Unit-1

Introduction to AI

Why Study AI?

- AI makes computers more useful
- Intelligent computer would have huge impact on civilization
- AI cited as “field I would most like to be in” by scientists in all fields
- Computer is a good metaphor for talking and thinking about intelligence
- Turning theory into working programs forces us to work out the details
- AI yields good results for Computer Science
- AI yields good results for other fields
- Computers make good experimental subjects

What is the definition of AI?

- It is a branch of Computer Science that pursues creating the computers or machines as intelligent as human beings.
- It is the science and engineering of making intelligent machines, especially intelligent computer programs.
- Artificial Intelligence is the study of how to make computers do things, which, at the moment, people do better.
- According to the father of Artificial Intelligence, **John McCarthy**, it is “The science and engineering of making intelligent machines, especially intelligent computer programs”.
- Artificial Intelligence is a way of making a computer, a computer-controlled robot, or a software think intelligently, in the similar manner the intelligent humans think.

What is the definition of AI?

- Artificial Intelligence is concerned with the design of intelligence in an artificial device.
- The term was coined by McCarthy in 1956.
- There are two ideas in the definition.

1. Intelligence
2. artificial device

What is the definition of AI?

- AI is that sector in computer science that emphasizes the creation of intelligent machines that work, operate and react like human beings.
- AI is used in decision making by the machines considering the real-time scenario. An Artificially Intelligent machine reads the real-time data, understands the business scenario and reacts accordingly.
- Some of the activities that the artificially intelligent machines are designed for are:

➢ Speech recognition

➢ Learning

➢ Planning

➢ Problem-solving

What is the definition of AI?

Charniak & McDermott, 1985

"The study of mental faculties through the use of computational models"

Bellman, 1978

"[The automation of] activities that we associate with human thinking, activities such as decision making, problem solving, learning"

Dean et al., 1995

"The design and study of computer programs that behave intelligently. These programs are constructed to perform as would a human or an animal whose behavior we consider intelligent"

Haugeland, 1985

"The exciting new effort to make computers think *machines with minds*, in the full and literal sense"

Kurzweil, 1990

"The art of creating machines that perform functions that require intelligence when performed by people"

What is the definition of AI?

Nilsson, 1998

“Many human mental activities such as writing computer programs, doing mathematics, engaging in common sense reasoning, understanding language, and even driving an automobile, are said to demand intelligence. We might say that [these systems] exhibit artificial intelligence”

Rich & Knight, 1991

“The study of how to make computers do things at which, at the moment, people are better”

Schalkoff, 1990

“A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes”

Winston, 1992

“The study of the computations that make it possible to perceive, reason, and act”

Goals of Artificial Intelligence

- To Create Intelligent & Expert Systems: The development began to making systems that exhibit intelligent behavior. The expected functions of these machines are learning, demonstrating, explaining, and advising its users.
- To Inculcate Human Intelligence into the Machines: Creating systems and developing software that understands, think, learn, and behave like humans.

History of AI

- 1950 : The Turing test, originally called the imitation game by Alan Turing
- 1956 : The Scientist John McCarthy defined the term AI
- 1981 : Japan was the first to take this initiative and launched a scheme called 5th Generation

