Unit 1: Introduction

Intelligence

Scientists have proposed two major "consensus" definitions of **intelligence**:

(i) from *Mainstream Science on Intelligence* (1994);

A very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings- making sense" of things, or "figuring out" what to do.

(ii) from *Intelligence: Knowns and Unknowns* (1995);

Individuals differ from one another in their ability to understand complex ideas, to adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, [and] to overcome obstacles by taking thought. Although these individual differences can be substantial, they are never entirely consistent: a given person's intellectual performance will vary on different occasions, in different domains, as judged by different criteria. Concepts of "intelligence" are attempts to clarify and organize this complex set of phenomena.

Thus**, Intelligence** is:

- the ability to reason
- the ability to understand
- the ability to create
- the ability to Learn from experience
- the ability to plan and execute complex tasks

Artificial Intelligence

What is Artificial Intelligence?

"Giving machines ability to perform tasks normally associated with *human* intelligence."

- The term “Artificial Intelligence” was coined by John McCarthy, in 1956. He defined AI as "the science and engineering of making intelligent machines, especially intelligent computer programs”.

AI is intelligence of machines and branch of computer science that aims to create it. AI consists of design of intelligent agents, which is a program that perceives its environment and takes action that maximizes its chance of success. With AI it comes issues like deduction, reasoning, problem solving, knowledge representation, planning, learning, natural language processing, perceptron, etc.

“Artificial Intelligence is the part of computer science concerned with designing intelligence computer systems, that is, systems that exhibit the characteristics we associate with intelligence in human behavior.”

- **AI is the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.**

Artificial intelligence (AI) is wide-ranging branch of computer science concerned with building smart machines capable of performing tasks the typically require human intelligence. AI is an interdisciplinary science with multiple approaches, but advancements in machine learning and deep learning are creating a paradigm shift in virtually every sector of the tech industry.

- Major AI text books define artificial intelligence as “**the study and design of intelligent agents**, “where *an intelligent agent is as system that perceives its environment and takes actions which maximize its chances of success*.

AI Perspectives: acting and thinking humanly, acting and thinking rationally

Different definitions of AI are given by different books/writers. These definitions can be divided into four approaches and summarized as follows:

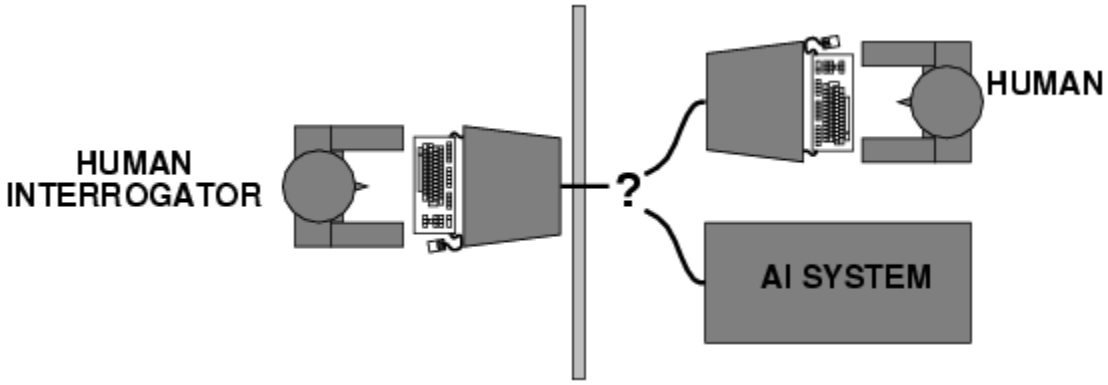
Thinking Humanly	**Thinking Rationally**
"The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly	**Acting Rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	"Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998) "AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

- Top dimension is concerned with ***thought processes and reasoning***, whereas bottom dimension addresses the ***behavior***.
- The definition on the left measures the success in terms of fidelity of *human performance*, whereas definitions on the right measure an *ideal concept of intelligence*, which is called **rationality**.
- Human-centered approaches must be an empirical science, involving hypothesis and experimental confirmation.
- A rationalist approach involves a combination of mathematics and engineering.

These four approaches in more detail are as follows:

1. Acting Humanly: The Turing Test Approach

- The **Turing test**, proposed by Alan Turing (1950) was designed to convince the people that whether a particular machine can think or not.
- He suggested a test based on indistinguishability from undeniably intelligent entities- human beings.
- **The test involves an interrogator who interacts with one human and one machine. Within a given time the interrogator has to find out which of the two the human is, and which one the machine**.



