Artificial Intelligence-BSCE-306L

Module 1:

Introduction

Dr . Saurabh Agrawal

Faculty Id: 20165

School of Computer Science and Engineering

VIT, Vellore-632014

Tamil Nadu, India

Outline

- Introduction to AI
- Applications of AI
- Evolution of AI
- State of Art
- Different Types of Artificial Intelligence
- Subfields of AI
- Intelligent Agents
- Structure of Intelligent Agents
- AI Environments

Introduction of Artificial Intelligence

Definitions of AI:

1. Thinking Humanly

- "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)*

2. 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)*

Definitions of AI:

3. 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)*

4. 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)*

❑Acting Humanly: The Turing Test approach:

- The Turing Test, 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.
- We note that programming a computer to pass a rigorously applied test provides plenty to work on.
- The computer would need to possess the following capabilities:

I. **Natural Language Processing** to enable it to communicate successfully in English;

II. **Knowledge Representation** to store what it knows or hears;

III. **Automated Reasoning** to use the stored information to answer questions and to draw new conclusions;

IV. **Machine Learning** to adapt to new circumstances and to detect and extrapolate patterns.

❑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:

I. **Through introspection**: trying to catch our own thoughts as they go by;

II. **Through psychological experiments**: observing a person in action;

III. **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 program's mechanisms could also be operating in humans.

❑ 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,** Logicians in the 19th century **developed a precise notation for statements about all kinds of objects in the world and the relations among them**.

❑*By 1965, programs existed* that could, in principle, solve *any solvable problem described in logical notation.*

❑The so-called **logicist tradition within** artificial intelligence hopes to build on such programs to create intelligent systems.

❑ Acting Rationally: The rational agent approach

❑An **agent is just something that acts**.

❑All computer programs do something, but computer agents are expected to do more: operate autonomously, perceive their environment, persist over a prolonged time period, adapt to change, and create and pursue goals.

❑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 on 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 that a given action will achieve one’s goals and then to act on that conclusion.

Introduction of Artificial Intelligence

- **Artificial Intelligence** (AI) refers to the *simulation of human intelligence in machines that are programmed to think and act like humans*.
- It involves the development of algorithms and computer programs that can perform tasks that typically require human intelligence such as visual perception, speech recognition, decision-making, and language translation.
- AI has the potential to revolutionize many industries and has a wide range of applications, from virtual personal assistants to self-driving cars.
- **Intelligence:** The ability to learn and solve problems.
  - Intelligence, as we know, is the ability to acquire and apply knowledge.
  - Knowledge is the information acquired through experience.
  - Experience is the knowledge gained through exposure(training).

Introduction of Artificial Intelligence

❑Intelligence is composed of:

1. **Reasoning:** The process of thinking about something in a logical way in order to form a conclusion or judgment.
2. **Learning:** Knowledge/Experience that you get from studying/working.
3. **Problem-Solving:** Act of defining a problem; determining the cause of the problem; identifying, prioritizing, and selecting alternatives for a solution; and implementing a solution
4. **Perception:** Act of perceiving or the ability to perceive; mental grasp of objects, qualities, etc. by means of the senses; awareness; comprehension.
5. **Linguistic Intelligence:** The ability to think in words and to use language to express and appreciate complex meanings.

Introduction of Artificial Intelligence

- Many tools are used in AI, including versions of search and mathematical optimization, logic, and methods based on probability and economics.
- The AI field draws upon computer science, mathematics, psychology, linguistics, philosophy, neuroscience, artificial psychology, and many others.
- The main focus of artificial intelligence is towards understanding human behavior and performance.
- This can be done by **creating computers with human-like intelligence and capabilities**.
- This includes natural language processing, facial analysis and robotics.
- The main applications of AI are in military, healthcare, and computing; however, it's expected that these applications will start soon and become part of our everyday lives.

Applications of Artificial Intelligence

❑Artificial Intelligence has many practical applications across various industries and domains, including:

1. **Healthcare:** AI is used for medical diagnosis, drug discovery, and predictive analysis of diseases.
2. **Finance:** AI helps in credit scoring, fraud detection, and financial forecasting.
3. **Retail:** AI is used for product recommendations, price optimization, and supply chain management.
4. **Manufacturing:** AI helps in quality control, predictive maintenance, and production optimization.
5. **Transportation:** AI is used for autonomous vehicles, traffic prediction, and route optimization.
6. **Customer service:** AI-powered chatbots are used for customer support, answering frequently asked questions, and handling simple requests.
7. **Security:** AI is used for facial recognition, intrusion detection, and cybersecurity threat analysis.
8. **Marketing:** AI is used for targeted advertising, customer segmentation, and sentiment analysis.
9. **Education:** AI is used for personalized learning, adaptive testing, and intelligent tutoring systems.

Evolution of Artificial Intelligence

❑Birth of AI: 1950-1956

❑This range of time was when the interest in AI really came to a head. Alan Turing published his work "Computer Machinery and Intelligence" which eventually became The Turing Test, which experts used to measure computer intelligence.

❑The term "artificial intelligence" was coined and came into popular use.

❑Dates of note:

- **1950:** Alan Turing published "Computer Machinery and Intelligence" which proposed a test of machine intelligence called The Imitation Game.
- **1952:** A computer scientist named Arthur Samuel developed a program to play checkers, which is the first to ever learn the game independently.
- **1955:** John McCarthy held a workshop at Dartmouth on "artificial intelligence" which is the first use of the word, and how it came into popular usage.

Evolution of Artificial Intelligence

❑AI maturation: 1957-1979

❑The time between when the phrase “artificial intelligence” was created, and the 1980s was a period of both rapid growth and struggle for AI research.

❑The late 1950s through the 1960s was a time of creation.

❑From programming languages that are still in use to this day to books and films that explored the idea of robots, AI became a mainstream idea quickly.

❑The 1970s showed similar improvements, such as the first anthropomorphic robot being built in Japan, to the first example of an autonomous vehicle being built by an engineering grad student.

❑However, it was also a time of struggle for AI research, as the U.S. government showed little interest in continuing to fund AI research.

Evolution of Artificial Intelligence

❑AI maturation: 1957-1979

❑Notable dates include:

- **1958:** John McCarthy created LISP (acronym for List Processing), the first programming language for AI research, which is still in popular use to this day.
- **1959:** Arthur Samuel created the term "machine learning" when doing a speech about teaching machines to play chess better than the humans who programmed them.
- **1961:** The first industrial robot Unimate started working on an assembly line at General Motors in New Jersey, tasked with transporting die casings and welding parts on cars (which was deemed too dangerous for humans).
- **1965:** Edward Feigenbaum and Joshua Lederberg created the first "expert system" which was a form of AI programmed to replicate the thinking and decision-making abilities of human experts.

Evolution of Artificial Intelligence

❑AI maturation: 1957-1979

❑Notable dates include:

- **1966:** Joseph Weizenbaum created the first "chatterbot" (later shortened to chatbot), ELIZA, a mock psychotherapist, that used natural language processing (NLP) to converse with humans.1968: Soviet mathematician Alexey Ivakhnenko published "Group Method of Data Handling" in the journal "Avtomatika," which proposed a new approach to AI that would later become what we now know as "Deep Learning."
- **1973:** An applied mathematician named James Lighthill gave a report to the British Science Council, underlining that strides were not as impressive as those that had been promised by scientists, which led to much-reduced support and funding for AI research from the British government.
- **1979:** James L. Adams created The Standford Cart in 1961, which became one of the first examples of an autonomous vehicle. In '79, it successfully navigated a room full of chairs without human interference.
- **1979:** The American Association of Artificial Intelligence which is now known as the Association for the Advancement of Artificial Intelligence (AAAI) was founded.

Evolution of Artificial Intelligence

❑AI boom: 1980-1987

❑Most of the 1980s showed a period of rapid growth and interest in AI, now labeled as the “AI boom.”

❑This came from both breakthroughs in research, and additional government funding to support the researchers.

❑Deep Learning techniques and the use of Expert System became more popular, both of which allowed computers to learn from their mistakes and make independent decisions.

❑Notable dates in this time period include:

- **1980:** First conference of the AAAI was held at Stanford.
- **1980:** The first expert system came into the commercial market, known as XCON (expert configurer). It was designed to assist in the ordering of computer systems by automatically picking components based on the customer’s needs.

Evolution of Artificial Intelligence

❑AI boom: 1980-1987

❑Notable dates in this time period include:

- **1981:** The Japanese government allocated $850 million (over $2 billion dollars in today's money) to the Fifth Generation Computer project. Their aim was to create computers that could translate, converse in human language, and express reasoning on a human level.
- **1984:** The AAAI warns of an incoming "AI Winter" where funding and interest would decrease, and make research significantly more difficult.
- **1985:** An autonomous drawing program known as AARON is demonstrated at the AAAI conference.
- **1986:** Ernst Dickmann and his team at Bundeswehr University of Munich created and demonstrated the first driverless car (or robot car). It could drive up to 55 mph on roads that didn't have other obstacles or human drivers.
- **1987:** Commercial launch of Alacrity by Alactrious Inc. Alacrity was the first strategy managerial advisory system, and used a complex expert system with 3,000+ rules.

