Unit I: Introduction to Artificial Intelligence (6 Hours)

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1.1 Introduction to AI, AI Perspectives: Acting and thinking , Acting and thinking rationally

Introduction to AI

Artificial Intelligence (AI) is a field of computer science that focuses on building systems capable of performing tasks that normally require human intelligence such as understanding language, recognizing patterns, learning from experience, reasoning, and making decisions.

Artificial Intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to perform tasks requiring reasoning, learning, and decision-making.

Artificial Intelligence (AI) is a technology that enables machines and computers to perform tasks that typically require human intelligence.
It helps systems learn from data, recognize patterns and make decisions to solve complex problems.
It is used in healthcare, finance, e-commerce and transportation offering personalized recommendations and enabling self-driving cars.

John McCarthy (1956) — Father of Artificial Intelligence
Definition: “Artificial Intelligence is the science and engineering of making intelligent machines, especially intelligent computer programs”.

Some of the most common examples of AI in use today include:

ChatGPT: Uses large language models (LLMs) to generate text in response to questions or comments posed to it.

Google Translate: Uses deep learning algorithms to translate text from one language to another.
Netflix: Uses machine learning algorithms to create personalized recommendation engines for users based on their previous viewing history.

Apple's Siri: Apple's voice-activated personal assistant, Siri, is powered by deep neural networks (DNNs) to interact with users and complete their requests.

AI Perspectives: Acting and thinking , Acting and thinking rationally

According to Russell and Norvig (2021), AI perspectives can be categorized into four main approaches, depending on whether the system aims to think or act, and whether it models human or rational behavior.

1) Acting Humanly (The Turing Test Approach)
2) Thinking Humanly (Cognitive Modeling Approach)
3) Acting Rationally (Rational Agent Approach)
4) Thinking Rationally (Laws of Thought Approach)

A. Acting Humanly (The Turing Test Approach)

Acting humanly involves designing AI systems that can mimic human behaviors and interactions. This perspective is particularly relevant in applications such as social robotics and intelligent tutoring systems, where understanding and responding to human emotions and actions is crucial.

Focus: Systems that behave like humans.
A machine is intelligent if it can imitate human behavior indistinguishably.
AI behaves like a human — if people can't tell whether it's a human or a machine, it passes the Turing Test.
Proposed by Alan Turing (1950) in his famous Turing Test.
Example:
Chatbots like ChatGPT, ELIZA, or Siri, which can hold human-like conversations.
Goal: To replicate observable human behavior (speech, perception, reasoning).

B. Thinking Humanly (Cognitive Modeling Approach)

This perspective focuses on creating AI systems that emulate human thought processes. It involves understanding how humans think, reason, and make decisions, often incorporating elements of psychology and cognitive science. The goal is to develop machines that can replicate human-like reasoning and emotional responses.

Focus: Systems that think like humans
Attempts to model human thought processes and cognitive functions.
AI tries to think the way humans think — by simulating how the human brain learns and solves problems.
Based on psychology and neuroscience
. Example:
Neural networks modeled after brain neurons, such as image recognition systems that "learn" patterns like humans.
Goal: Understand how humans think and replicate that process in machines.

C. Acting Rationally (Rational Agent Approach)

Acting rationally focuses on creating agents that make decisions aimed at achieving specific goals based on logical reasoning and available information. This perspective prioritizes the outcomes of actions rather than the processes that lead to them. Rational agents are designed to evaluate their environment and choose actions that maximize their performance, often using techniques from decision theory, game theory, and reinforcement learning.

Focus: Systems that act to achieve the best outcome based on logic and data.

AI acts to achieve the best possible result or goal logically — not necessarily like a human, but optimally.

Rational agents perceive their environment and act to maximize performance.

Emphasizes decision-making and goal achievement rather than mimicry.

Example:

Autonomous drones and self-driving cars making optimal navigation decisions.

Goal:

Choose the best possible action for a given objective.