- The computer passes the test if a human interrogator after posing some written questions, cannot tell whether the written response come from human or not.
- To pass a Turing test, a computer must have following capabilities:
  - **natural language processing :**to enable it to communicate successfully in English;
  - **knowledge representation :**to store what it knows or hears;
  - **automated reasoning :**to use the stored information to answer questions and to draw new conclusions;
  - **machine learning:** to adapt to new circumstances and to detect and extrapolate patterns
- Turing test avoid the physical interaction with human interrogator. Physical simulation of human beings is not necessary for testing the intelligence.

The total Turing test includes video signals and manipulation capability so that the interrogator can test the subject's perceptual abilities and object manipulation ability. To pass the total Turing test computer must have following additional capabilities:

(a) Computer Vision: To perceive objects **(b) Robotics:** To manipulate objects and move

2. Thinking Humanly: The Cognitive Modeling Approach

- If we are going to say that a given program thinks like a human, we must have some way of determining how humans think.
- We need to get inside the actual workings of human minds. There are three ways to do this:

  through introspection—trying to catch our own thoughts as they go by;
  through psychological experiments—observing a person in action; and
  through brain imaging—observing the brain in action.
- Once we have a sufficiently precise theory of the mind, it becomes possible to express the theory as a computer program. If the program's input–output behavior matches corresponding human behavior, that is evidence that some of the programs mechanisms could also be operating in humans.
- Once we have precise theory of mind, it is 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 try to construct precise and testable theories of the workings of the human mind

3. Thinking Rationally: The "laws of thought" Approach

- The Greek philosopher Aristotle was one of the first to attempt to codify "right thinking," that is, irrefutable reasoning processes.
- His syllogisms provided patterns for argument structures that always yielded correct conclusions when given correct premises—for example, "Socrates is a man; all men are mortal; therefore, Socrates is mortal."
- These laws of thought were supposed to govern the operation of the mind; their study initiated the field called logic
- The logicist tradition in AI hopes to create intelligent systems using logic programming. However there are two obstacles to this approach.
  - First, It is not easy to take informal knowledge and state in the formal terms required by logical notation, particularly when knowledge is not 100% certain.

- Second, solving problem principally is different from doing it in practice. Even problems with certain dozens of fact may exhaust the computational resources of any computer unless it has some guidance as which reasoning step to try first.

4. Acting Rationally: The Rational Agent Approach

Agent is something that acts.

Computer agent is expected to have following attributes:

- ✓ Autonomous control
- ✓ Perceiving their environment
- ✓ Persisting over a prolonged period of time
- ✓ Adapting to change
- ✓ Capable of taking on another's goal

Rational behavior: doing the right thing.

The right thing: that which is expected to maximize goal achievement, given the available information.

A rational agent is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome.

- ✓ In the "laws of thought" approach to AI, the emphasis was given to correct inferences. Making correct inferences is sometimes part of being a rational agent, because one way to act rationally is to reason logically to the conclusion and act on that conclusion. On the other hand, there are also some ways of acting rationally that cannot be said to involve inference. *For Example, recoiling from a hot stove is a reflex action that usually more successful than a slower action taken after careful deliberation.*

  Advantages:
  - It is more general than laws of thought approach, because correct inference is just one of several mechanisms for achieving rationality.
  - It is more amenable to scientific development than are approaches based on human behavior or human thought because the standard of rationality is clearly defined and completely general

History of AI

1. **The gestation of artificial intelligence (1943–1955)**
    - The first work that is now generally recognized as AI was done by Warren McCulloch and Walter Pitts (1943). They drew on three sources: knowledge of the basic physiology and function of neurons in the brain; a formal analysis of propositional logic due to Russell and Whitehead; and Turing's theory of computation. (**McCulloch –Pitt** Neuron)
    - Donald Hebb (1949) demonstrated a simple updating rule for modifying the connection strengths between neurons. His rule, now called **Hebbian learning**, remains an influential model to this day.
    - Two undergraduate students at Harvard, Marvin Minsky and Dean Edmonds, built the first neural network computer in 1950
    - There were a number of early examples of work that can be characterized as AI, but Alan Turing's vision was perhaps the most influential. He gave lectures on the topic as early as 1947 at the London Mathematical Society and articulated a persuasive agenda in his 1950 article "Computing Machinery and Intelligence." Therein, he introduced the Turing Test, machine learning, genetic algorithms, and reinforcement learning. He proposed the Child Programme idea, explaining "Instead of trying to produce a programme to simulate the adult mind, why not rather try to produce one which simulated the child's?"

