.
  2. It is more amenable to scientific development than the approaches based on human behavior or human thought.
- The standard of rationality is mathematically well defined and completely general.

Types of AI

Based on Capabilities, AI can be broken into 3 main types:

- ANI: Artificial Narrow Intelligence
- AGI: Artificial General Intelligence
- ASI: Artificial Super Intelligence

Based on functionality, AI can be broken into 4 main types:

- Reactive Machines
- Limited Memory
- Theory of Mind
- Self-Awareness

Artificial Narrow Intelligence

- It is also known as weak AI.
- ANI is trained and focused to perform specific tasks.
- All forms of modern AI systems can be classified as narrow AI.
- It enables some very robust applications, such as Apple's Siri, Amazon's Alexa, IBM Watson, and autonomous vehicles.

Artificial General Intelligence (AGI)

- It is also known as strong AI.
- AGI is a theoretical form of AI where a machine would have ability to perform any intellectual task that a human being can.
- it would have a self-aware consciousness that has the ability to solve problems, learn, and plan for the future.

Artificial Super Intelligence(ASI)

- It is also known as superintelligence—would surpass the intelligence and ability of the human brain.
- Presently, it is seen as hypothetical as depicted in movies and any science fiction book.

Reactive Machines

- Purely reactive machines are the most basic types of Artificial Intelligence.
- Such AI systems do not store memories or past experiences for future actions.
- These machines only focus on current scenarios and react on it as per possible best action.
- IBM's Deep Blue system is an example of reactive machines.
- Google's AlphaGo is also an example of reactive machines.
- The Netflix recommendation engine

Limited memory

- Limited memory machines can store past experiences or some data for a short period of time.
- These machines can use stored data for a limited time period only.
- Self-driving cars are one of the best examples of Limited Memory systems. These cars can store recent speed of nearby cars, the distance of other cars, speed limit, and other information to navigate the road.

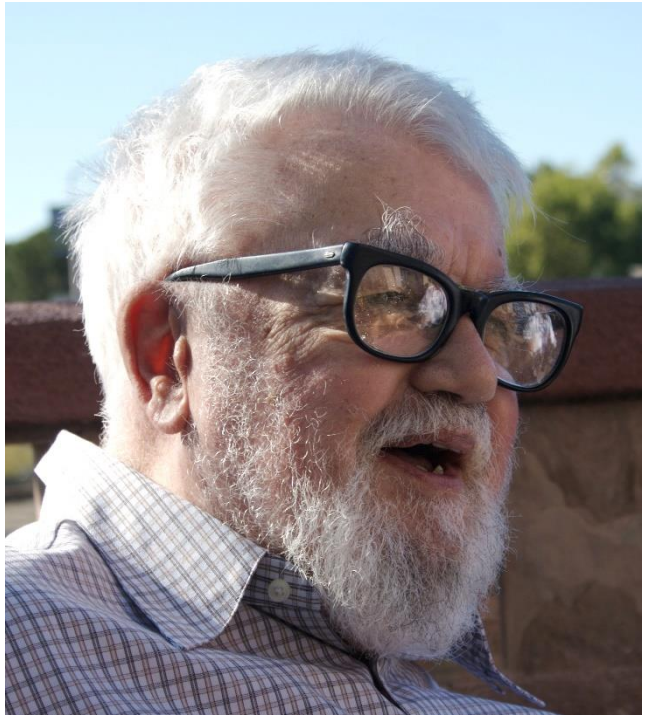
Theory of Mind

- Theory of Mind AI should understand the human emotions, people, beliefs, and be able to interact socially like humans.
- This type of AI machines are still not developed, but researchers are making lots of efforts and improvement for developing such AI machines.
- Although theory of mind AI has not been fully achieved, the robots Kismet (introduced in 2000) and Sophia (2016) showed some aspects of this type of AI.
  - Humanoid robot Sophia, developed by Hanson Robotics in Hong Kong, can recognize faces and respond to interactions with her own facial expressions.

Self-Awareness

- Self-awareness AI is the future of Artificial Intelligence. These machines will be super intelligent, and will have their own consciousness, sentiments, and self-awareness.
- These machines will be smarter than human mind.
- Self-Awareness AI does not exist in reality still and it is a hypothetical concept.

