"Artificial Intelligence and Machine Learning"
BECE309L

Foundations of AI
Module -1

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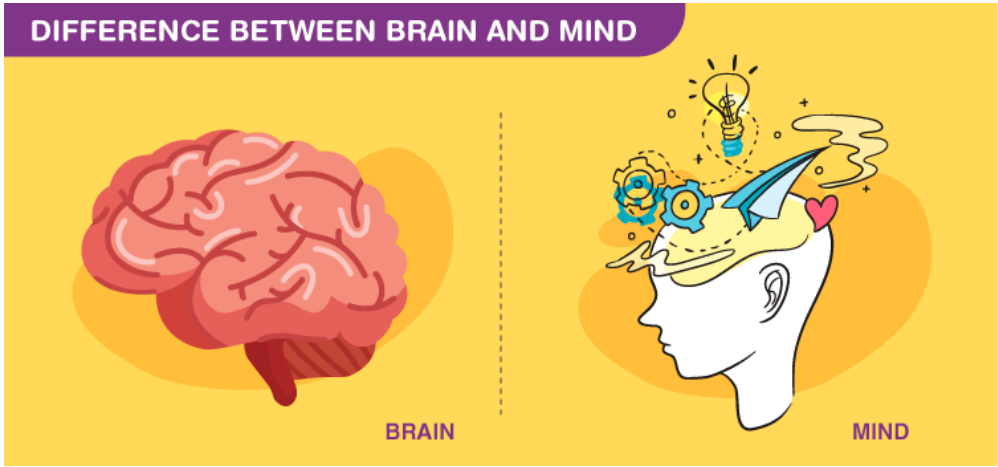
- Introduction
- Agents and rationality
- Task environment
- Agent Architecture Types.

Brain Verses Mind



Properties	Brain	Mind
Definition	The brain is defined as a physical thing.	The mind is defined as a mental thing.
Shape	It has defined structure and shape.	The mind do not have any shape and structure.
Production	It is the production of blood vessels and nerve cells.	It is hypothetical, it is not made of any cells.
Touch	Yes, you can touch the brain as it is a physical thing.	No, you cannot touch the mind.
Function	It helps in coordinating, feelings, movements, and different functions of the body.	It is just a person's understanding and thought process.

Table: **Without AI Verses With AI**

Programming Without AI	**Programming With AI**
A computer program without AI can answer the specific questions it is meant to solve.	A computer program with AI can answer the generic questions it is meant to solve.
Modification in the program leads to change in its structure.	AI programs can absorb new modifications by putting highly independent pieces of information together. Hence you can modify even a minute piece of information of program without affecting its structure.
Modification is not quick and easy. It may lead to affecting the program adversely.	Quick and Easy program modification.

Definition of AI

"Intelligence: The ability to learn and solve problems"

–**Webster's Dictionary.**

"Artificial intelligence (AI) is the intelligence exhibited by machines or software'

–**Wikipedia**

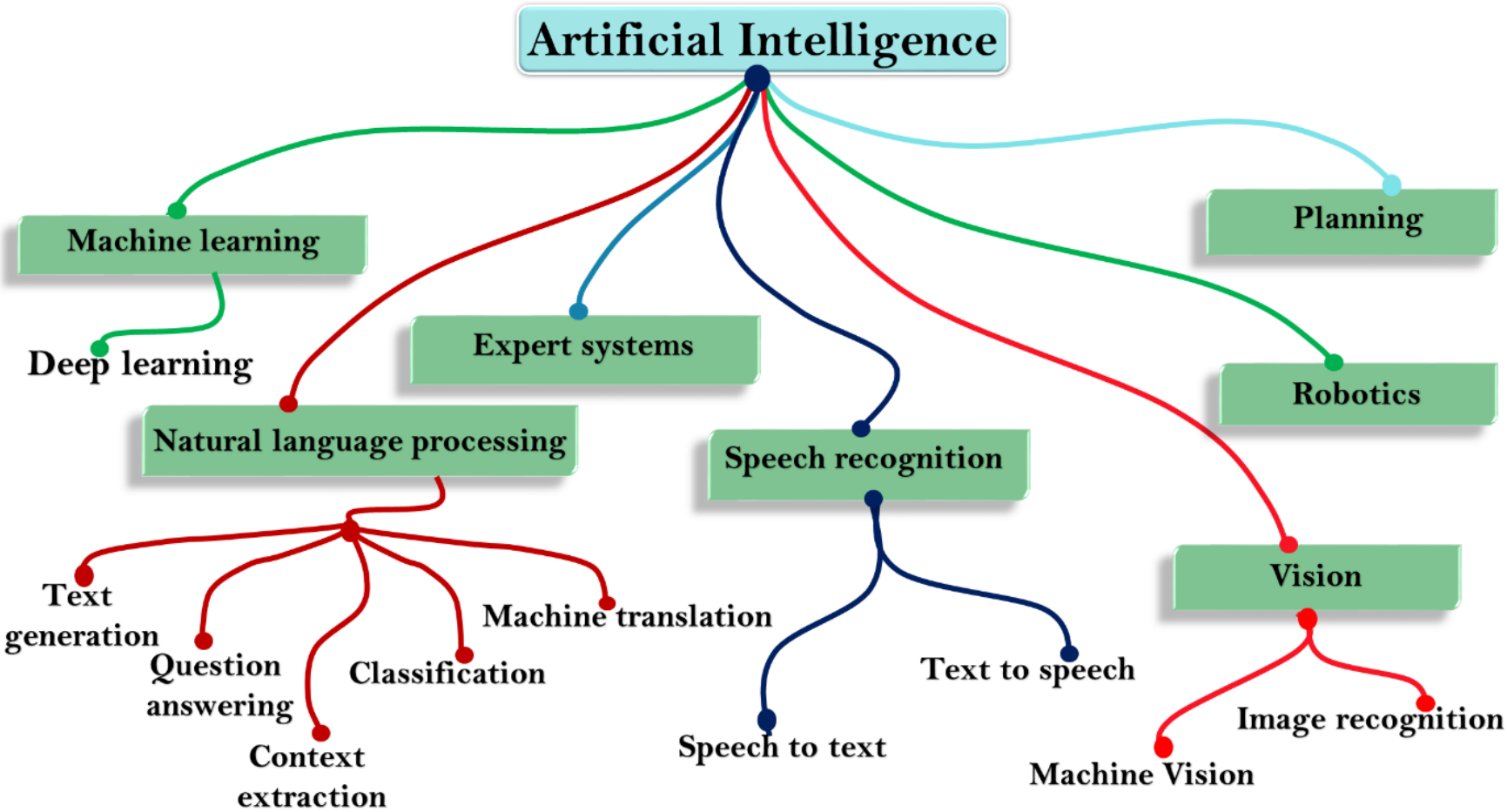
"The science and engineering of making intelligent machines"

–**McCarthy**

"The study and design of intelligent agents, where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success."

– **Russel and Norvig AI book.**

AI Contains...!


Artificial Intelligence
Machine learning
Deep learning
Natural language processing
Text generation
Question answering
Context extraction
Classification
Machine translation
Expert systems
Speech recognition
Speech to text
Text to speech
Planning
Robotics
Vision
Machine Vision
Image recognition