Evolution of Artificial Intelligence

❑AI winter: 1987-1993

❑As the AAAI warned, an AI Winter came, the term describes a period of low consumer, public, and private interest in AI which leads to decreased research funding, which, in turn, leads to few breakthroughs.

❑Both private investors and the government lost interest in AI and halted their funding due to high cost versus seemingly low return.

❑This AI Winter came about because of some setbacks in the machine market and expert systems, including the end of the Fifth Generation project, cutbacks in strategic computing initiatives, and a slowdown in the deployment of expert systems.

❑Notable dates include:

- **1987:** The market for specialized LISP-based hardware collapsed due to cheaper and more accessible competitors that could run LISP software, including those offered by IBM and Apple.
- **1988:** A computer programmer named Rollo Carpenter invented the chatbot Jabberwacky, which he programmed to provide interesting and entertaining conversation to humans.

Evolution of Artificial Intelligence

❑AI agents: 1993-2011

❑Despite the lack of funding during the AI Winter, the early 90s showed some impressive strides forward in AI research, including the introduction of the first AI system that could beat a reigning world champion chess player.

❑This era also introduced AI into everyday life via innovations such as the first Roomba and the first commercially-available speech recognition software on Windows computers.

❑The surge in interest was followed by a surge in funding for research, which allowed even more progress to be made.

❑Notable dates include:

- **1997:** Deep Blue (developed by IBM) beat the world chess champion, Gary Kasparov, in a highly-publicized match, becoming the first program to beat a human chess champion.
- **1997:** Windows released a speech recognition software (developed by Dragon Systems).

Evolution of Artificial Intelligence

❑AI agents: 1993-2011

❑Notable dates include:

- **2000:** Professor Cynthia Breazeal developed the first robot that could simulate human emotions with its face,which included eyes, eyebrows, ears, and a mouth. It was called Kismet.
- **2002:** The first Roomba was released.
- **2003:** Nasa landed two rovers onto Mars (Spirit and Opportunity) and they navigated the surface of the planet without human intervention.
- **2006:** Companies such as Twitter, Facebook, and Netflix started utilizing AI as a part of their advertising and user experience (UX) algorithms.
- **2010:** Microsoft launched the Xbox 360 Kinect, the first gaming hardware designed to track body movement and translate it into gaming directions.
- **2011:** An NLP computer programmed to answer questions named Watson (created by IBM) won Jeopardy against two former champions in a televised game.
- **2011:** Apple released Siri, the first popular virtual assistant.

Evolution of Artificial Intelligence

❑Artificial General Intelligence: 2012-present

❑That brings us to the most recent developments in AI, up to the present day.

❑We've seen a surge in common-use AI tools, such as virtual assistants, search engines, etc.

❑This time period also popularized Deep Learning and Big Data..

Notable dates include:

- **2012:** Two researchers from Google (Jeff Dean and Andrew Ng) trained a neural network to recognize cats by showing it unlabeled images and no background information.
- **2015:** Elon Musk, Stephen Hawking, and Steve Wozniak (and over 3,000 others) signed an open letter to the worlds' government systems banning the development of (and later, use of) autonomous weapons for purposes of war.
- **2016:** Hanson Robotics created a humanoid robot named Sophia, who became known as the first "robot citizen" and was the first robot created with a realistic human appearance and the ability to see and replicate emotions, as well as to communicate.

Evolution of Artificial Intelligence

❑Artificial General Intelligence: 2012-present

❑Notable dates include:

- **2017:** Facebook programmed two AI chatbots to converse and learn how to negotiate, but as they went back and forth they ended up forgoing English and developing their own language, completely autonomously.
- **2018:** A Chinese tech group called Alibaba's language-processing AI beat human intellect on a Stanford reading and comprehension test.
- **2019:** Google's AlphaStar reached Grandmaster on the video game StarCraft 2, outperforming all but .2% of human players.
- **2020:** OpenAI started beta testing GPT-3, a model that uses Deep Learning to create code, poetry, and other such language and writing tasks. While not the first of its kind, it is the first that creates content almost indistinguishable from those created by humans.
- **2021:** OpenAI developed DALL-E, which can process and understand images enough to produce accurate captions, moving AI one step closer to understanding the visual world.

State of Art

❑Following are few the State of Arts of Artificial Intelligence

❑**Robotic vehicles:** A driverless robotic car named STANLEY sped through the rough terrain of the Mojave dessert at 22 mph, finishing the 132-mile course first to win the 2005 DARPA Grand Challenge. STANLEY is a Volkswagen Touareg outfitted with cameras, radar, and laser rangefinders to sense the environment and onboard software to command the steering, braking, and acceleration.

❑**Speech recognition:** A traveler calling United Airlines to book a flight can have the entire conversation guided by an automated speech recognition and dialog management system.

❑**Autonomous planning and scheduling:** A hundred million miles from Earth, NASA's Remote Agent program became the first on-board autonomous planning program to control the scheduling of operations for a spacecraft. *REMOTE AGENT generated* plans from high-level goals specified from the ground and monitored the execution of those plans—detecting, diagnosing, and recovering from problems as they occurred.

State of Art

❑Following are few the State of Arts of Artificial Intelligence

❑**Game playing:** IBM's DEEP BLUE became the first computer program to defeat the world champion in a chess match when it bested Garry Kasparov by a score of 3.5 to 2.5 in an exhibition match. Kasparov said that he felt a "new kind of intelligence" across the board from him.

❑**Spam fighting:** Each day, learning algorithms classify over a billion messages as spam, saving the recipient from having to waste time deleting what, for many users, could comprise 80% or 90% of all messages, if not classified away by algorithms.

❑**Logistics planning:** During the Persian Gulf crisis of 1991, U.S. forces deployed a Dynamic Analysis and Replanning Tool, DART, to do automated logistics planning and scheduling for transportation. This involved up to 50,000 vehicles, cargo, and people at a time, and had to account for starting points, destinations, routes, and conflict resolution among all parameters. The AI planning techniques generated in hours a plan that would have taken weeks with older methods. The Defense Advanced Research Project Agency (DARPA) stated that this single application more than paid back DARPA's 30-year investment in AI.

State of Art

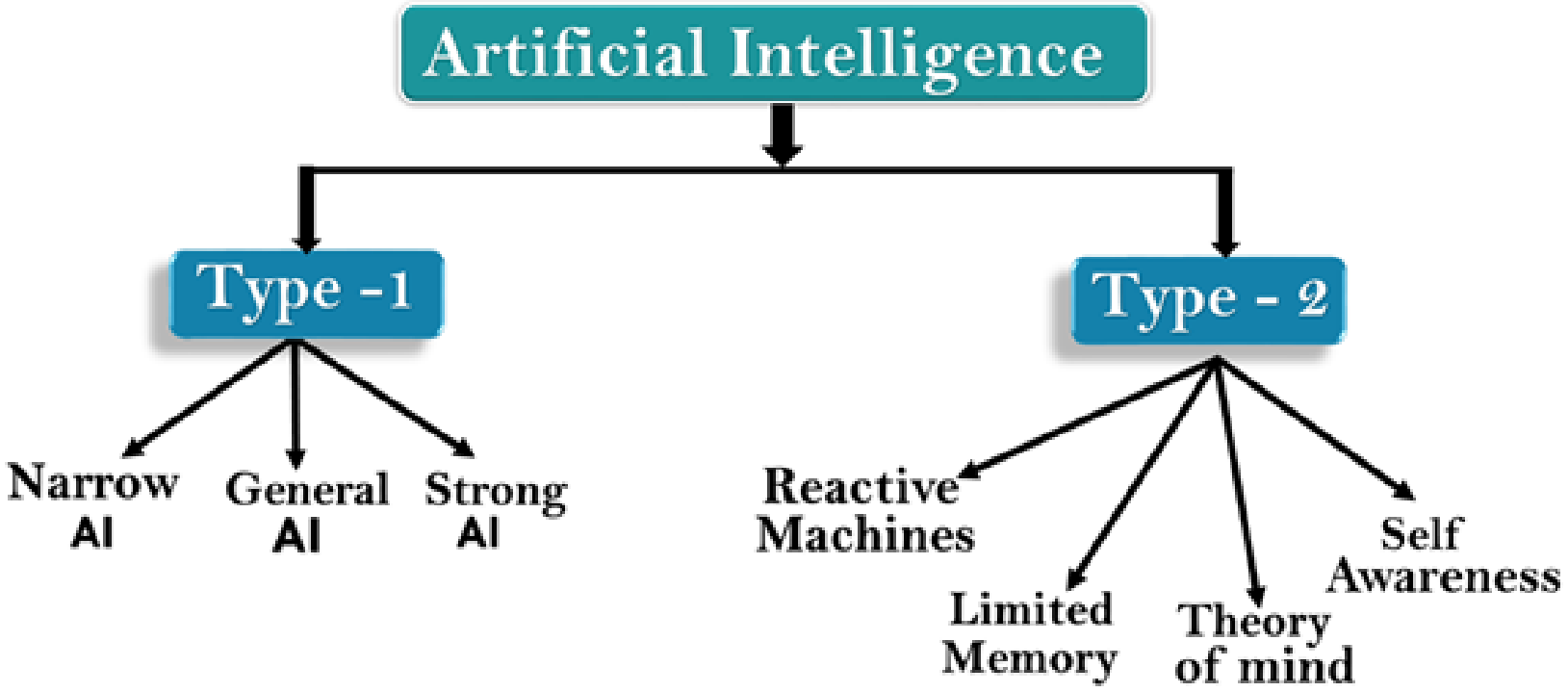
❑**Following are few the State of Arts of Artificial Intelligence**

❑**Robotics:** The iRobot Corporation has sold over two million Roomba robotic vacuum cleaners for home use. The company also deploys the more rugged PackBot to Iraq and Afghanistan, where it is used to handle hazardous materials, clear explosives, and identify the location of snipers.