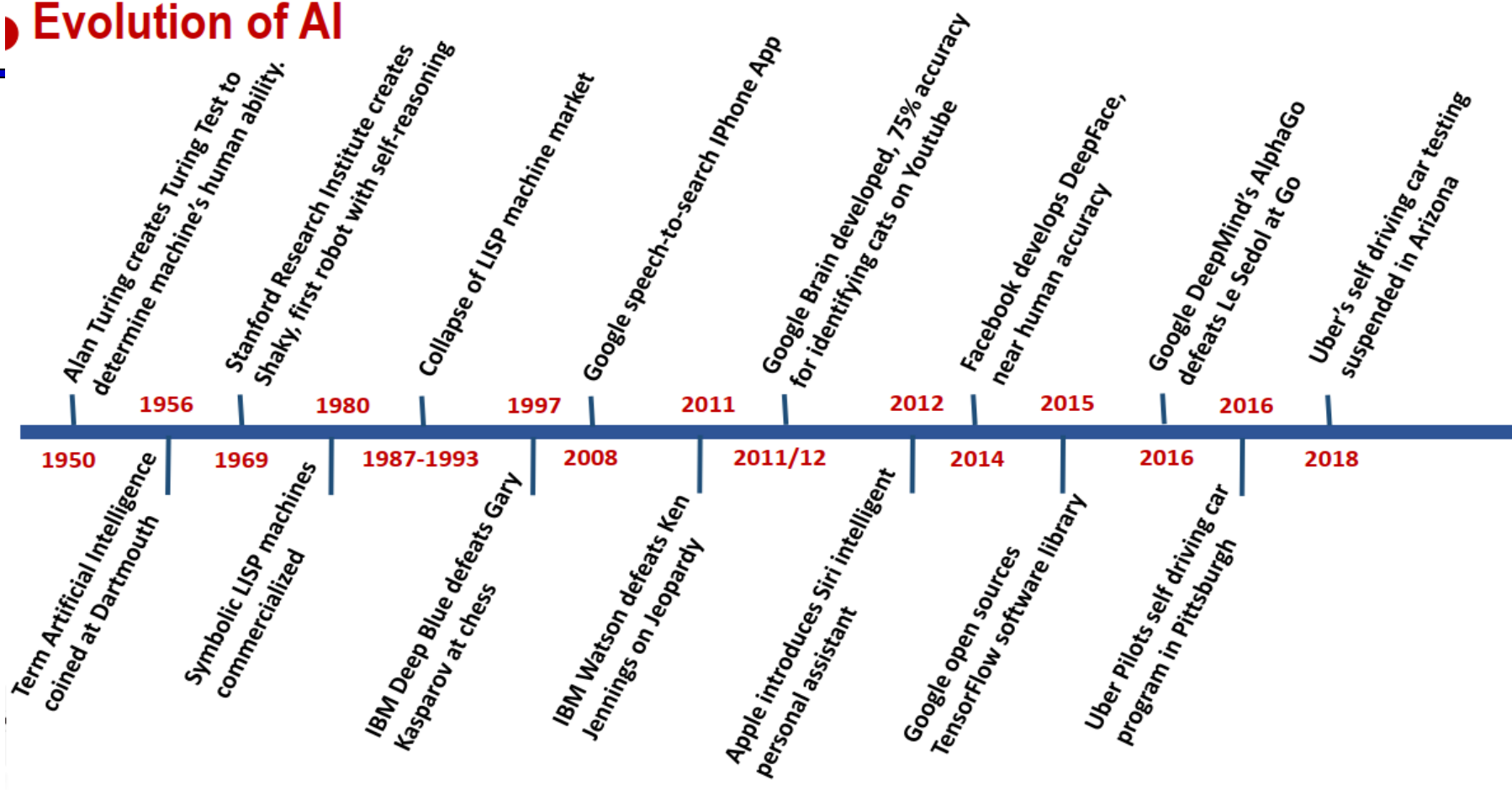
Father of AI



McCarthy at a conference in 2006

- **John McCarthy** (September 4, 1927 – October 24, 2011) was an American computer scientist and cognitive scientist. He was one of the founders of the discipline of artificial intelligence. He was co-authored the document that coined the term "artificial intelligence" (AI), developed the programming language family Lisp.

Evolution of AI



Foundation of AI

- Following disciplines contributed their ideas, viewpoints, and techniques to AI:
  - Philosophy
  - Mathematics
  - Economics
  - Neuroscience
  - Psychology
  - Computer Engineering
  - Control Theory
  - Linguistics
- Each of the above-mentioned discipline, answered a series of questions and helped in the foundation of AI techniques.