2. **The birth of artificial intelligence (1956)**
    - Dartmouth Workshop bringing together top minds on automata theory, neural nets and the study of intelligence.
        - Allen Newell and Herbert Simon: The logic theorist (first nonnumeric thinking program used for theorem proving)
        - For the next 20 years the field was dominated by these participants

3. **Early enthusiasm, great expectations (1952–1969)**
    - Newell and Simon introduced the General Problem Solver.
        - Imitation of human problem-solving
    - Arthur Samuel (1952-) investigated game playing (checkers) with great success.
    - John McCarthy(1958-) :
        - Inventor of Lisp (second-oldest high-level language)

  - Logic oriented, Advice Taker (separation between knowledge and reasoning)
- Marvin Minsky (1958 -)
  - Introduction of microworlds that appear to require intelligence to solve: e.g. blocks-world.
  - Anti-logic orientation, society of the mind.

4. **A dose of reality (1966–1973)**
   - Progress was slower than expected.
     — Unrealistic predictions.
   - Some systems lacked scalability.
     — Combinatorial explosion in search.
   - Fundamental limitations on techniques and representations.
     — Minsky and Papert (1969) Perceptrons.

5. **Knowledge-based systems: The key to power? (1969–1979)**
   - General-purpose vs. domain specific
     — E.g. the DENDRAL project (Buchanan et al. 1969)
     First successful knowledge intensive system.
   - Expert systems
     — MYCIN to diagnose blood infections (Feigenbaum et al.)
     Introduction of uncertainty in reasoning.
   - Increase in knowledge representation research.
     — Logic, frames, semantic nets, …

6. **AI becomes an industry (1980–present)**
   - The first successful commercial expert system, R1, began operation at the Digital Equipment Corporation (McDermott, 1982).
   - In 1981, the Japanese announced the "Fifth Generation" project, a 10-year plan to build intelligent computers running Prolog. In response, the United States formed the Microelectronics and Computer Technology Corporation (MCC) as a research consortium designed to assure national competitiveness.
   - A periodcalled the "AIWinter," in which many companies fell by the wayside as they failed to deliver on extravagant promises.

7. **The return of neural networks (1986–present)**
   - Parallel distributed processing (RumelHart and McClelland, 1986); backpropagation algorithm.
   - Connectionist models of intelligent systems
8. **AI adopts the scientific method (1987–present)**
   - In speech recognition: hidden markov models
   - In neural networks
   - In uncertain reasoning and expert systems: Bayesian network formalism
9. **The emergence of intelligent agents (1995–present)**
   - The whole agent problem:

     > "How does an agent act/behave embedded in real environments with continuous sensory inputs"

   - Human-level AI or HLAI; (Minsky et al., 2004).
   - Artificial General Intelligence or AGI (Goertzel and Pennachin, 2007)
10. **The availability of very large data sets (2001–present)**
    - Some recent work in AI suggests that for many problems, it makes more sense to worry about the data and be less picky about what algorithm to apply.
    - Increasing availability of very large data sources

Foundations of AI

Philosophy

Logic, reasoning, mind as a physical system, foundations of learning, language and rationality.

- Where does knowledge come from?
- How does knowledge lead to action?
- How does mental mind arise from physical brain?
- Can formal rules be used to draw valid conclusions?

Economics

Formal theory of rational decisions, game theory, operation research.

- How should we make decisions so as to maximize payoff?
- How should we do this when others may not go along?
- How should we do this when the payoff may be far in the future?

Mathematics

Formal representation and proof algorithms, computation, undecidability, intractability, probability.

- What are the formal rules to draw the valid conclusions?
- What can be computed?
- How do we reason with uncertain information?

Psychology

Adaptation, phenomena of perception and motor control.

- How humans and animals think and act?

Linguistics

Knowledge representation, grammar

- How does language relate to thought?

Neuroscience

Physical substrate for mental activities

- How do brains process information?

Control theory

Homeostatic systems, stability, optimal agent design

- How can artifacts operate under their own control?

Computer science

Hardware and software for implementing AI.

- How can we build an efficient computer?

Applications of AI:

(Describe these application areas yourself)

- Autonomous planning and scheduling
- Game playing
- Autonomous Control
- Expert Systems
- Logistics Planning
- Robotics
- Language understanding and problem solving
- Speech Recognition
- Computer Vision etc.