D. Thinking Rationally (Laws of Thought Approach)

Thinking rationally emphasizes logical reasoning and decision-making based on objective criteria. This approach aims to develop AI that can make the best possible decisions by analyzing data and outcomes logically. It is rooted in formal logic and mathematical models, seeking to create systems that can solve problems and make decisions in a way that aligns with rational thought processes. This perspective is often associated with the development of algorithms and models that guide AI behavior.

Focus: Systems that reason logically like mathematicians or philosophers.

AI makes decisions based on logical reasoning — using facts and rules to reach conclusions.

Uses formal logic to derive conclusions from facts and rules.

Foundation of expert systems and rule-based AI.

Example:

Medical expert systems that use “if–then” logic to suggest correct diagnoses or treatments.

Goal:

Develop machines that can reason correctly using formal rules of inference.

1.2 Scope of AI

Scope of AI refers to the range of fields, functions, and real-world applications where Artificial Intelligence can be applied to perform human-like tasks — including learning, reasoning, decision-making, problem-solving, and perception.
AI's scope is vast and continues to grow across almost every domain of human life and industry.

1.2.1. Game Playing

It involves designing intelligent agents that can play games and make strategic decisions like
human players.
Game Playing in AI is about making intelligent, rational decisions in competitive environments — balancing strategy, prediction, and learning to achieve success.
In simple terms: Game Playing AI means teaching a computer how to "think ahead" and choose the best possible move.

Examples include chess, Go, video games, and online gaming bots.
AI uses techniques like search algorithms, minimax, and reinforcement learning to improve performance.

1.2.2. Problem Solving

Problem Solving in AI is the process of finding a sequence of actions that leads from an initial state to a desired goal state.
An AI agent must reason, plan, and choose actions to achieve the goal efficiently and intelligently.
In simple words: Problem solving in AI means teaching machines to "think" logically and find solutions like humans.
AI helps in solving complex problems by using logical reasoning and heuristics.
It involves finding optimal or near-optimal solutions efficiently.
Examples include pathfinding, scheduling, planning, and puzzle solving.

1.2.3. Natural Language Processing

NLP enables machines to understand, interpret, and generate human language.
It allows interaction between humans and computers using text or speech.
Examples include chatbots, voice assistants, language translation, and sentiment analysis.

1.2.4 Robotics

AI in robotics allows machines to perform tasks autonomously or semi-autonomously.
Robots can sense their environment, make decisions, and take actions.
Applications include industrial robots, medical robots, drones, and service robots.

1.2.5 Computer Vision

Computer Vision enables machines to interpret and understand visual information from images and videos.
It mimics human vision using cameras and image-processing algorithms.
Examples include face recognition, object detection, medical imaging, and self-driving cars.

1.2.6 Expert Systems

Expert systems are AI programs that simulate the decision-making ability of a human expert.
They use knowledge bases and inference engines to provide solutions or advice.
Applications include medical diagnosis, fault detection, and financial decision support.

1.3 Turing Machine and Turing Test

A Turing Machine is a theoretical mathematical model of computation proposed by Alan Turing in 1936.
It describes how a machine can perform calculations by following a set of rules.

Main Components:
Infinite tape divided into cells (stores symbols)
Tape head that reads and writes symbols
State register (current state)
Finite set of rules (transition function)

Working:
The machine reads a symbol from the tape
Writes a new symbol
Moves the tape left or right
Changes its state according to rules

Significance:
Forms the foundation of modern computers
Used to understand what problems can be computed
Helps in analyzing algorithm complexity