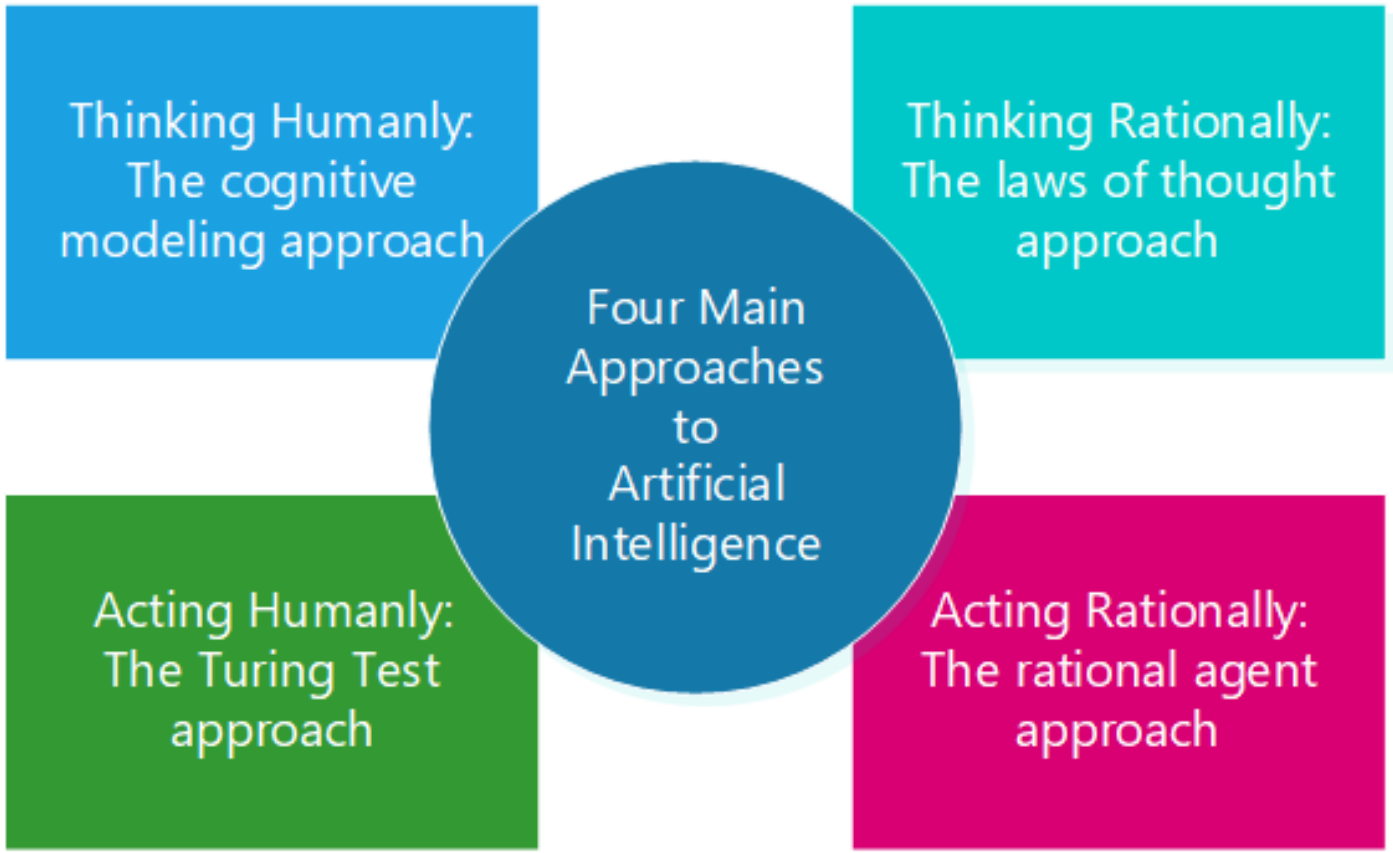


Figure: Views of AI

What is AI...? I

Thought Process and Reasoning

Success in terms of Fidelity to Human Performance

Measure against an Ideal Performance Measures (Rationality – Right thing)

Thinking Human

"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)

Thinking Rationally

"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

"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)

Acting Rationally

"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)

Behaviour

What is AI...? II

Historically, all four approaches to AI have been followed, each by different people with different methods

- A human-centered approach must be in part an empirical science, involving **observations** and **hypotheses** about human behavior.
- A **rationalist** approach involves a combination of mathematics and engineering.

Why AI?

"Just as the Industrial Revolution freed up a lot of humanity from physical drudgery, I think AI has the potential to free up humanity from a lot of the mental drudgery."

Andrew Ng

The Turing Test Approach

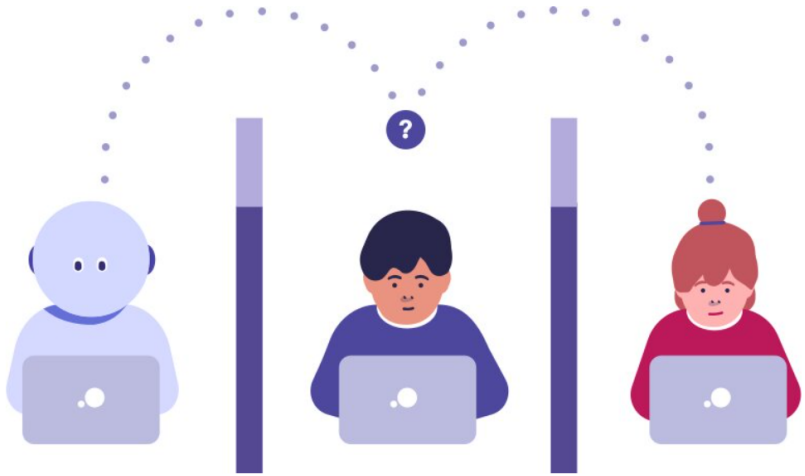


Figure: Turing Test Approach

- It is proposed by **Alan Turing** (1950), was designed to provide a satisfactory operational definition of intelligence.
- A computer passes the test if a human interrogator, after posing some written questions, cannot tell whether the written responses come from a person or from a computer.
- The computer would need to possess the 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.

- This Test, avoids direct physical interaction between the interrogator and the computer (unnecessary for intelligence).
- It is called TOTAL TURING Test includes a **video signal** so that the interrogator can test the subject's perceptual abilities, and can pass physical objects "through the hatch."
- To pass the total Turing Test, the computer will need
  - **Computer Vision** to perceive objects, and
  - **Robotics** to manipulate objects and move about.
- These 6 disciplines compose most of AI, and Turing deserves credit for designing a test

The Cognitive Modeling Approach Thinking humanly is to make a system or program to think like a human. But to achieve that, we need to know how does a human thinks.

Suppose if we ask a person to explain how his brain connects different things during the thinking process, he/she will probably close both eyes and will start to check how he/she thinks but he/she cannot explain or interpret the process.

Ask the same question to yourself, and most likely you will have the same pattern and will end up saying "you do not know, or you may say something like "I am thinking through my mind", but you cannot express more than that. Read through neuroscience books to get a deeper understanding of this.

For Ex : If we want to model the thinking of **Roger Federer** and make the model system to compete with someone or against him to play in a tennis game, it may not be possible to replicate the exact thinking as **Roger Federer**, however, a good build of Intelligence systems (Robot) can play and win the game against him.

To understand the exact process of how we think, we need to go inside the human mind to see how this giant machine works.

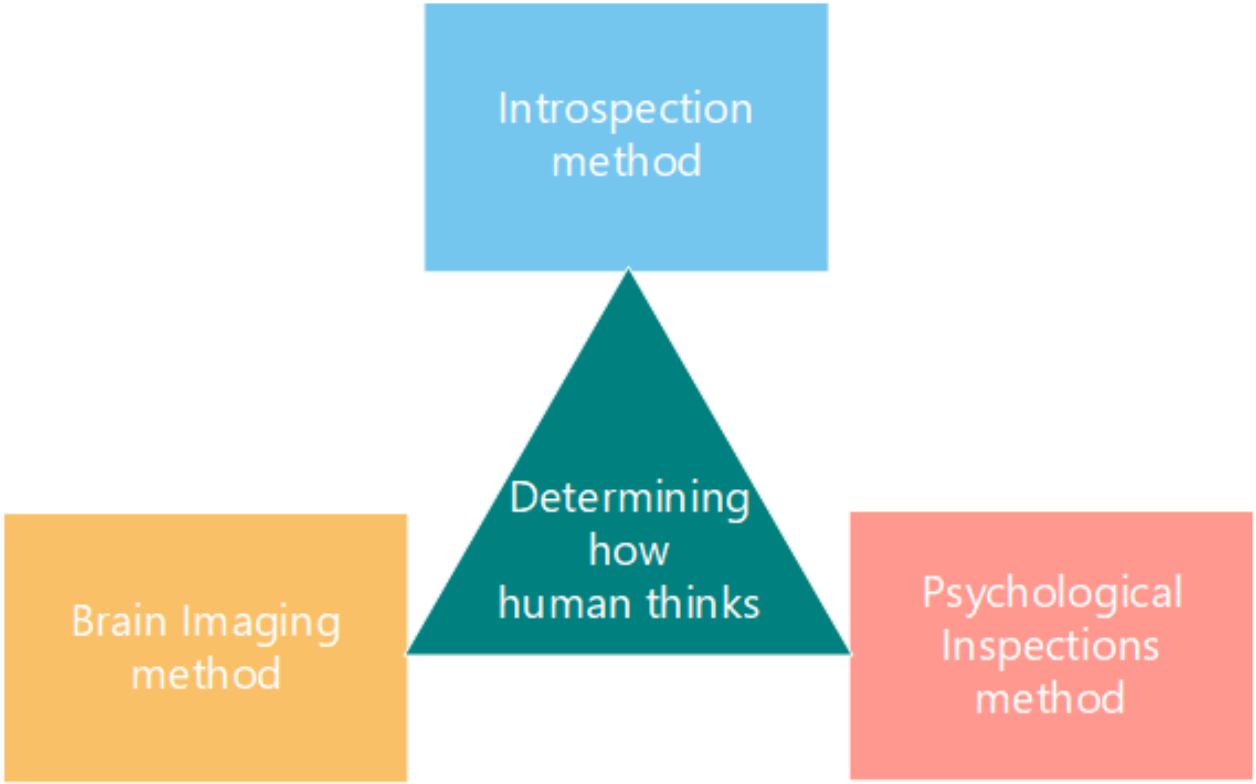


Figure: Human mind thinks

- **Introspection method** – Catch our thoughts and see how it flows.
- **Psychological Inspections method** – Observe a person on the action.
- **Brain Imaging method** (MRI (Magnetic resonance imaging) or fMRI (Functional Magnetic resonance imaging) scanning) – Observe a person's brain in action.