Philosophy – reasoning and learning

- Can formal rules be used to draw valid conclusions?
  - Syllogism approach
  - Thomas Hobbes- reasoning is numerical computation in which we add/subtract thoughts
- Where does knowledge come from?
  - Doctrine of logical positivism- knowledge can be characterized by logical theories connected to observation sentences that correspond to sensory input.
  - Confirmation theory- knowledge can be acquired from experience.
- How does knowledge lead to action?
  - Actions are justified by a logical connection between goals and the knowledge of action's outcome

- Mathematics - logic, probability, decision making, computation
  - What are the formal rules to draw conclusions?
  - What can be computed?
  - How do we reason with uncertain information?
- Economics
  - How should we make decisions so as to maximize payoff?
    - decision and utility theory
  - How should we do this when the payoff may be far in the future?
    - operations research and markov decision process

- Neuroscience
  - How do brains process information?
- Psychology - investigating human mind
  - How do humans and animals think and act?
- Computer engineering
  - How can we build an efficient computer?
    - supplied operating systems, programming languages, and tools needed to write modern programs.

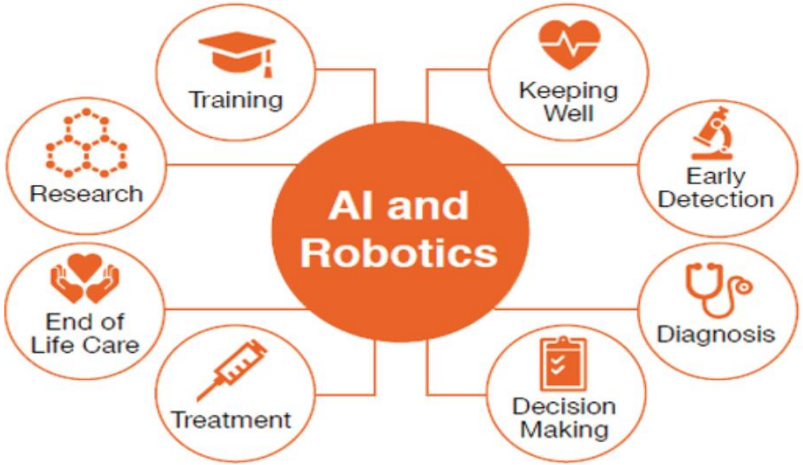
- Control theory and Cybernetics
  - How can artifacts operate under their own control?
    - design systems that maximize an objective function over time
- Linguistics - the structure and meaning of language
  - How does language relate to thought?
    - knowledge representation, grammar

Rational Agents

- An agent is an entity that perceives and acts
  - All computer programs do something, but agents are expected to do more; Computer agents operate under autonomous control, perceiving their environment, adaptable to change, and create and pursue goals.
- A rational agent is one that acts so as to achieve the best outcome.
- For any given class of environments and tasks, we seek the agent (or class of agents) with the optimal (best) performance
- computational limitations make perfect rationality unachievable
  - So, we attempt to design the best (most intelligent) program, under the given resources.

Application of AI

Healthcare



Application of AI in healthcare can help address issues of high barriers to access to healthcare facilities, particularly in rural and remote areas that suffer from poor connectivity and limited supply of healthcare professionals.

Construction

- AI-based applications have been widely being used in the construction sectors.
- The AI-based application will make the engineers more productive and capable of delivering high-quality work in the stipulated time frame.

Agriculture

- There are incredible opportunities for AI or machine learning in agriculture.
- Agriculture is one of the core sectors and we have been modifying the cultivation process to yield more from it.
- The technologies like AI & IoT will be very useful in understanding a timely planting, getting predictions, using fertilizers, and harvesting.
- Drones can be used for crop health monitoring and fertilizer spraying.

Entertainment

- AI or machine learning has brought a big change in the entertainment industry.
- When it comes to the entertainment, the algorithms being used by various application make our life much simpler.
- We are currently using some AI based applications in our daily life with some entertainment services such as Netflix or Amazon. With the help of ML/AI algorithms, these services show the recommendations for programs or shows.

Application of AI in Defense

- ❑Military drones for surveillance
- ❑Robot soldiers for combat
- ❑Intelligent systems for awareness
- ❑Secure web-portals for cybersecurity