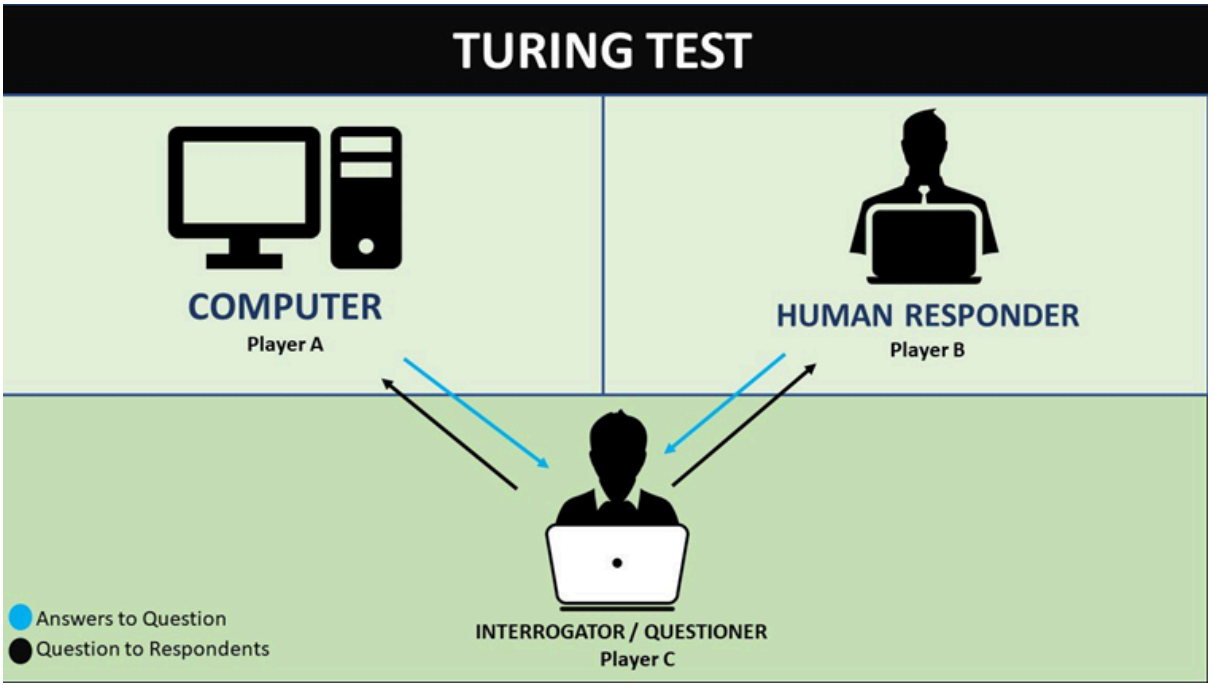
The Turing Test is one of the earliest and most influential ideas in Artificial Intelligence (AI). It was proposed by Alan Turing (1950) in his paper "Computing Machinery and Intelligence".
Turing introduced a practical question: "Can machines think?"
To answer it scientifically, he reframed it as an "imitation game" — a way to test whether a machine can imitate human intelligence convincingly enough to be indistinguishable from a human.

Concept of the Turing Test (The Imitation Game)

The test involves three participants:
1. A Human Interrogator (Judge)
2. A Human Respondent
3. A Machine (AI Program)

All participants communicate through text only (e.g., a chat terminal) so that appearance or voice does not influence judgment.

The interrogator's task: to ask any question and determine which one is human and which is the machine.



The Rule :
If the machine's answers are so convincing that the human judge cannot reliably distinguish it from the human respondent, then the machine is said to have passed the Turing Test.

Objective of the Test
• To measure a machine's ability to exhibit intelligent, human-like behavior.
• Focuses on behavioral intelligence rather than the internal process.
• The test does not require consciousness or emotion — only the appearance of understanding.

Example Scenario
Imagine a judge chatting with two unseen entities (A and B):
Judge: What do you like to do in your free time?
A: I enjoy reading books and sometimes coding small games.
B: I like watching cricket and chatting with friends.
If A is a computer program and the judge cannot tell, then A has passed the Turing Test.