Using the above methods, if we are able to catch the human brain's actions and give it as a theory, then we can convert that theory into a computer program.

If the input/output of the computer program matches with human behavior, then it may be possible that a part of the program may be behaving like a human brain.

The **General Problem Solver** (GPS) programme was created by **Allen Newell** and **Herbert Simon** to simulate human thought and test whether it can answer issues by using the same steps in reasoning as a person. The program's goal is to solve the problem using the same process that a human brain would use, not only to solve it correctly.

The "Laws of Thought" Approach The Greek philosopher Aristotle was the one who first codifies "right-thinking" reasoning processes.

Aristotle's syllogisms provided patterns for argument structures that always provide correct premises.

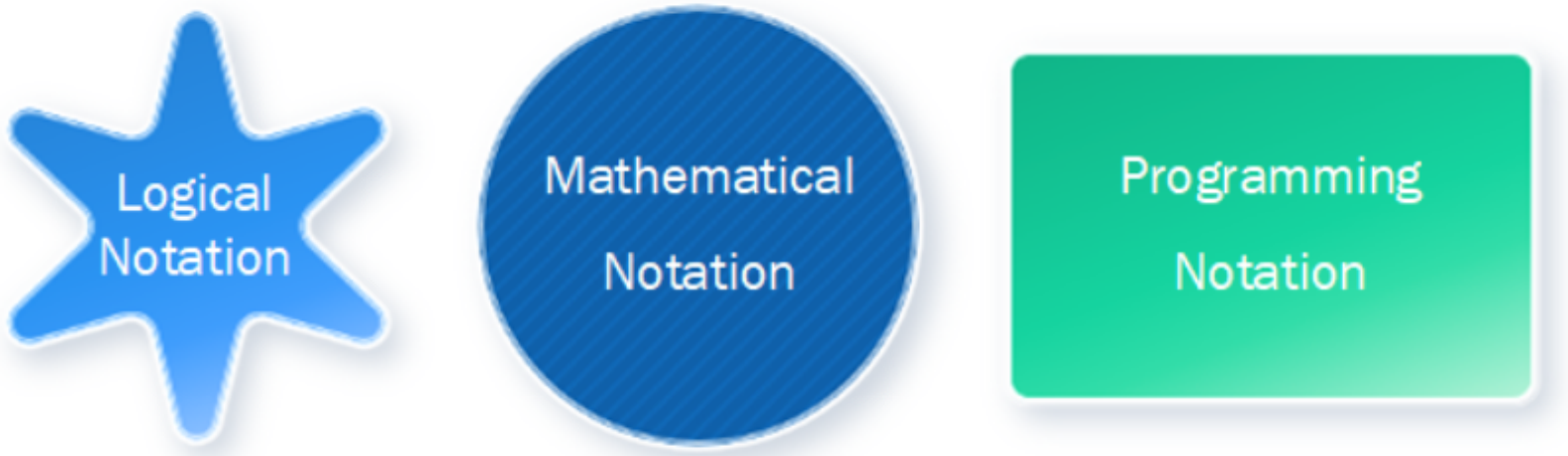
Examples:

- "Socrates is a man; all men are mortal; therefore, Socrates is mortal."
- "All TVs use energy; Energy generates heat; ∴ all TVs generate heat."
- "All dogs are animals; all animals have four legs; ∴ all dogs have four legs".

These arguments initiated the field called **logic**. Notations for statements for all kinds of objects were developed and interrelated between them to show logic.

By 1965, programs existed that could solve problems that were described in logical notation and provides a solution.

In order to develop intelligence systems, programmes, or computational models, AI aspires to expand on such Programs.



The Limitations:

1. First, when there is not enough assurance in the information, it is difficult to utilise logical notation to represent informal knowledge.
2. There are big differences between solving in theory and actually.

The Rational Agent Approach A traditional computer program blindly executes the code that we write. Neither it acts on its own nor it adapts to change itself based on the outcome.

The so-called **agent** program that we refer to here is expected to do more than the traditional computer program. It is expected to create and **pursue the goal**, **change state**, and **operate autonomously**.

A **rational agent** is an agent that acts to achieve its best performance for a given task.

The "Logical Approach" to AI emphasizes correct inferences and achieving a correct inference is a part of the rational agent.

The rational agent approach to AI has a couple of advantage over other approaches:

- A correct inference is considered a possible way to achieve rationality but is not always required to achieve rationality.
- It is a more manageable scientific approach to define rationality than others that are based on human behavior or human thought.

Goal of AI

- **To Create Expert Systems** : The systems which exhibit intelligent behavior, learn, demonstrate, explain, and advice its users.
- **To Implement Human Intelligence in Machines** : Creating systems that understand, think, learn, and behave like humans.

History of Artificial Intelligence

Year	Milestone / Innovation
1923	Karel Čapek play named "Rossum's Universal Robots" (RUR) opens in London, first use of the word "robot" in English.
1943	Foundations for neural networks laid.
1945	Isaac Asimov, a Columbia University alumni, coined the term Robotics.

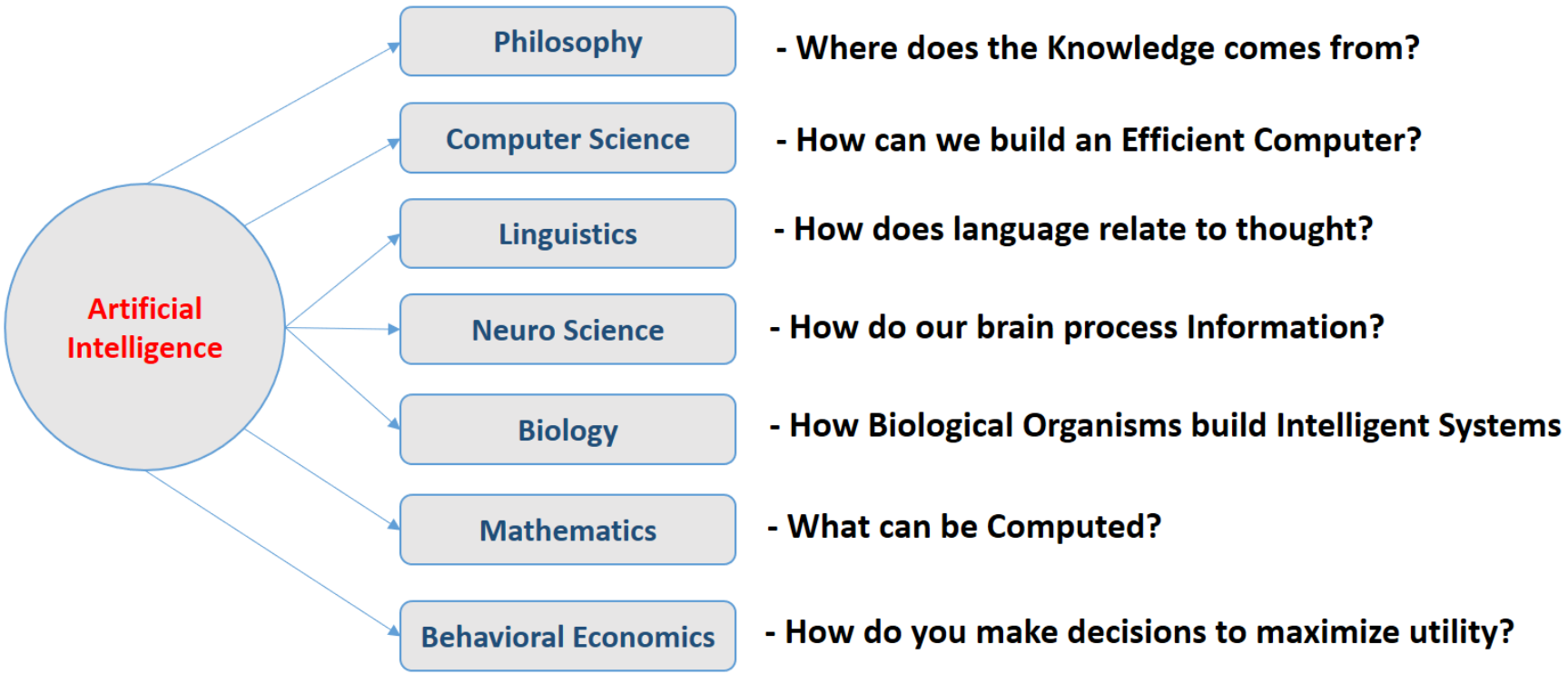
1950	Alan Turing introduced Turing Test for evaluation of intelligence and published Computing Machinery and Intelligence. Claude Shannon published Detailed Analysis of Chess Playing as a search.
1956	John McCarthy coined the term Artificial Intelligence. Demonstration of the first running AI program at Carnegie Mellon University.
1958	John McCarthy invents LISP programming language for AI.
1964	Danny Bobrow's dissertation at MIT showed that computers can understand natural language well enough to solve algebra word problems correctly.
1965	Joseph Weizenbaum at MIT built ELIZA, an interactive problem that carries on a dialogue in English.
1969	Scientists at Stanford Research Institute Developed Shakey, a robot, equipped with locomotion, perception, and problem solving.
1973	The Assembly Robotics group at Edinburgh University built Freddy, the Famous Scottish Robot, capable of using vision to locate and assemble models.