❑**Machine Translation:** A computer program automatically translates from Arabic to English, allowing an English speaker to see the headline “Ardogan Confirms That Turkey Would Not Accept Any Pressure, Urging Them to Recognize Cyprus.” The program uses a statistical model built from examples of Arabic-to-English translations and from examples of English text totaling two trillion words. *None of the computer scientists* on the team speak Arabic, but they do understand statistics and machine learning algorithms.

Types of Artificial Intelligence

- Artificial Intelligence can be divided in various types, there are mainly two types of main categorization which are **based on capabilities (Type-1)** and **based on functionally (Type-2)** of AI.
- Following is flow diagram which explain the types of AI.



Types of Artificial Intelligence

❑Type-1: Based on Capabilities

A. Weak AI or Narrow AI:

I. Narrow AI is a type of AI which is able to perform a dedicated task with intelligence.

II. Narrow AI cannot perform beyond its field or limitations, as it is only trained for one specific task, hence it is also termed as weak AI.

III. Apple Siriis a good example of Narrow AI, but it operates with a limited pre-defined range of functions.

IV. IBM's Watson supercomputer also comes under Narrow AI, as it uses an Expert system approach combined with Machine learning and natural language processing.

V. Some Examples of Narrow AI are playing chess, purchasing suggestions on e-commerce site, self-driving cars, speech recognition, and image recognition.

Types of Artificial Intelligence

❑Type-1: Based on Capabilities

B. General AI:

I. General AI is a type of intelligence which could perform any intellectual task with efficiency like a human.

II. The idea behind the general AI to make such a system which could be smarter and think like a human by its own.

III. Currently, there is no such system exist which could come under general AI and can perform any task as perfect as a human.

IV. The worldwide researchers are now focused on developing machines with General AI.

Types of Artificial Intelligence

❑Type-1: Based on Capabilities

C. Super AI:

I. Super AI is a level of Intelligence of Systems at which machines could surpass human intelligence, and can perform any task better than human with cognitive properties.

II. It is an outcome of general AI.

III. Some key characteristics of strong AI include capability include the ability to think, to reason,solve the puzzle, make judgments, plan, learn, and communicate by its own.

IV. Super AI is still a hypothetical concept of Artificial Intelligence.

V. Development of such systems in real is still world changing task.

Types of Artificial Intelligence

❑Type-2: Based on Functionality

A. Reactive Machines

I. Purely reactive machines are the most basic types of Artificial Intelligence.

II. Such AI systems do not store memories or past experiences for future actions.

III. These machines only focus on current scenarios and react on it as per possible best action.

IV. IBM's Deep Blue system is an example of reactive machines.

V. Google's AlphaGo is also an example of reactive machines.

Types of Artificial Intelligence

❑Type-2: Based on Functionality

B. Limited Memory

I. Limited memory machines can store past experiences or some data for a short period of time.

II. These machines can use stored data for a limited time period only.

III. Self-driving cars are one of the best examples of Limited Memory systems.

IV. These cars can store recent speed of nearby cars, the distance of other cars, speed limit, and other information to navigate the road.

Types of Artificial Intelligence

❑Type-2: Based on Functionality

C. Theory of Mind

I. Theory of Mind AI should understand the human emotions, people, beliefs, and be able to interact socially like humans.

II. This type of AI machines are still not developed, but researchers are making lots of efforts and improvement for developing such AI machines.

Types of Artificial Intelligence

❑Type-2: Based on Functionality

D. Self-Awareness

I. 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.

II. These machines will be smarter than human mind.

III. Self-Awareness AI does not exist in reality still and it is a hypothetical concept.

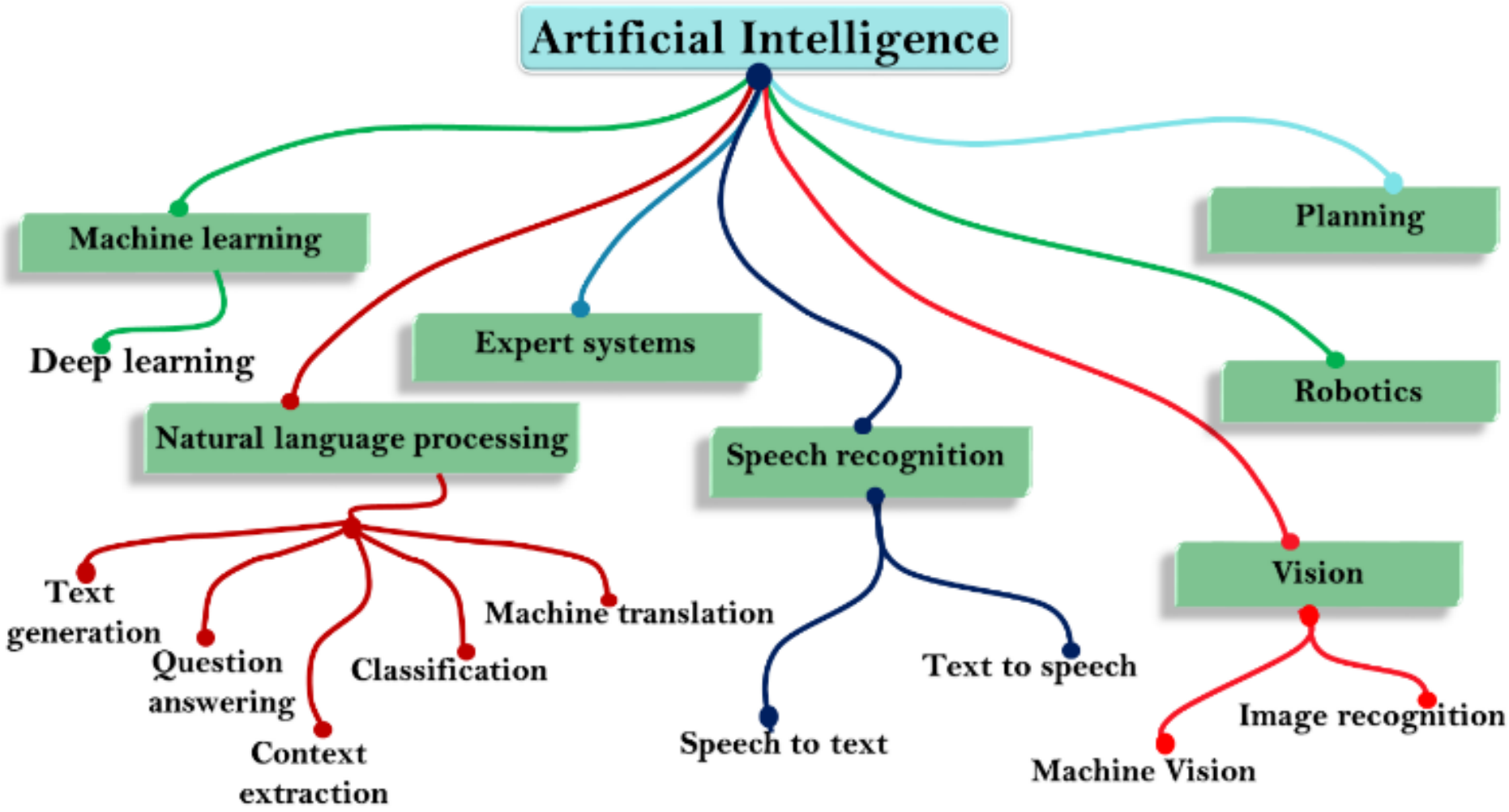
Subfields of Artificial Intelligence

❑Following are the most common subsets of AI

1. Machine Learning
2. Deep Learning
3. Natural Language processing
4. Expert System
5. Robotics
6. Machine Vision
7. Speech Recognition

Subfields of Artificial Intelligence

- Following are the most common subsets of AI



Subfields of Artificial Intelligence

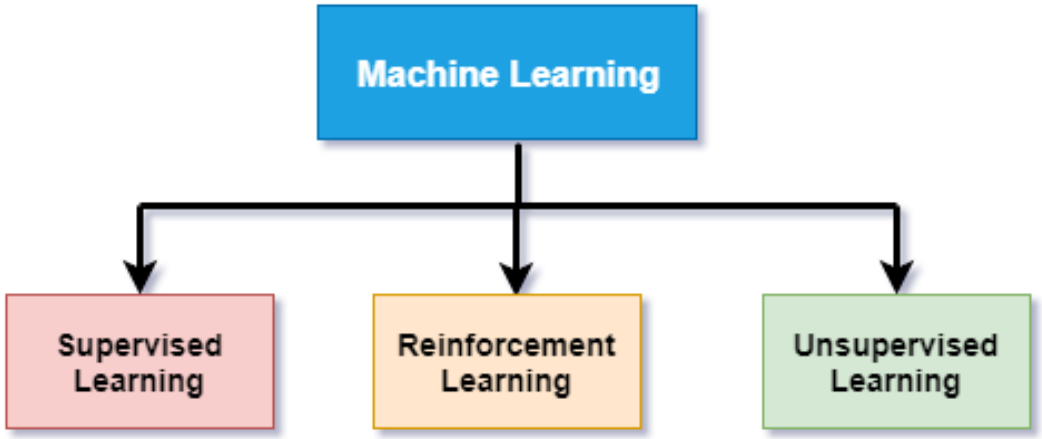
1. Machine Learning:

❑Machine learning is a part of AI which provides intelligence to machines with the ability to automatically learn with experiences without being explicitly programmed.