➢ Britain created a project called “Elvi” for this scheme

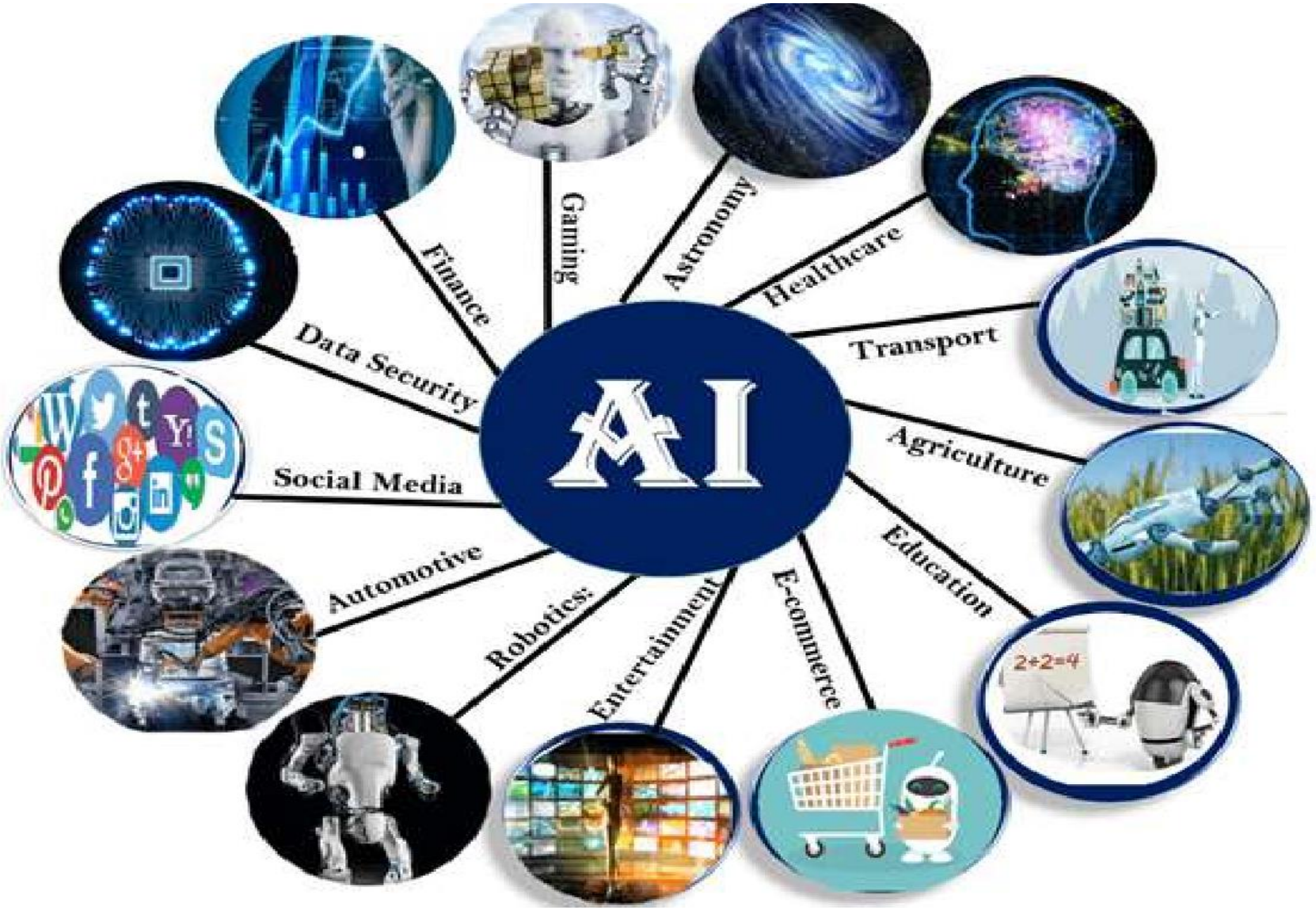
➢ European Union countries also started a program called “Esprit”

- 1983 : some private organizations jointly established a consortium “ Micro Electronics and Computer Technology” to develop advanced technologies applicable to AI such as VLSI Circuits

History of AI

- 2010 : Google DeepMind was british company founded in 2010. Its headquartered in London. In 2014, the American Company Google bought it and its name was changed from DeepMind to Google DeepMind.
- 2011 : Apple has launched Siri
- 2014 : Amazon has launched Alexa
- 2016 : AlphaGo program by Google's DeepMind AI, has won Korean Lee Sedol, one of Go's most dominant player.
- 2016 : Google Assistant is an AI powered virtual assitant developed by Google
- 2016 : Sophia Robot in HongKong