1979	The first computer-controlled autonomous vehicle, Stanford Cart, was built.
1985	Harold Cohen created and demonstrated the drawing program, Aaron.
1990	Major advances in all areas of AI Significant demonstrations in machine learning Case-based reasoning Multi-agent planning Scheduling Data mining, Web Crawler natural language understanding and translation Vision, Virtual Reality Games
1997	The Deep Blue Chess Program beats the world chess champion, Garry Kasparov.
2000	Interactive robot pets become commercially available. MIT displays Kismet, a robot with a face that expresses emotions. The robot Nomad explores remote regions of Antarctica and locates meteorites.

What Contributes to AI?

AI is a science and technology based on disciplines such as Computer Science, Biology, Psychology, Linguistics, Mathematics, and Engineering.

A major thrust of AI is in the development of computer functions associated with human intelligence, such as reasoning, learning, and problem solving.



AI has been dominant in various fields such as :

1. **Gaming** : AI plays crucial role in strategic games such as **chess**, **poker**, **tic-tac-toe**, etc., where machine can think of large number of possible positions based on heuristic knowledge.
2. **Natural Language Processing** : It is possible to interact with the computer that understands natural language spoken by humans.
3. **Expert Systems** : There are some applications which integrate machine, software, and special information to impart reasoning and advising. They provide explanation and advice to the users.
4. **Vision Systems** : These systems understand, interpret, and comprehend visual input on the computer. For example,
   - A spying aeroplane takes photographs, which are used to figure out spatial information or map of the areas.
   - Doctors use clinical expert system to diagnose the patient.
   - Police use computer software that can recognize the face of criminal with the stored portrait made by forensic artist.

5. **Speech Recognition** : Some intelligent systems are capable of hearing and comprehending the language in terms of sentences and their meanings while a human talks to it. It can handle different accents, slang words, noise in the background, change in human's noise due to cold, etc.
6. **Handwriting Recognition** : The handwriting recognition software reads the text written on paper by a pen or on screen by a stylus. It can recognize the shapes of the letters and convert it into editable text.
7. **Intelligent Robots** : Robots are able to perform the tasks given by a human. They have sensors to detect physical data from the real world such as light, heat, temperature, movement, sound, bump, and pressure.

Artificial Intelligence is all about building intelligent machines from vast volumes of data and getting them to perform human-like tasks, leading to an enhancement in speed, precision, and effectiveness of human efforts.

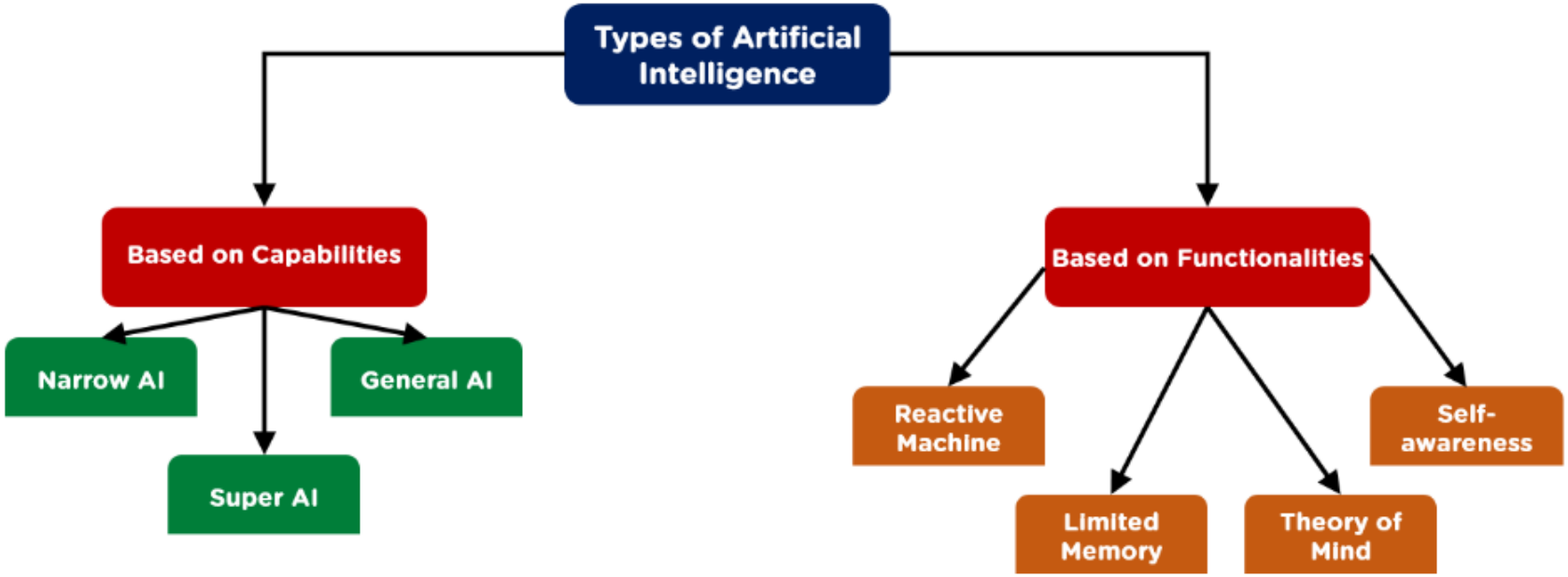


Figure: Classification of AI

Based on Capabilities - Narrow AI :

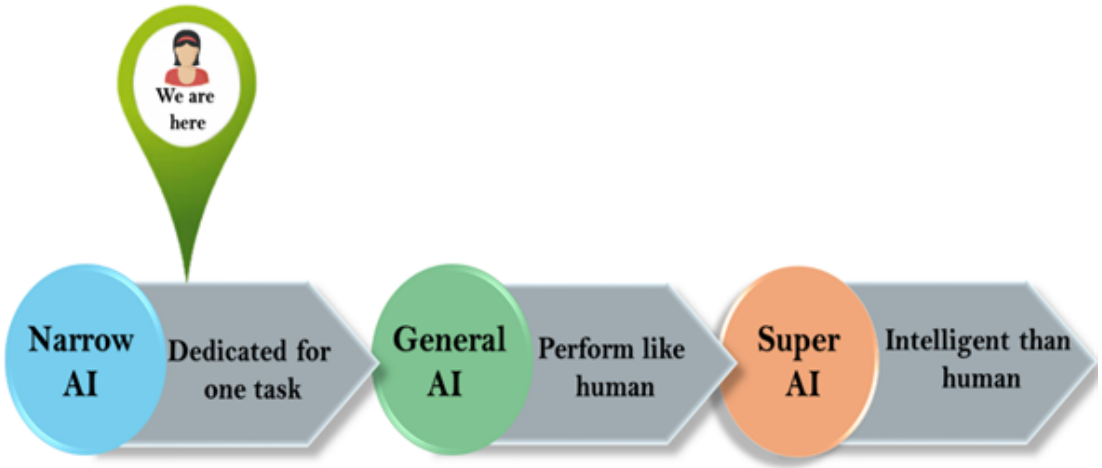
- It also called as Weak AI, focuses on one narrow task and cannot perform beyond its limitations.
- It targets a single subset of cognitive abilities and advances in that spectrum.
- Narrow AI applications are becoming increasingly common in our day-to-day lives as machine learning and deep learning methods continue to develop.
- **Examples** : Apple Siri, Alex, IBM Watson, Google Translate, Image Recognition, Recommendation Systems, Spam Filtering, Google Page Ranking .....