❑It is primarily concerned with the design and development of algorithms that allow the system to learn from historical data.

❑Machine Learning is based on the idea that machines can learn from past data, identify patterns, and make decisions using algorithms.

❑Machine learning algorithms are designed in such a way that they can learn and improve their performance automatically.



Subfields of Artificial Intelligence

2. Deep Learning

- Deep learning is a subset of machine learning which provides the ability to machine to perform human-like tasks without human involvement.
- It provides the ability to an AI agent to mimic the human brain.
- Deep learning can use both supervised and unsupervised learning to train an AI agent.
- Deep learning is implemented through neural networks architecture hence also called a deep neural network.
- Deep learning is the primary technology behind self-driving cars, speech recognition, image recognition, automatic machine translation, etc.
- The main challenge for deep learning is that it requires lots of data with lots of computational power.

Subfields of Artificial Intelligence

3. Natural Language processing

- Natural language processing is a subfield of computer science and artificial intelligence.
- NLP enables a computer system to understand and process human language such as English.
- NLP plays an important role in AI as without NLP, AI agent cannot work on human instructions, but with the help of NLP, we can instruct an AI system on our language.
- Today we are all around AI, and as well as NLP, we can easily ask Siri, Google or Cortana to help us in our language.
- Natural language processing application enables a user to communicate with the system in their own words directly.

4. Expert System

- An expert system is an application of artificial intelligence.
- In artificial intelligence, expert systems are the computer programs that rely on obtaining the knowledge of human experts and programming that knowledge into a system.
- Expert systems emulate the decision-making ability of human experts.
- These systems are designed to solve the complex problem through bodies of knowledge rather than conventional procedural code.
- One of the examples of an expert system is a Suggestion for the spelling error while typing in the Google search box.
- Following are some characteristics of expert systems:
  - High performance
  - Reliable
  - Highly responsive
  - Understandable

Subfields of Artificial Intelligence

5. Robotics

- Robotics is a branch of artificial intelligence and engineering which is used for designing and manufacturing of robots.
- Robots are the programmed machines which can perform a series of actions automatically or semi-automatically.
- AI can be applied to robots to make intelligent robots which can perform the task with their intelligence.
- AI algorithms are necessary to allow a robot to perform more complex tasks.
- Nowadays, AI and machine learning are being applied on robots to manufacture intelligent robots which can also interact socially like humans.
- One of the best examples of AI in robotics is Sophia robot.

6. Machine Vision

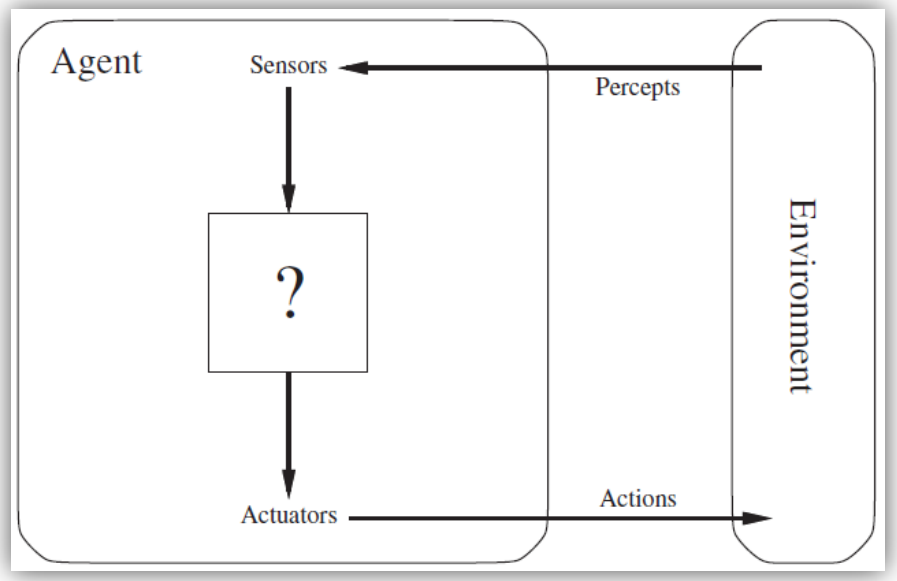
- Machine vision is an application of computer vision which enables a machine to recognize the object.
- Machine vision captures and analyses visual information using one or more video cameras, analog-to-digital conversations, and digital signal processing.
- Machine vision systems are programmed to perform narrowly defined tasks such as counting objects, reading the serial number, etc.
- Computer systems do not see in the same way as human eyes can see, but it is also not bounded by human limitations such as to see through the wall.
- With the help of machine learning and machine vision, an AI agent can be able to see through walls.

7. Speech Recognition

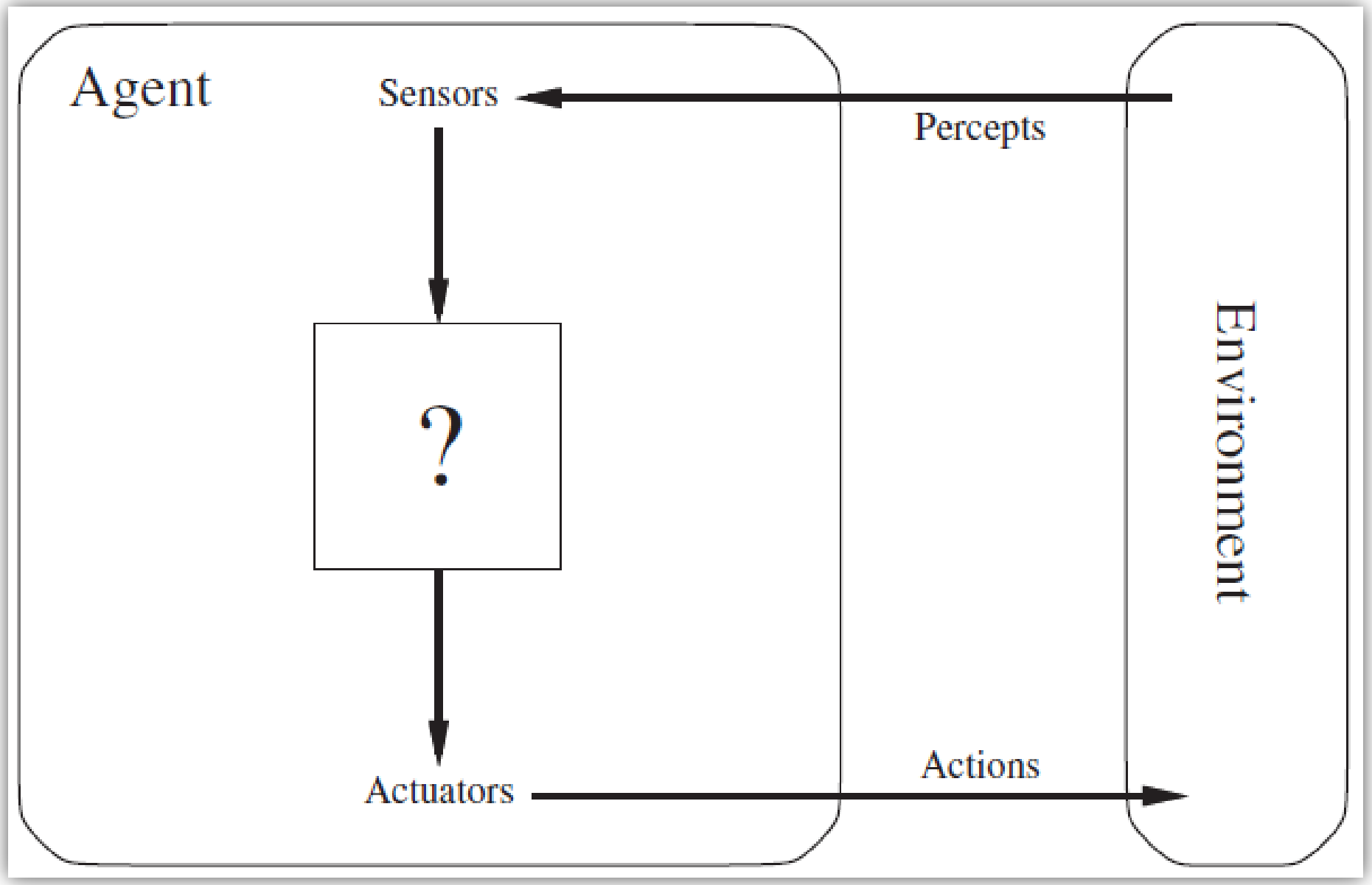
- Speech recognition is a technology which enables a machine to understand the spoken language and translate into a machine-readable format.
- It can also be said as automatic Speech recognition and computer speech recognition.
- It is a way to talk with a computer, and on the basis of that command, a computer can perform a specific task.