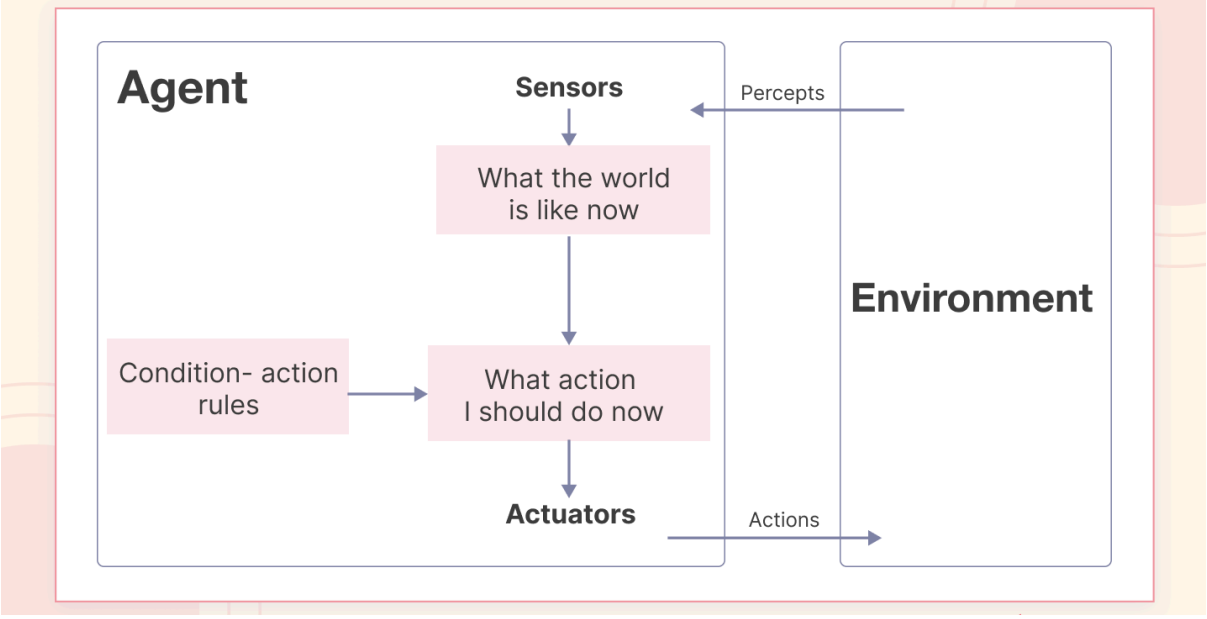
1.4. Intelligent Agents, Structure of Intelligent agent, Properties of Intelligent Agents

Intelligent Agent

An Intelligent Agent (IA) is an entity that can perceive its environment through sensors, analyze the situation, and act upon that environment using actuators to achieve specific goals intelligently.

In short: An Intelligent Agent "senses → thinks → acts" in its environment to accomplish objectives.

Examples of Intelligent Agents: Software Agent→ ChatGPT answering questions. Robotic Agent→ Self-driving car navigating roads.



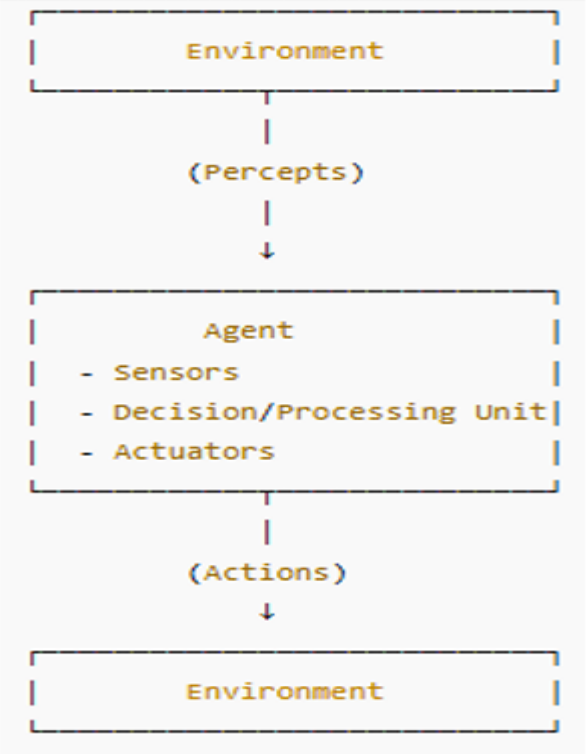
Example 1: Case Scenario: Self-Driving Car (Autonomous Vehicle Agent)

Imagine a self-driving car driving through city traffic. It uses cameras, radar, GPS, and sensors to perceive the world and AI algorithms to decide what to do — such as steering, braking, or changing lanes.