Based on Capabilities - General AI

- General AI, also known as strong AI
- It can understand and learn any intellectual task that a human being can
- It can learn, perceive, understand, and function entirely like a human
- It allows a machine to apply knowledge and skills in different contexts.
- With the connections and logic it can build on its own, the training required for general AI is significantly less.
- Large organizations worldwide have invested billions of dollars in developing strong AI – the most notable of them being Microsoft's investment through Open AI.
- **Examples**
  - Fujitsu has built the K computer, which is one of the fastest supercomputers in the world
  - Tianhe-2 is a supercomputer that was developed by the China's National University of Defense Technology. It holds the record for cps (calculations per second) at 33.86 petaflops (quadrillions of cps).

Based on Capabilities - Super AI

- Super AI surpasses human intelligence and can perform any task better than a human.
- The concept of artificial super intelligence sees AI evolved to be so akin to human sentiments and experiences that it doesn't merely understand them;
- It also evokes emotions, needs, beliefs, and desires of its own. Its existence is still hypothetical.
- Some of the critical characteristics of super AI include thinking, solving puzzles, making judgments, and decisions on its own.



Based on Functionalities - Reactive Machines

- It is the primary form of AI that does not store memories or use past experiences to determine future actions.
- It works only with present data. They perceive the world and react to it.
- Reactive machines are provided with specific tasks, and they don't have capabilities beyond those tasks.
- **Example** :
  - IBM's Deep Blue that defeated chess grand master **Garry Kasparov** in 1997. It could see all the chessboard pieces and kept reacting to each situation with a new move without storing data for the previous move.

Based on Functionalities - Limited Memory

- Limited Memory AI trains from past data to make decisions. The memory of such systems is short-lived.
- They can use this past data for a specific period of time, but they cannot add it to a library of their experiences. [Example : **Self Driving Vehicles**]
- It observes how other vehicles are moving around them, at present, and as time passes. [**Mitsubishi Electric** has been figuring out how to improve such technology for applications like self-driving cars.]

Based on Functionalities - Theory of Mind

- Theory of Mind AI, although mostly **hypothetical** at the moment, represents an exciting potential. By definition, it shall understand humans as entities who have emotions, sentiments, and thoughts. While many improvements have been made in the field, the Theory of Mind remains an undeveloped area.
- **Examples**
  - **Kismet**(real world example) is a robot head made in the late 90s by a Massachusetts Institute of Technology researcher.

    It can **mimic human emotions** and recognize them.

    Both abilities are key advancements in theory of mind AI, but Kismet can't follow gazes or convey attention to humans.
  - **Sophia** from Hanson Robotics is another example where the theory of mind AI was implemented. Cameras present in Sophia's eyes, combined with computer algorithms, allow her to see. She can sustain eye contact, recognize individuals, and follow faces.

Based on Functionalities - Self Awareness

- Self-awareness AI only exists hypothetically. Such systems understand their internal traits, states, and conditions and perceive human emotions.
- These machines will be smarter than the human mind.
- This type of AI will not only be able to understand and evoke emotions in those it interacts with, but also have emotions, needs, and beliefs of its own.

The ability of a system to calculate, reason, perceive relationships and analogies, learn from experience, store and retrieve information from memory, solve problems, comprehend complex ideas, use natural language fluently, classify, generalize, and adapt new situations.

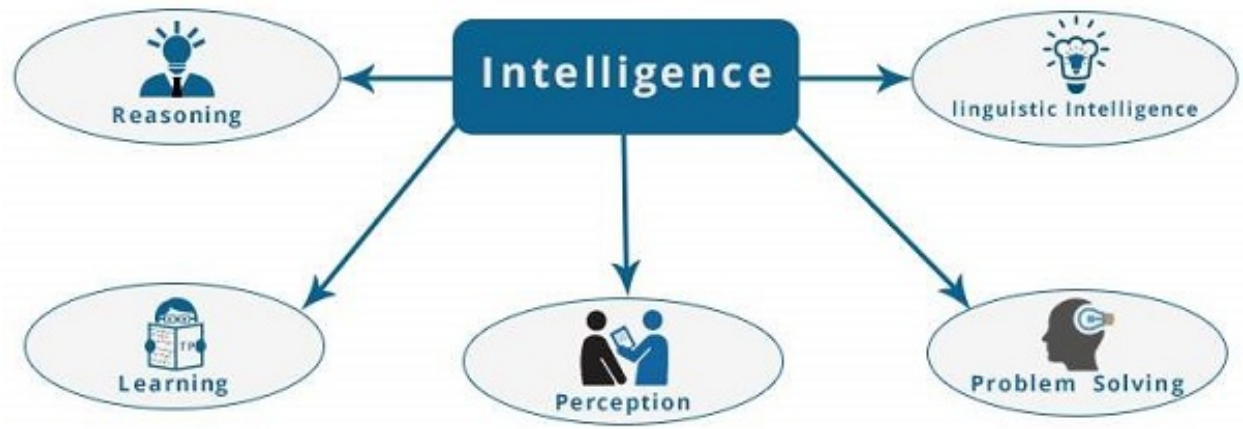


Figure: Intelligence Components

- **Reasoning** : It is the set of processes that enables us to provide basis for judgement, making decisions, and prediction. There are broadly two types :

Inductive Reasoning	Deductive Reasoning
It conducts specific observations to makes broad general statements.	It starts with a general statement and examines the possibilities to reach a specific, logical conclusion.
Even if all of the premises are true in a statement, It allows for the conclusion to be false.	If something is true of a class of things in general, it is also true for all members of that class.
Example : "Nita is a teacher. Nita is studious. Therefore, All teachers are studious."	Example : "All women of age above 60 years are grandmothers. Shalini is 65 years. Therefore, Shalini is a grandmother."

- **Problem Solving** : It is the process in which one perceives and tries to arrive at a desired solution from a present situation by taking some path, which is blocked by known or unknown hurdles.
  Problem solving also includes decision making, which is the process of selecting the best suitable alternative out of multiple alternatives to reach the desired goal are available.

- **Perception** : It is the process of acquiring, interpreting, selecting, and organizing sensory information.
  Perception presumes sensing. In humans, perception is aided by sensory organs. In the domain of AI, perception mechanism puts the data acquired by the sensors together in a meaningful manner.
- **Linguistic Intelligence** : It is one's ability to use, comprehend, speak, and write the verbal and written language. It is important in interpersonal communication.
- **Learning** : It is the activity of gaining knowledge or skill by studying, practising, being taught, or experiencing something. Learning enhances the awareness of the subjects of the study.
  The ability of learning is possessed by humans, some animals, and AI-enabled systems. Learning is categorized as :
  - **Auditory Learning** : It is learning by listening and hearing. For example, students listening to recorded audio lectures.
  - **Episodic Learning** : To learn by remembering sequences of events that one has witnessed or experienced. This is linear and orderly.
  - **Motor Learning** : It is learning by precise movement of muscles. For example, picking objects, Writing, etc.

- **Observational Learning** : To learn by watching and imitating others. For example, child tries to learn by mimicking her parent.
- **Perceptual Learning** : It is learning to recognize stimuli that one has seen before. For example, identifying and classifying objects and situations.
- **Relational Learning** It involves learning to differentiate among various stimuli on the basis of relational properties, rather than absolute properties. For Example, Adding 'little less' salt at the time of cooking potatoes that came up salty last time, when cooked with adding say a tablespoon of salt.
- **Spatial Learning** : It is learning through visual stimuli such as images, colors, maps, etc. For Example, A person can create roadmap in mind before actually following the road.
- **Stimulus-Response Learning** : It is learning to perform a particular behavior when a certain stimulus is present. For example, a dog raises its ear on hearing doorbell.