Intelligent Agents

- In artificial intelligence, an agent is a computer program or system that is designed to perceive its environment, make decisions and take actions to achieve a specific goal or set of goals.
- The agent operates autonomously, meaning it is not directly controlled by a human operator.
- Agents can be classified into different types based on their characteristics, such as whether they are reactive or proactive, whether they have a fixed or dynamic environment, and whether they are single or multi-agent systems.



Intelligent Agents



Intelligent Agents

- Reactive agents are those that respond to immediate stimuli from their environment and take actions based on those stimuli.
- Proactive agents, take initiative and plan ahead to achieve their goals. The environment in which an agent operates can also be fixed or dynamic, fixed environments have a static set of rules that do not change, while dynamic environments are constantly changing and require agents to adapt to new situations.
- Multi-agent systems involve multiple agents working together to achieve a common goal, these agents may have to coordinate their actions and communicate with each other to achieve their objectives.
- Agents are used in a variety of applications, including robotics, gaming, and intelligent systems.
- They can be implemented using different programming languages and techniques, including machine learning and natural language processing.

Intelligent Agents

- Artificial intelligence is defined as the study of **rational agents**.
- A rational agent could be anything that makes decisions, such as a person, firm, machine, or software.
- It carries out an action with the best outcome after considering past and current percepts(agent's perceptual inputs at a given instance).
- An AI system is composed of an **agent and its environment**.
- The agents act in their environment.
- The environment may contain other agents.

AI Environment for Intelligent Agents (PEAS)

- **PEAS** stands for a **P**erformance Measure, **E**nvironment, **A**ctuator, **S**ensor.
- **Rational Agent:** The rational agent considers all possibilities and chooses to perform a highly efficient action.
- For example, it chooses the shortest path with low cost for high efficiency.

Agent Type	Performance Measure	Environment	Actuators	Sensors
Taxi driver	Safe, fast, legal, comfortable trip, maximize profits	Roads, other traffic, pedestrians, customers	Steering, accelerator, brake, signal, horn, display	Cameras, sonar, speedometer, GPS, odometer, accelerometer, engine sensors, keyboard

PEAS description of the task environment for an automated taxi

AI Environment for Intelligent Agents (PEAS)

❑**Performance Measure:** Performance measure is the unit to define the success of an agent. Performance varies with agents based on their different precepts.

❑**Environment:** Environment is the surrounding of an agent at every instant. It keeps changing with time if the agent is set in motion. There are 5 major types of environments:

- Fully Observable & Partially Observable
- Episodic & Sequential
- Static & Dynamic
- Discrete & Continuous
- Deterministic & Stochastic

❑**Actuator:** An actuator is a part of the agent that delivers the output of action to the environment.

❑**Sensor:** Sensors are the receptive parts of an agent that takes in the input for the agent.

AI Environment for Intelligent Agents (PEAS)

Agent Type	Performance Measure	Environment	Actuators	Sensors
Medical diagnosis system	Healthy patient, reduced costs	Patient, hospital, staff	Display of questions, tests, diagnoses, treatments, referrals	Keyboard entry of symptoms, findings, patient's answers
Satellite image analysis system	Correct image categorization	Downlink from orbiting satellite	Display of scene categorization	Color pixel arrays
Part-picking robot	Percentage of parts in correct bins	Conveyor belt with parts; bins	Jointed arm and hand	Camera, joint angle sensors
Refinery controller	Purity, yield, safety	Refinery, operators	Valves, pumps, heaters, displays	Temperature, pressure, chemical sensors
Interactive English tutor	Student's score on test	Set of students, testing agency	Display of exercises, suggestions, corrections	Keyboard entry

AI Environment for Intelligent Agents (Types of Environment)

- An environment in artificial intelligence is the surrounding of the agent.
- The agent takes input from the environment through sensors and delivers the output to the environment through actuators.
- There are several types of environments:
  - Fully Observable vs Partially Observable
  - Deterministic vs Stochastic
  - Competitive vs Collaborative
  - Single-agent vs Multi-agent
  - Static vs Dynamic
  - Discrete vs Continuous
  - Episodic vs Sequential
  - Known vs Unknown

AI Environment for Intelligent Agents (Types of Environment)

❑ Fully Observable vs Partially Observable

- When an agent sensor is capable to sense or access the complete state of an agent at each point in time, it is said to be a fully observable environment else it is partially observable.
- Maintaining a fully observable environment is easy as there is no need to keep track of the history of the surrounding.
- An environment is called **unobservable** when the agent has no sensors in all environments.
- **Examples:**

1. **Chess –** the board is fully observable, and so are the opponent's moves.
2. **Driving –** the environment is partially observable because what's around the corner is not known.

AI Environment for Intelligent Agents (Types of Environment)

❑ Deterministic vs Stochastic

- When a uniqueness in the agent's current state completely determines the next state of the agent, the environment is said to be deterministic.
- The stochastic environment is random in nature which is not unique and cannot be completely determined by the agent.
- **Examples:**

1. **Chess –** there would be only a few possible moves for a coin at the current state and these moves can be determined.
2. **Self-Driving Cars-** the actions of a self-driving car are not unique, it varies time to time.

AI Environment for Intelligent Agents (Types of Environment)

❑ Competitive vs Collaborative

- An agent is said to be in a competitive environment when it competes against another agent to optimize the output.
- The game of chess is competitive as the agents compete with each other to win the game which is the output.
- An agent is said to be in a collaborative environment when multiple agents cooperate to produce the desired output.
- When multiple self-driving cars are found on the roads, they cooperate with each other to avoid collisions and reach their destination which is the output desired.

AI Environment for Intelligent Agents (Types of Environment)

❑ Single-agent vs Multi-agent

- An environment consisting of only one agent is said to be a single-agent environment.
- A person left alone in a maze is an example of the single-agent system.
- An environment involving more than one agent is a multi-agent environment.
- The game of football is multi-agent as it involves 11 players in each team.

AI Environment for Intelligent Agents (Types of Environment)

❑ Dynamic vs Static

- An environment that keeps constantly changing itself when the agent is up with some action is said to be dynamic.
- A roller coaster ride is dynamic as it is set in motion and the environment keeps changing every instant.
- An idle environment with no change in its state is called a static environment.
- An empty house is static as there's no change in the surroundings when an agent enters.

AI Environment for Intelligent Agents (Types of Environment)

❑ Discrete vs Continuous

- If an environment consists of a finite number of actions that can be deliberated in the environment to obtain the output, it is said to be a discrete environment.
- The game of chess is discrete as it has only a finite number of moves. The number of moves might vary with every game, but still, it's finite.
- The environment in which the actions are performed cannot be numbered i.e. is not discrete, is said to be continuous.
- Self-driving cars are an example of continuous environments as their actions are driving, parking, etc. which cannot be numbered.

AI Environment for Intelligent Agents (Types of Environment)

❑ Episodic vs Sequential

- In **an Episodic task environment**, each of the agent's actions is divided into atomic incidents or episodes. There is no dependency between current and previous incidents. In each incident, an agent receives input from the environment and then performs the corresponding action.
- **Example:** Consider an example of **Pick and Place robot**, which is used to detect defective parts from the conveyor belts. Here, every time robot(agent) will make the decision on the current part i.e. there is no dependency between current and previous decisions.
- In a **Sequential environment**, the previous decisions can affect all future decisions. The next action of the agent depends on what action he has taken previously and what action he is supposed to take in the future.
- **Example: Checkers-** Where the previous move can affect all the following moves.

AI Environment for Intelligent Agents (Types of Environment)

❑ Known vs Unknown

- In a known environment, the output for all probable actions is given.
- Obviously, in case of unknown environment, for an agent to make a decision, it has to gain knowledge about how the environment works.