Component	Description	Example in Car
Agent	AI control system that decides.	The car's onboard computer.
Environment	Everything external to the agent.	Roads, signals, traffic, weather.
Sensors	Devices that perceive environment.	Cameras, radar, GPS.
Actuators	Devices that act on environment.	Steering, brakes, engine.
Condition–Action Rules	Decision-making logic.	If obstacle → stop.
Percepts	Information sensed.	"Car ahead slowing."
Actions	Responses to percepts.	"Brake smoothly."

Structure of an Intelligent Agent

The structure of an intelligent agent combines its architecture and agent program, enabling it to function effectively in dynamic environments.
Agent = Architecture + Program



Core Components of an Intelligent Agent

Environment: The external context in which the agent operates. It can be physical (e.g., a room) or virtual (e.g., a game world or the internet). The agent interacts with this environment to achieve its objectives.

Sensors: Devices or mechanisms that allow the agent to perceive its environment. Examples include cameras, microphones, temperature sensors, or software-based inputs like file data.

Actuators: Tools that enable the agent to perform actions in its environment. These can be physical (e.g., robotic arms, motors) or digital (e.g., sending messages or displaying outputs).

Effectors: Components that translate the agent's decisions into actions via actuators. They ensure that the agent's decisions are executed effectively.

Agent Program: The "brain" of the agent, which processes data from sensors and determines actions. It maps percepts (inputs) to actions based on the agent's goals and objectives.

Properties of Intelligent Agents

1.Autonomy
Works independently without human control.
Example:Self-driving car controlling its route.

2.Reactivity
Responds to environmental changes.
Example:Thermostat adjusting temperature automatically.

3.Proactiveness
Takes initiative toward goals.
Example:AI assistant scheduling reminders.

4.Adaptability (Learning)
Learns and improves from experience.
Example:Email spam filter improving with new data.

5.Rationality
Acts logically to achieve the best outcome.
Example:GPS system finding the shortest route.

6.Goal-Oriented
Always directed toward achieving a purpose.
Example: Game AI trying to win.

7.Social Ability
Can communicate with other agents or humans.
Example:Chatbots interacting in natural language.

Extra:

What is Rationality in AI?

In Artificial Intelligence, rationality refers to the ability of an agent to make the best possible decision to achieve its goals, based on:
• The knowledge it has,
• The percepts it receives,
• The actions available, and
• The performance measure that defines
success.

A rational agent is not necessarily perfect — it simply does the best it can given what it knows.
Example:
A self-driving car (agent) stops when it sees a red light — because, based on its knowledge and goals (safety, legality), that's the most rational decision.

Rational Agent

Definition: A Rational Agent is one that acts to achieve the best expected outcome (or maximize performance) according to its percepts and knowledge. It always chooses the action that is expected to maximize its success.
Real-World Examples • Google Maps AI: Chooses the fastest route considering traffic — acts rationally.

PEAS Model

The PEAS model is used to define the performance measure and environment of an intelligent agent. PEAS stands for:
P – Performance measure
E – Environment
A – Actuators
S – Sensors

It helps in designing rational agents by clearly specifying what success means and how the agent interacts with its environment.

Components of PEAS

1. Performance Measure

A performance measure defines what counts as success for an agent in its environment. It's a quantitative or qualitative metric used to evaluate how well an agent performs its task. It answers the question: "How do we know the agent is doing well?"
For example, a self-driving car's performance measure might combine "safety score" and "trip efficiency" rather than just speed.
Criteria used to evaluate the success of an agent
Example: accuracy, speed, safety, efficiency

2. Environment

The external world in which the agent operates
Example: roads, rooms, internet, games

3. Actuators

Devices used by the agent to take actions
Example: motors, wheels, speakers, displays

4. Sensors

Devices used to perceive the environment
Example: cameras, microphones, GPS, keyboard input

Example of PEAS Model

Autonomous Taxi

PEAS Element	Description
Performance	Safety, passenger satisfaction, fuel efficiency, legality
Environment	Roads, traffic, pedestrians, weather
Actuators	Steering wheel, accelerator, brake, horn
Sensors	Cameras, GPS, speedometer, radar