Types of Intelligence

Intelligence	Description	Example
Linguistic intelligence	The ability to speak, recognize, and use mechanisms of phonology (speech sounds), syntax (grammar), and semantics (meaning).	Narrators, Orators
Musical intelligence	The ability to create, communicate with, and understand meanings made of sound, understanding of pitch, rhythm.	Musicians, Singers, Composers
Logical-mathematical intelligence	The ability of use and understand relationships in the absence of action or objects. Understanding complex and abstract ideas.	Mathematicians, Scientists
Spatial intelligence	The ability to perceive visual or spatial information, change it, and re-create visual images without reference to the objects, construct 3D images, and to move and rotate them.	Map readers, Astronauts, Physicists
Bodily-Kinesthetic intelligence	The ability to use complete or part of the body to solve problems or fashion products, control over fine and coarse motor skills, and manipulate the objects.	Players, Dancers
Intra-personal intelligence	The ability to distinguish among one's own feelings, intentions, and motivations.	Gautam Buddhha
Interpersonal intelligence	The ability to recognize and make distinctions among other people's feelings, beliefs, and intentions.	Mass Communicators, Interviewers

Difference between Human and Machine Intelligence :

- Humans perceive by patterns whereas the machines perceive by set of rules and data.
- Humans store and recall information by patterns, machines do it by searching algorithms. For example, the number 40404040 is easy to remember, store, and recall as its pattern is simple.
- Humans can figure out the complete object even if some part of it is missing or distorted; whereas the machines cannot do it correctly.

- Knowledge inference refers to acquiring new knowledge from existing facts based on certain rules and constraints.
- One way of representing these rules and constraints is through the use of logic rules, formally known as **Knowledge representation(KR)**.
- The mechanism behind inferring new knowledge based on the existing facts and logic rules is typically known as **Reasoning**.
- **KR** - is a study of how the **beliefs**, **intentions**, and **judgments** of an intelligent agent can be expressed suitably for automated reasoning.
- Knowledge Representation and Reasoning (**KRR**) represents information from the real world for a computer to understand and then utilize this knowledge to solve complex real-life problems like communicating with human beings in natural language.
- Knowledge representation in AI is not just about storing data in a database, it allows a machine to learn from that knowledge and behave intelligently like a human being.

The different kinds of knowledge that need to be represented in AI include:

- Objects
- Events
- Performance
- Facts
- Meta-Knowledge
- Knowledge-base

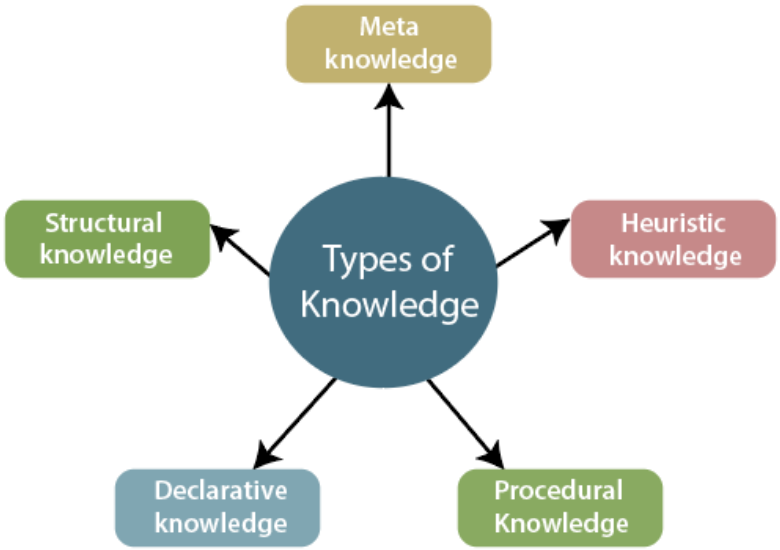


Figure: Types of Knowledge

1. **Declarative Knowledge** (Descriptive Knowledge)
   - It is all about concepts, facts, and objects and expressed in declarative sentences.
   - It is simpler than procedural language.
2. **Procedural Knowledge** (imperative knowledge)
   - It is responsible for knowing how to do something and can apply directly to any task.
   - It includes rules, strategies, procedures, agendas, etc. And depends on the task to which it can be applied.
3. **Meta Knowledge** : Knowledge about the other types of knowledge
4. **Heuristic Knowledge** :
   - It is representing knowledge of some experts in a filed or subject.
   - It is rules of thumb based on previous experiences, awareness of approaches, and which are good to work but not guaranteed.
5. **Structural Knowledge** :
   - It is basic knowledge to problem-solving and describes relationships between various concepts such as kind of, part of, and grouping of something.
   - It describes the relationship that exists between concepts or objects.

State-of-the-art applications

- Speech recognition
- Autonomous planning and scheduling
- Financial forecasting
- Game playing, video games
- Spam fighting
- Logistics planning
- Robotics (household, surgery, navigation)
- Machine translation
- Information extraction
- VLSI layout
- Automatic assembly
- Sentiment analysis
- Fraud detection
- Recommendation systems
- Web search engines
- Autonomous cars
- Energy optimization
- Question answering systems
- Social network analysis
- Medical diagnosis, imaging
- Route finding
- Traveling salesperson
- Protein design
- Document summarization
- Transportation/scheduling
- Computer animation

Many more....!

Examples of AI

- Google Maps and Ride-Hailing Applications
- Face Detection and recognition
- Text Editors and Autocorrect
- Chatbots
- E-Payments
- Search and Recommendation algorithms
- Digital Assistant
- Social media
- Healthcare
- Gaming
- Online Ads-Network
- Banking and Finance
- Smart Home devices
- Security and Surveillance
- Smart Keyboard App
- Smart Speaker
- E-Commerce
- Smart Email Apps
- Music and Media Streaming Service
- Space Exploration

"Artificial Intelligence and Machine Learning"
BECE309L

Intelligent Agents

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What is an Agent...? I

What is an Agent?

- An agent is anything that can perceive its environment through **sensors** and acts upon that environment through **effectors**..

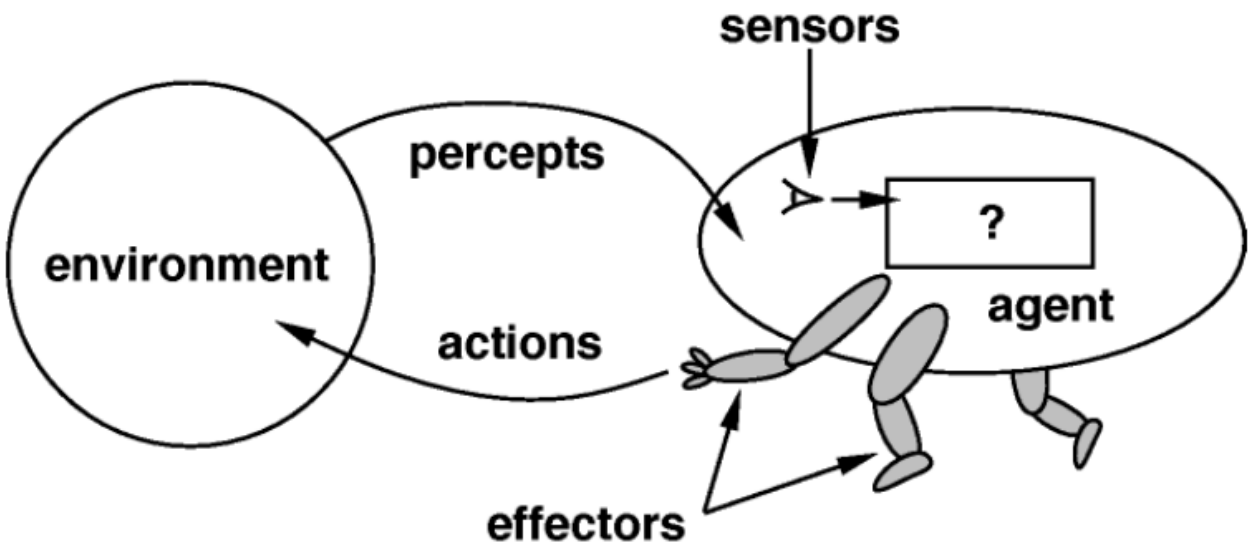
An agent can be:

- **Human-Agent**: A human agent has eyes, ears, and other organs which work for sensors and hand, legs, vocal tract work for actuators.
- **Robotic Agent**: A robotic agent can have cameras, infrared range finder, NLP for sensors and various motors for actuators.
- **Software Agent**: Software agent can have keystrokes, file contents as sensory input and act on those inputs and display output on the screen.

What are Sensors, Actuators, and Effectors

- **Sensor**: A device that detects the change in environment and sends it to other electronic devices. An agent observes its environment through sensors.
- **Actuators**: are the component of machines that converts energy into motion and are responsible for moving and controlling a system.
  Example : **Electric motor, Gears, Rails,** etc.
- **Effectors**: are the devices which affect the environment.
  Example : legs, wheels, arms, fingers, wings, fins, and display screen.

What is an Agent...? II



Following are the main four rules for an AI agent:

- Rule 1: An AI agent must have the ability to perceive the environment.
- Rule 2: The observation must be used to make decisions.
- Rule 3: Decision should result in an action.
- Rule 4: The action taken by an AI agent must be a rational action.