AI Environment for Intelligent Agents (Types of Environment)

Task Environment	Observable	Agents	Deterministic	Episodic	Static	Discrete
Crossword puzzle	Fully	Single	Deterministic	Sequential	Static	Discrete
Chess with a clock	Fully	Multi	Deterministic	Sequential	Semi	Discrete
Poker	Partially	Multi	Stochastic	Sequential	Static	Discrete
Backgammon	Fully	Multi	Stochastic	Sequential	Static	Discrete
Taxi driving	Partially	Multi	Stochastic	Sequential	Dynamic	Continuous
Medical diagnosis	Partially	Single	Stochastic	Sequential	Dynamic	Continuous
Image analysis	Fully	Single	Deterministic	Episodic	Semi	Continuous
Part-picking robot	Partially	Single	Stochastic	Episodic	Dynamic	Continuous
Refinery controller	Partially	Single	Stochastic	Sequential	Dynamic	Continuous
Interactive English tutor	Partially	Multi	Stochastic	Sequential	Dynamic	Discrete

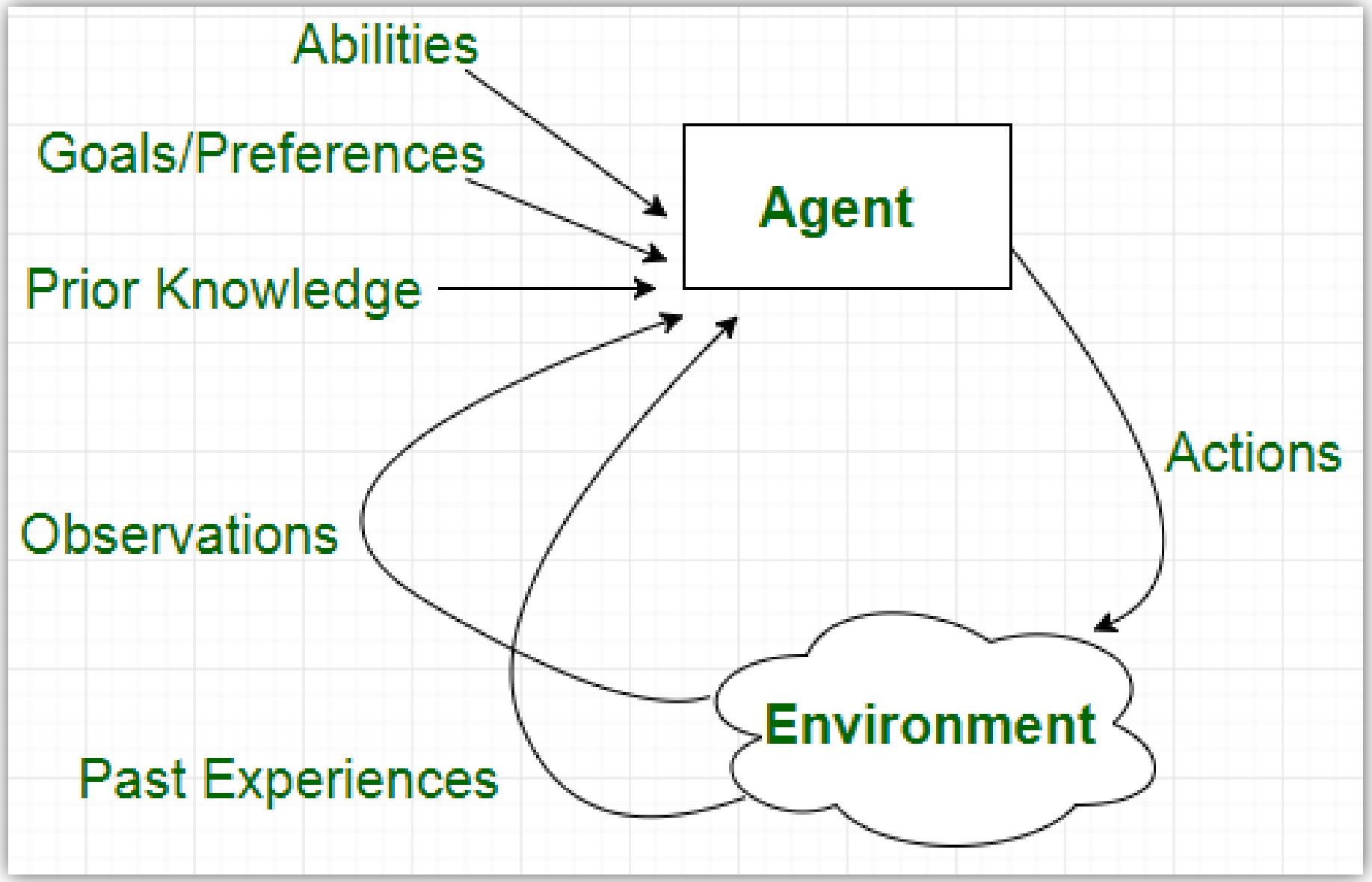
Examples of task environments and their characteristics

Structure of Intelligent Agents

- To understand the **structure of Intelligent Agents**, we should be familiar with Architecture and Agent programs.
- **Architecture** is the machinery that the agent executes on, it is a device with sensors and actuators, for example, a robotic car, a camera, and a PC.
- **Agent Program** is an implementation of an agent function.
- **Agent Function** is a map from the percept sequence(history of all that an agent has perceived to date) to an action.

Agent* = *Architecture + Agent Program

Structure of Intelligent Agents



Structure of Intelligent Agents

❑There are many examples of agents in artificial intelligence, following are few of them:

- **Intelligent personal assistants:** These are agents that are designed to help users with various tasks, such as scheduling appointments, sending messages, and setting reminders. Examples: Siri, Alexa, and Google Assistant.
- **Autonomous robots:** These are agents that are designed to operate autonomously in the physical world. They can perform tasks such as cleaning, sorting, and delivering goods. Examples: Roomba vacuum cleaner and the Amazon delivery robot.
- **Gaming agents:** These are agents that are designed to play games, either against human opponents or other agents. Examples: Chess-playing agents and Poker-playing agents.
- **Fraud detection agents:** These are agents that are designed to detect fraudulent behavior in financial transactions. They can analyze patterns of behavior to identify suspicious activity and alert authorities. Examples of fraud detection agents include those used by banks and credit card companies.

Structure of Intelligent Agents

- **Traffic management agents:** These are agents that are designed to manage traffic flow in cities. They can monitor traffic patterns, adjust traffic lights, and reroute vehicles to minimize congestion. Examples of traffic management agents include those used in smart cities around the world.
- **Software agent** has Keystrokes, file contents, received network packages that act as sensors and displays on the screen, files, and sent network packets acting as actuators.
- **Human-agent** has eyes, ears, and other organs which act as sensors, and hands, legs, mouth, and other body parts act as actuators.
- **Robotic agent** has Cameras and infrared range finders which act as sensors and various motors act as actuators.

Structure of Intelligent Agents (Types of Agents)

- Agents can be grouped into five classes based on their degree of perceived intelligence and capability.
- All these agents can improve their performance and generate better action over the time.
- These are given below:

1. **Simple Reflex Agent**
2. **Model-based reflex agent**
3. **Goal-based agents**
4. **Utility-based agent**
5. **Learning agent**

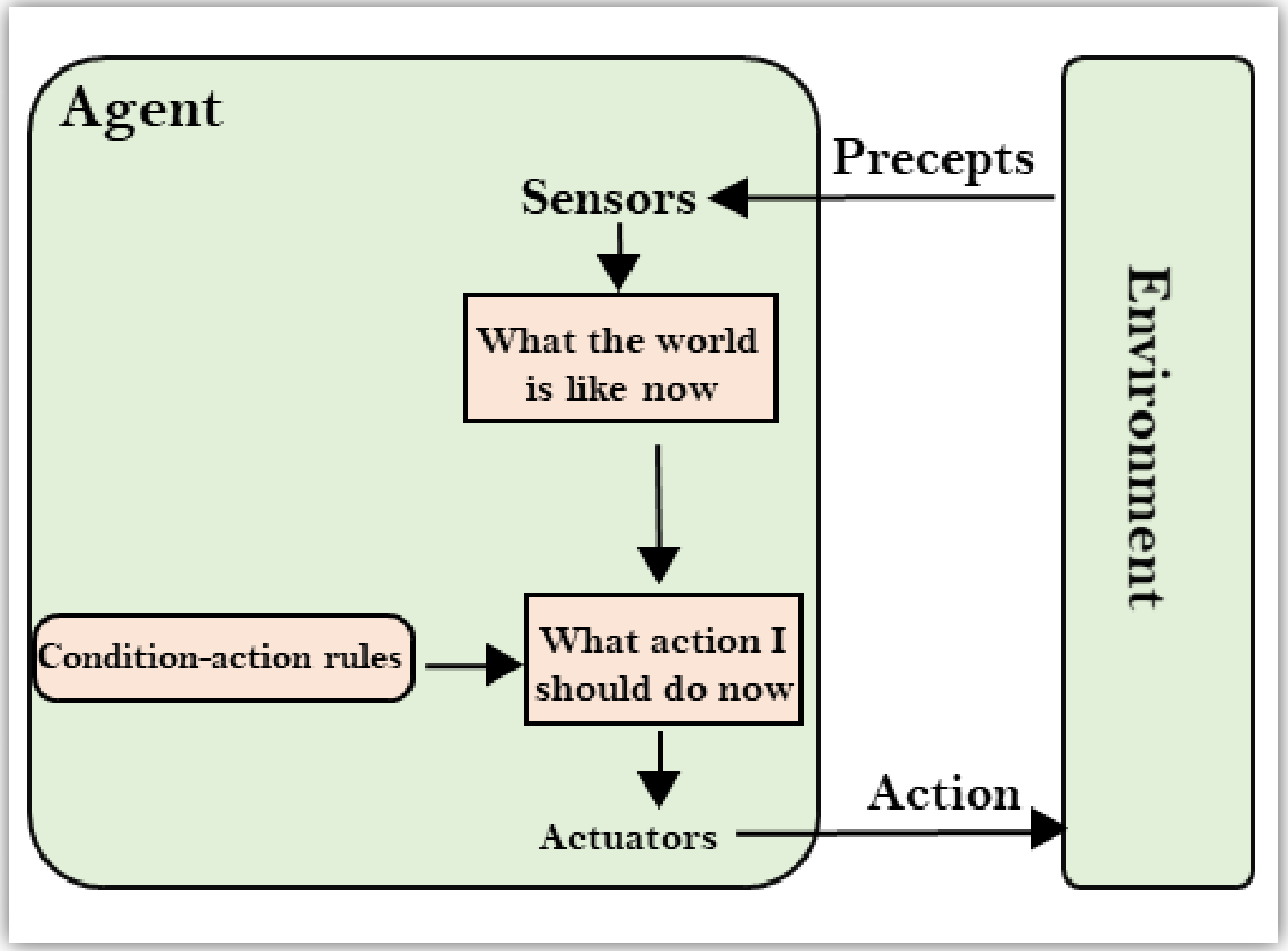
Structure of Intelligent Agents (Types of Agents)

❑Simple Reflex Agent:

- The Simple reflex agents are the simplest agents. These agents take decisions on the basis of the current percepts and ignore the rest of the percept history.
- These agents only succeed in the fully observable environment.
- The Simple reflex agent does not consider any part of percepts history during their decision and action process.
- The Simple reflex agent works on Condition-action rule, which means it maps the current state to action. Such as a Room Cleaner agent, it works only if there is dirt in the room.
- 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.

Structure of Intelligent Agents (Types of Agents)

❑Simple Reflex Agent:



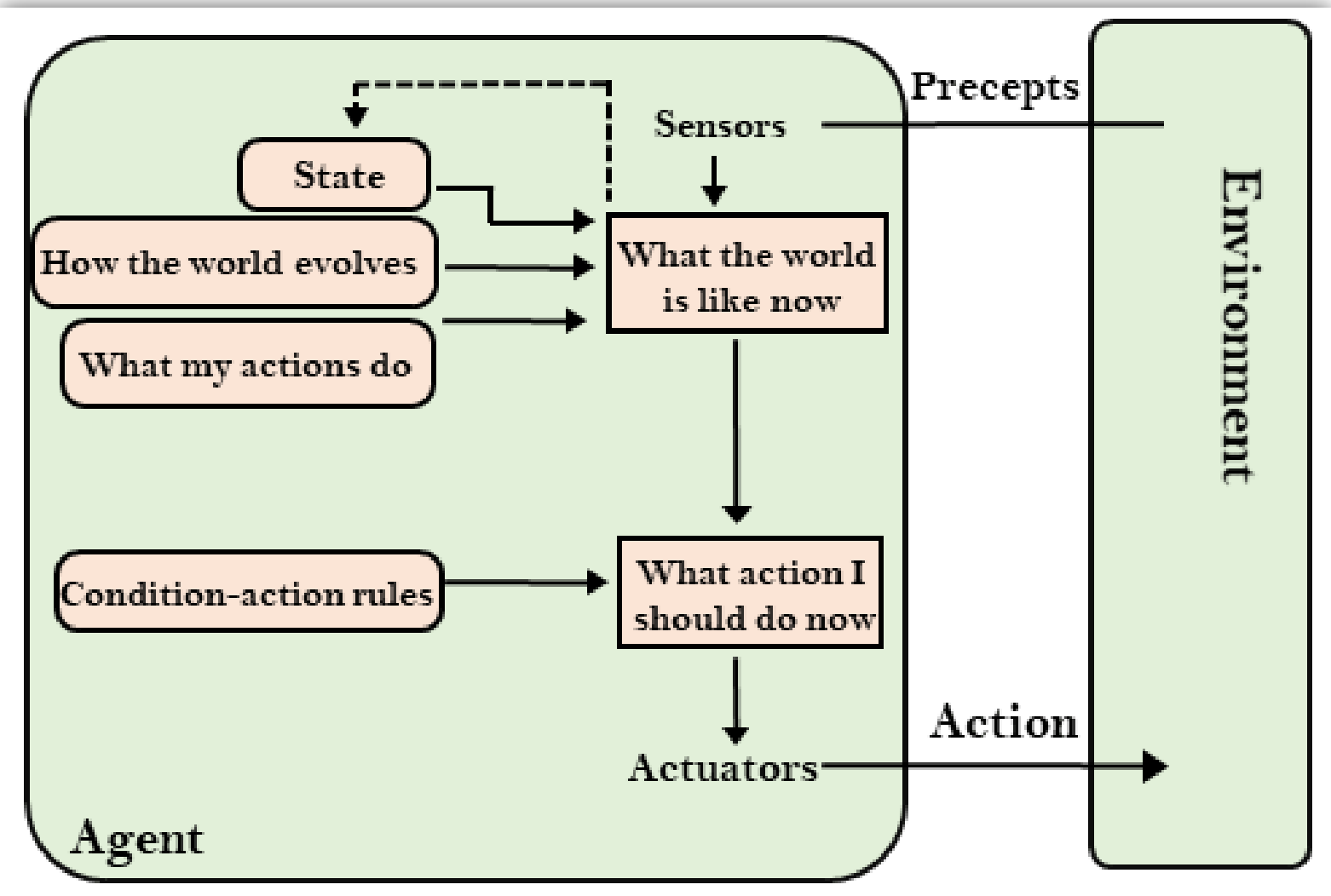
Structure of Intelligent Agents (Types of Agents)

❑Model-based reflex agent:

- The Model-based agent can work in a partially observable environment, and track the situation.
- A model-based agent 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:
  a) How the world evolves
  b) How the agent's action affects the world.

Structure of Intelligent Agents (Types of Agents)

❑Model-based reflex agent:

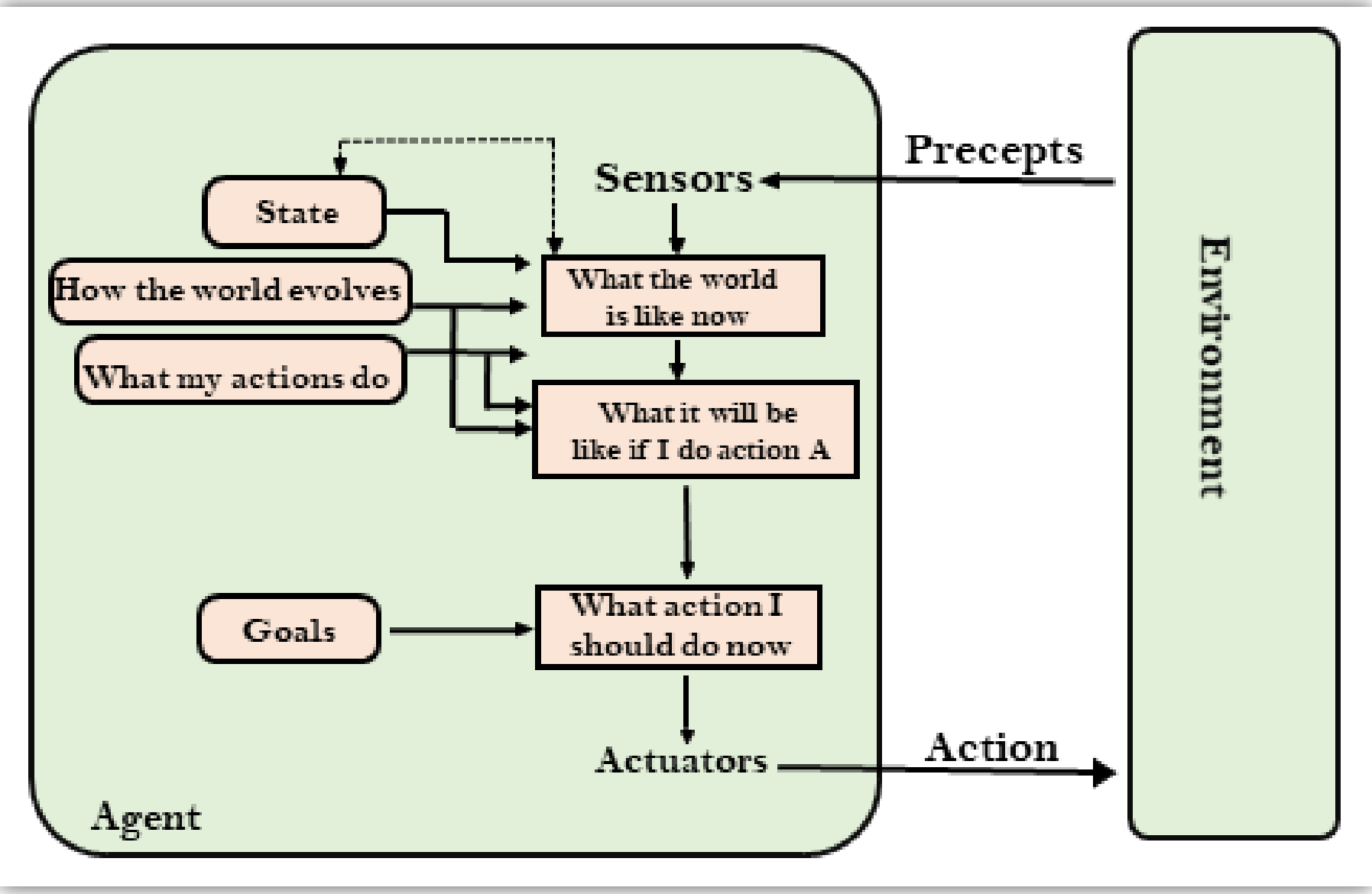


Structure of Intelligent Agents (Types of Agents)

❑Goal-based 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.
- Goal-based agents expand the capabilities of the model-based agent by having the "goal" information.
- They choose an action, so that they can achieve the goal.
- These agents may have to consider a long sequence of possible actions before deciding whether the goal is achieved or not.
- Such considerations of different scenario are called searching and planning, which makes an agent proactive.