Intelligent Agents:

- It is an autonomous entity which act upon an environment using sensors and actuators for achieving goals.
- It may learn from the environment to achieve their goals.
- A **thermostat** is an example of an intelligent agent.

Rational Agents:

- It is an agent which has clear preference, models uncertainty, and acts in a way to maximize its performance measure with all possible actions.
- It is said to perform the right things. AI is about creating rational agents to use for game theory and decision theory for various real-world scenarios.
- For an AI agent, the rational action is most important because in AI reinforcement learning algorithm.

  For each best possible action, Agent gets the positive reward

  For each wrong action, an agent gets a negative reward.

Note: Rational agents in AI are very similar to intelligent agents.

What is Rationality?

- The rationality of an agent is measured by its performance measure.
- Rationality can be judged on the basis of following points
  - Performance measure which defines the success criterion.
  - Agent prior knowledge of its environment.
  - Best possible actions that an agent can perform.
  - The sequence of percepts.

Agent Terminology

- **Performance Measure of an Agent** : It is the criteria, which determines how successful an agent is.
- **Behavior of an Agent** : It is the action that agent performs after any given sequence of percepts.
- **Percept** : It is agent's perceptual inputs at a given instance.
- **Percept Sequence** : It is the history of all that an agent has perceived till date.
- **Agent Function** : It is a map from the precept sequence to an action

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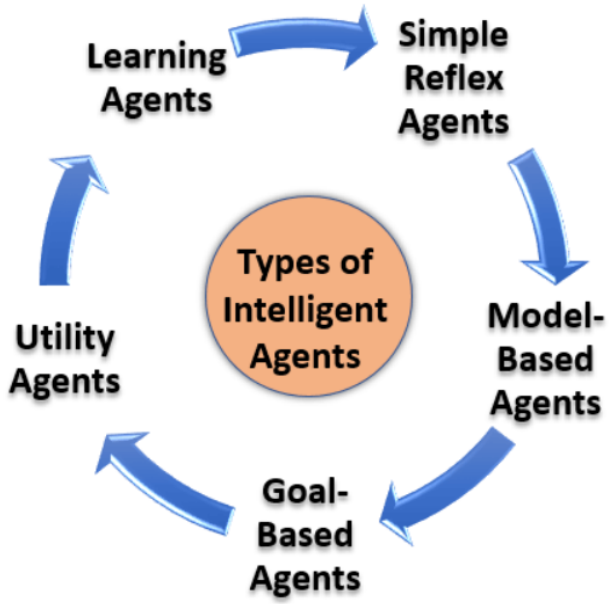
Designing an agent programme that performs the agent function is the AI task.

Agents structure is made up of both its architecture and agent programme.

Agent = Architecture + Agent program
Architecture = the machinery that an agent executes on.
Agent Program = an implementation of an agent function.

Agents can be grouped into five classes based on their degree of perceived intelligence and capability :



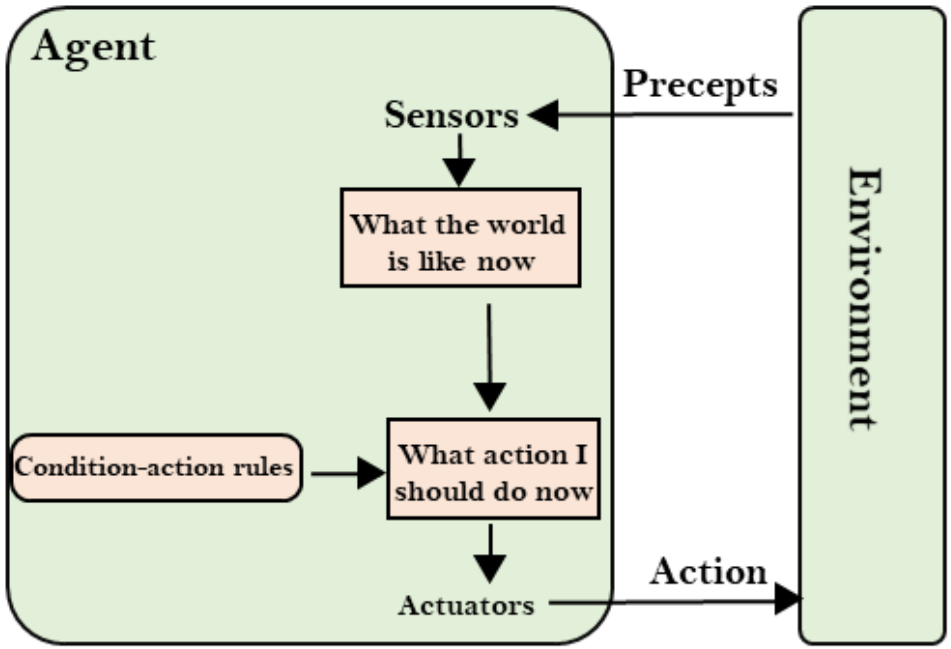


Figure: **Simple Reflex Agents**

- They choose actions only based on the current percept.
- They are rational only if a correct decision is made only on the basis of current precept.
- Their environment is completely observable.

Condition-Action Rule : It is a rule that maps a state (condition) to an action.

Problems for the simple reflex agent design approach:

- They have very limited intelligence
- They do not have knowledge of non-perceptual parts of the current state
- Mostly too big to generate and to store.
- Not adaptive to changes in the environment

- It can work in a partially observable environment, and track the situation.
- It has two important factors:
  - **Model**: It is knowledge about "how things happen in the world," so it is called a Model-based agent.
  - **Internal State**: It is a representation of the current state based on percept history.
- These agents have the model, "which is knowledge of the world" and based on the model they perform actions.
- Updating the agent state requires information about:
  - How the world evolves and the agent's action affects the world.

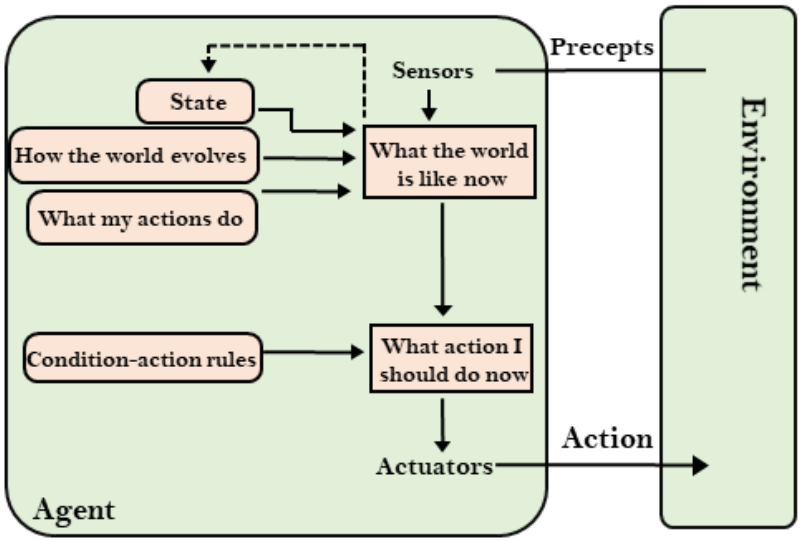


Figure: **Model Based Reflex Agents**

- The knowledge of the current state environment is not always sufficient to decide for an agent to what to do.
- The agent needs to know its goal which describes desirable situations.
- It expand the capabilities of the model-based agent by having the "goal" information and choose an action, so that goal can achieve.
- They must consider a long sequence of possible actions before deciding whether the goal is achieved or not. Searching and planning are such concerns of various scenarios, and makes an agent **proactive**.

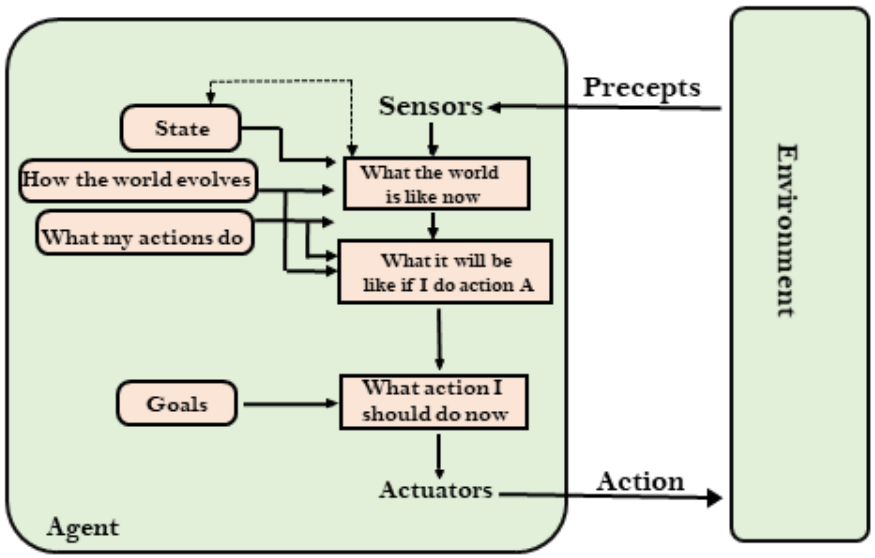


Figure: **Goal Based Reflex Agents**

- These agents are similar to the goal-based agent but provide an extra component of utility measurement which makes them different by providing a measure of success at a given state.
- It acts based not only goals but also the best way to achieve the goal.
- It is useful when there are multiple possible alternatives, and an agent has to choose in order to perform the best action.
- The utility function maps each state to a real number to check how efficiently each action achieves the goals.