Structure of Intelligent Agents (Types of Agents)

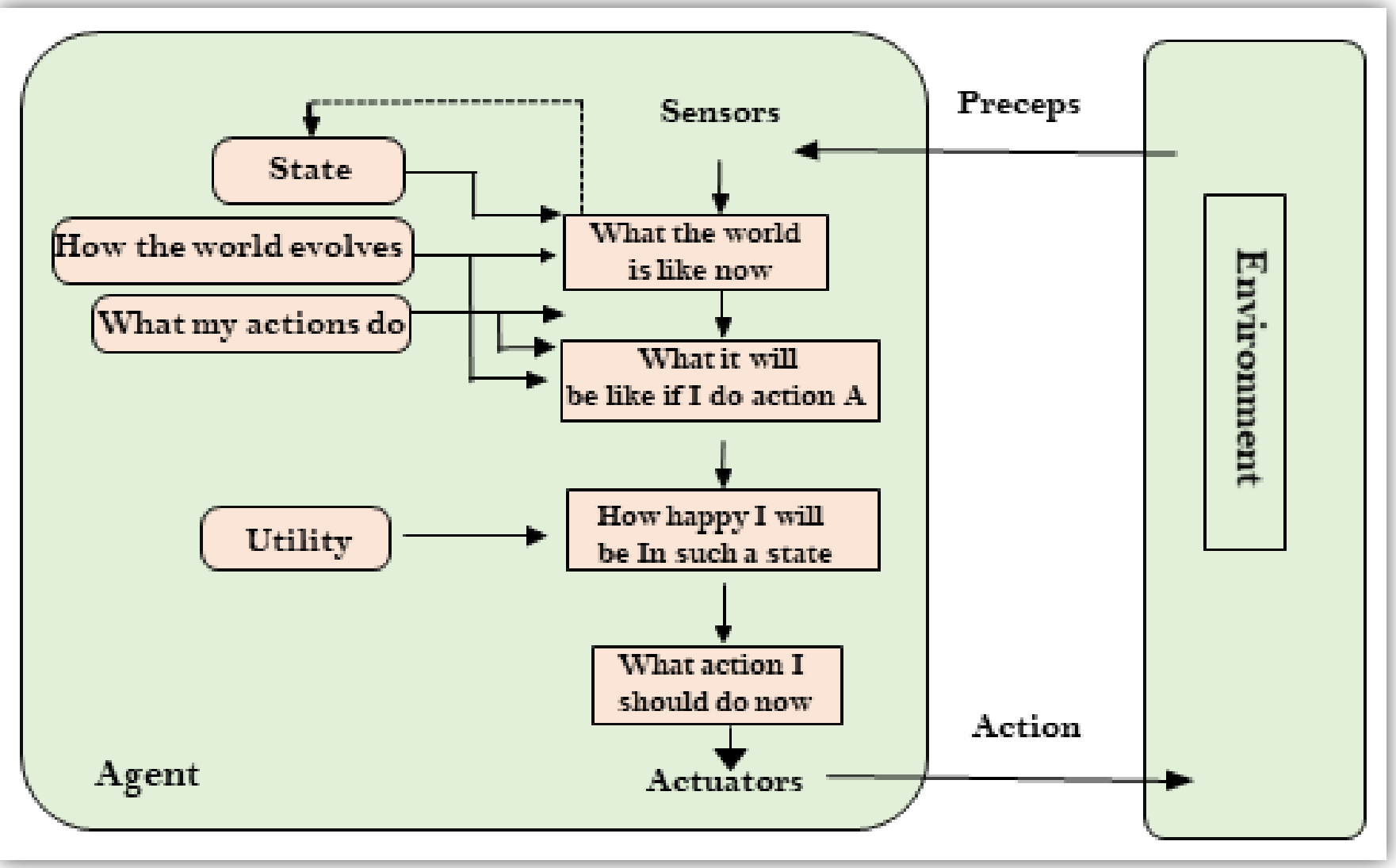


Structure of Intelligent Agents (Types of Agents)

❑Utility-based agent:

- 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.
- Utility-based agent act based not only goals but also the best way to achieve the goal.
- The Utility-based agent 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.

Structure of Intelligent Agents (Types of Agents)

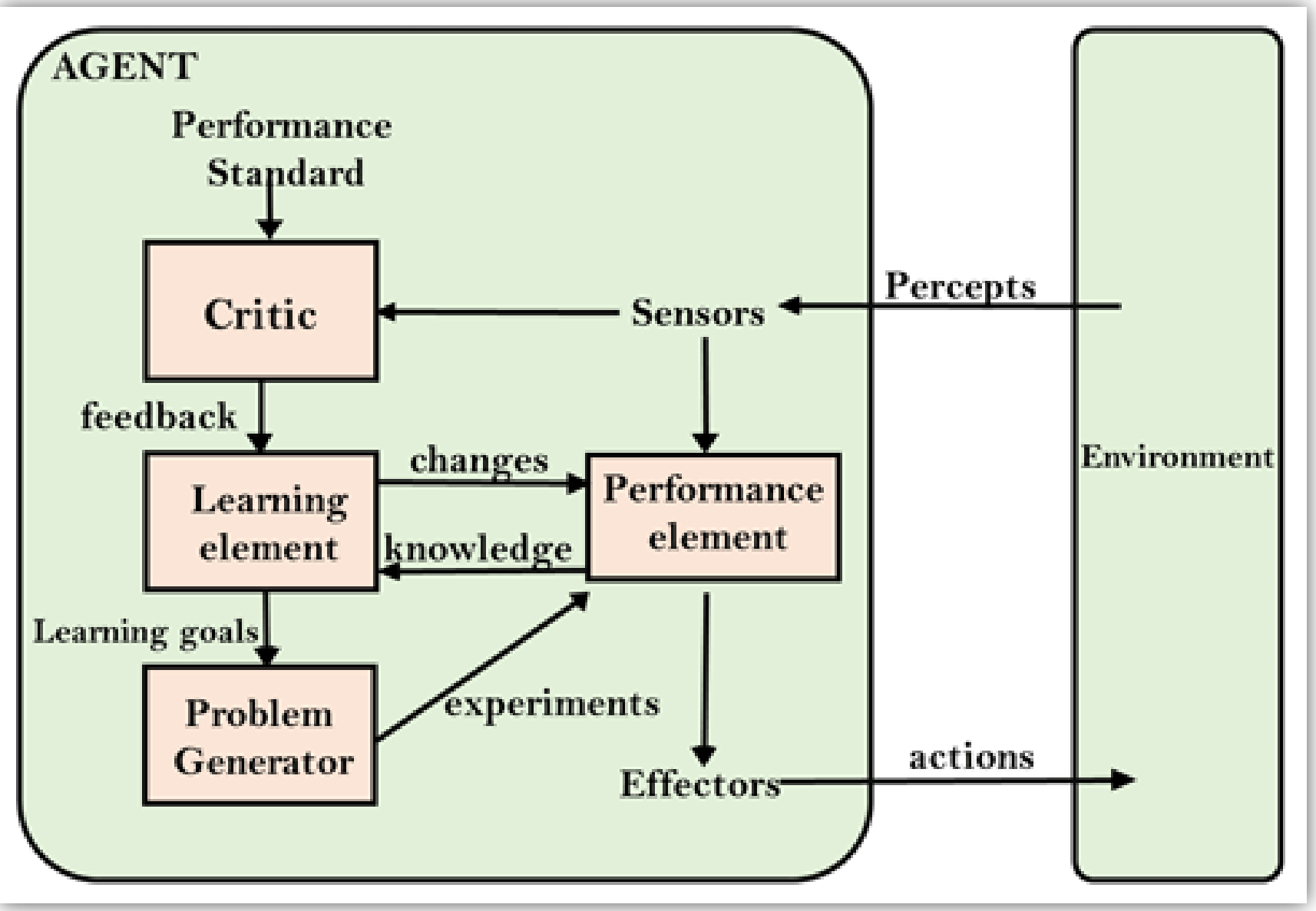


Structure of Intelligent Agents (Types of Agents)

❑Learning agent:

- 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:
  a. **Learning element:** It is responsible for making improvements by learning from environment
  b. **Critic:** Learning element takes feedback from critic which describes that how well the agent is doing with respect to a fixed performance standard.
  c. **Performance element:** It is responsible for selecting external action
  d. **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.

Structure of Intelligent Agents (Types of Agents)



Note for Students

- This power point presentation is for lecture, therefore it is suggested that also utilize the text books and lecture notes.