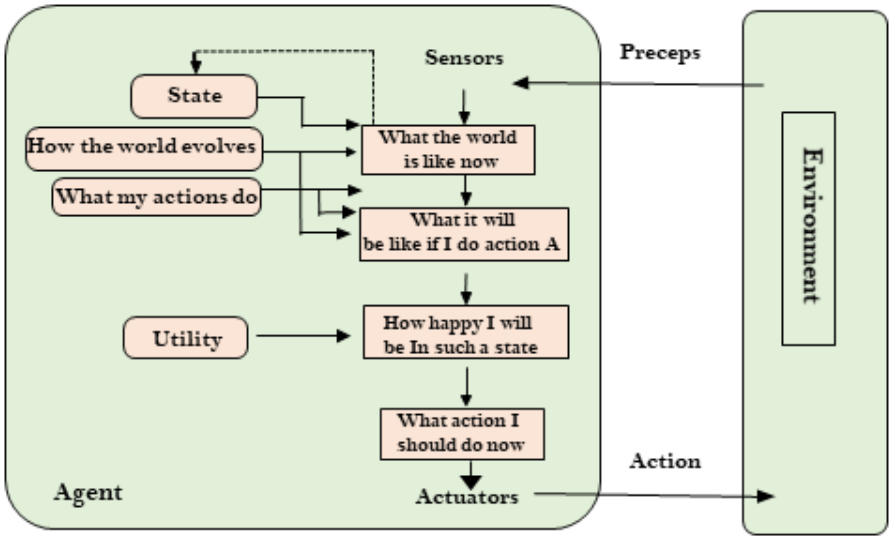


Figure: **Utility Based Reflex Agents**

- A learning agent in AI is the type of agent which can learn from its past experiences, or it has learning capabilities.
- It starts to act with basic knowledge and then able to act and adapt automatically through learning.
- A learning agent has mainly four conceptual components, which are:
  - **Learning element**: It is responsible for making improvements by learning from environment.
  - **Critic**: Learning element takes feedback from critic which describes that how well the agent is doing with respect to a fixed performance standard.
  - **Performance element**: It is responsible for selecting external action.
  - **Problem generator**: This component is responsible for suggesting actions that will lead to new and informative experiences.

  Hence, learning agents are able to learn, analyze performance, and look for new ways to improve the performance.

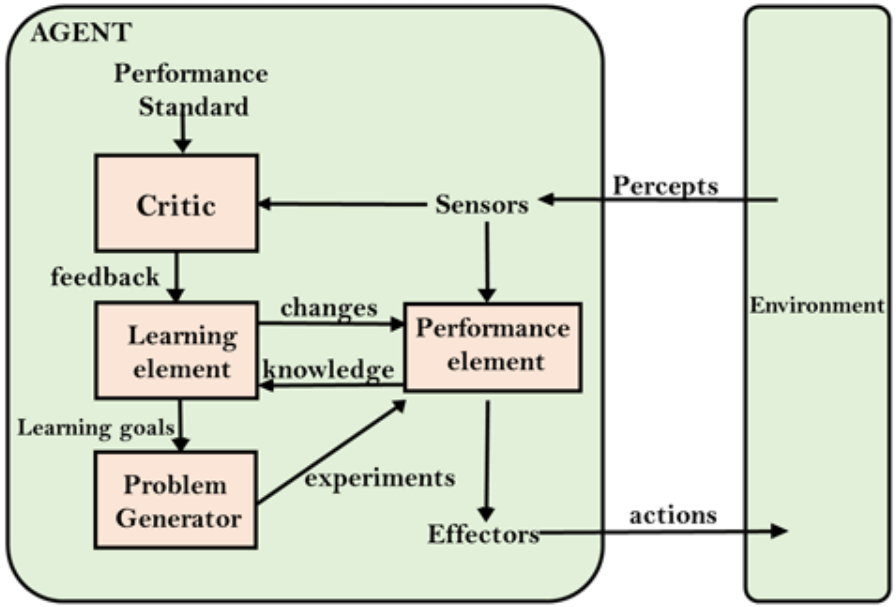


Figure: **Utility Based Reflex Agents**

An environment is everything in the world which surrounds the agent, but it is not a part of an agent itself. An environment can be described as a situation in which an agent is present.

The environment is where agent lives, operate and provide the agent with something to sense and act upon it. An environment is mostly said to be non-feministic.

Features of Environment :

- Fully observable vs Partially Observable
- Static vs Dynamic
- Discrete vs Continuous
- Deterministic vs Stochastic
- Single-agent vs Multi-agent
- Episodic vs sequential
- Known vs Unknown
- Accessible vs Inaccessible

1. **Fully observable vs Partially Observable:**
   - If an agent sensor can sense or access the complete state of an environment at each point of time then it is a fully observable environment, else it is partially observable.
   - A fully observable environment is easy as there is no need to maintain the internal state to keep track history of the world.
   - An agent with no sensors in all environments then such an environment is called as unobservable.
2. **Deterministic vs Stochastic:**
   - If an agent's current state and selected action can completely determine the next state of the environment, then such environment is called a deterministic environment.
   - A stochastic environment is random in nature and cannot be determined completely by an agent.
   - In a deterministic, fully observable environment, agent does not need to worry about uncertainty.

3. Episodic vs Sequential:

- In an episodic environment, there is a series of one-shot actions, and only the current percept is required for the action.
- However, in Sequential environment, an agent requires memory of past actions to determine the next best actions.

4. Static vs Dynamic:

- If the environment can change itself while an agent is deliberating then such environment is called a dynamic environment else it is called a static environment.
- Static environments are easy to deal because an agent does not need to continue looking at the world while deciding for an action.
- However for dynamic environment, agents need to keep looking at the world at each action.
- Taxi driving is an example of a dynamic environment whereas Crossword puzzles are an example of a static environment

5. Single Agent vs Multiple Agent:

- If only one agent is involved in an environment, and operating by itself then such an environment is called single agent environment.
- However, if multiple agents are operating in an environment, then such an environment is called a multi-agent environment.
- The agent design problems in the multi-agent environment are different from single agent environment.

6. Discrete vs Continuous:

- If in an environment there are a finite number of percepts and actions that can be performed within it, then such an environment is called a discrete environment else it is called continuous environment.
- A chess gamecomes under discrete environment as there is a finite number of moves that can be performed.
- A self-driving car is an example of a continuous environment.

7. Known vs UnKnown :

- Known and unknown are not actually a feature of an environment, but it is an agent's state of knowledge to perform an action.
- In a known environment, the results for all actions are known to the agent. While in unknown environment, agent needs to learn how it works in order to perform an action.
- It is quite possible that a known environment to be partially observable and an Unknown environment to be fully observable.

7. Accessible vs Inaccessible:

- If an agent can obtain complete and accurate information about the state's environment, then such an environment is called an Accessible environment else it is called inaccessible.
- An empty room whose state can be defined by its temperature is an example of an accessible environment.
- Information about an event on earth is an example of Inaccessible environment.

PEAS is a type of model on which an AI agent works upon. When we define an AI agent or rational agent, then we can group its properties under PEAS representation model. It is made up of four words:

Agent	**Performance(P) measure**	**Environment (E)**	**Actuators (A)**	**Sensors(S)**
Medical Diagnose	Healthy patient Minimized cost	Patient Hospital Staff	Tests Treatments	Keyboard (Entry of symptoms)
Vacuum Cleaner	Cleanness Efficiency Battery life Security	Room Table Wood floor Carpet Various obstacles	Wheels Brushes Vacuum Extractor	Camera Dirt detection sensor Cliff sensor Bump Sensor Infrared Wall Sensor
Part - picking Robot	Percentage of parts in correct bins.	Conveyor belt with parts, Bins	Jointed Arms Hand	Camera Joint angle sensors.


thank
YOU