Applications



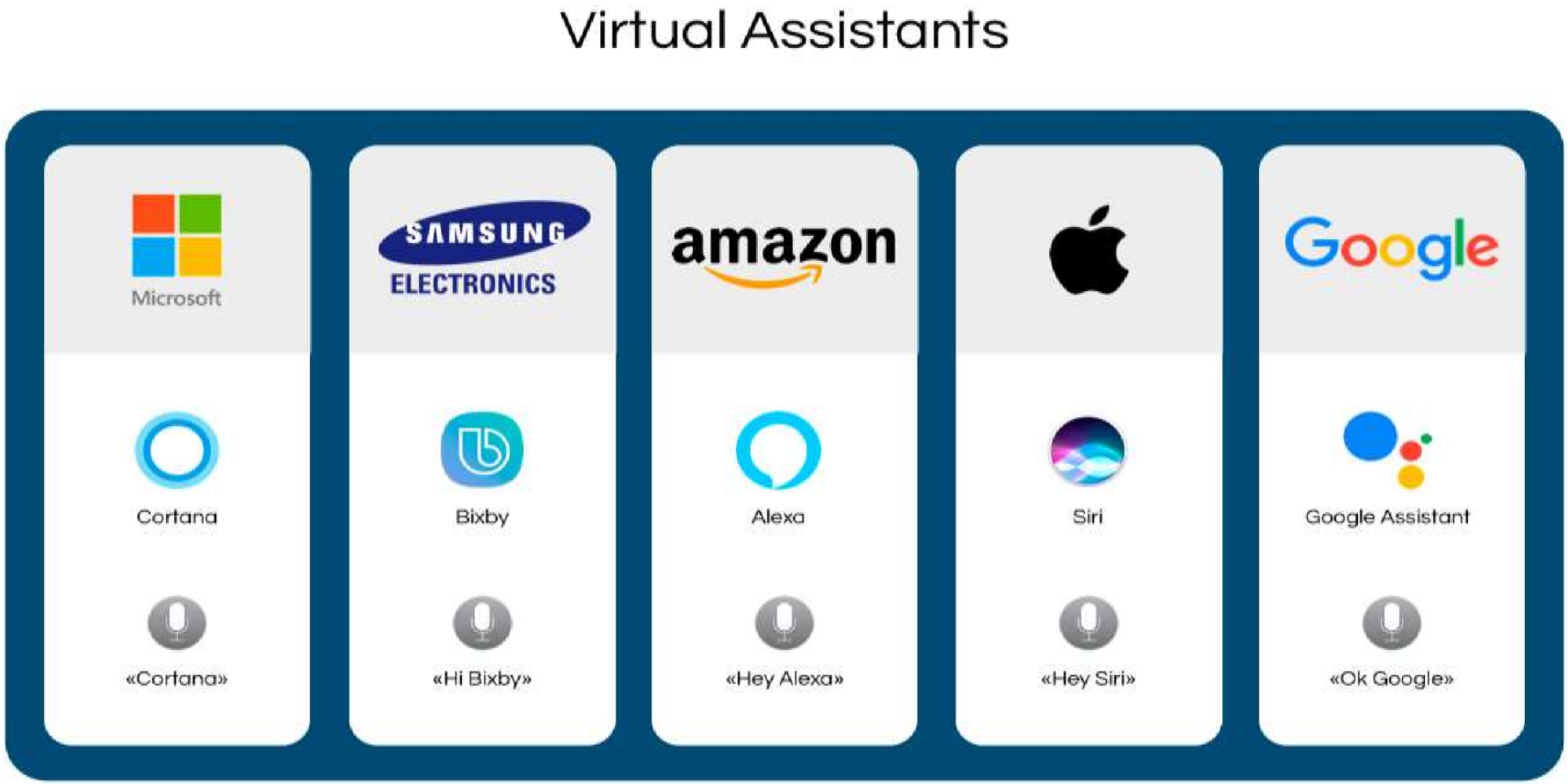
Applications

- AI is used in the **finance** industry, where personal data is collected, which can be later used to provide financial advice.
- AI is used in the field of **education**, where the grading system can be automated, and the performance of the students can be assessed based on which the learning process can be improved.
- In the field of **Healthcare**, AI is used to perform a better diagnosis where the technologies used to understand the natural language and respond to the questions asked. Also, computer programs like chatbots are used to assist customers in scheduling appointments and ease of billing process, etc.
- AI is used in **Business** to automate the repetitive tasks performed by humans with the help of Robotic Process Automation. To increase customer satisfaction, machine learning algorithms are integrated with analytics to gather information which helps in understanding customer needs.
- AI is used in **Smart Home devices**, **security and surveillance, navigation and travel, music and media streaming and video games**, etc.

Examples

- Self-driving cars
- Robo-advisors
- Conversational bots
- Email spam filters
- Netflix's recommendations
- A drone, spying camera or a spying airplane takes photographs, videos, which are used to understand the map of the area or figure out spatial information.
- Clinical expert systems use cameras inside the body and are often used by the doctors to diagnose the patient.
- Use of computer software is used in Police investigations for facial recognition. This program can identify the face of the suspect having a record in the police system called with the portrait mode with the description the witness gives to the forensic artist.

Examples


Virtual Assistants
Microsoft
Cortana
«Cortana»
SAMSUNG
ELECTRONICS
Bixby
«Hi Bixby»
amazon
Alexa
«Hey Alexa»
Siri
«Hey Siri»
Google
Google Assistant
«Ok Google»

Examples


LEFT REARWARD VEHICLE CAMERA
MEDIUM RANGE VEHICLE CAMERA
RIGHT REARWARD VEHICLE CAMERA

AI, a Multi-disciplinary domain

- Engineering: robotics, vision, control-expert systems, biometrics,
- Computer Science: AI-languages , knowledge representation, algorithms, …
- Pure Sciences: statistics approaches, neural nets, fuzzy logic, …
- Linguistics: computational linguistics, phonetics en speech, …
- Psychology: cognitive models, knowledge-extraction from experts, …
- Medicine: human neural models, neuro-science,...

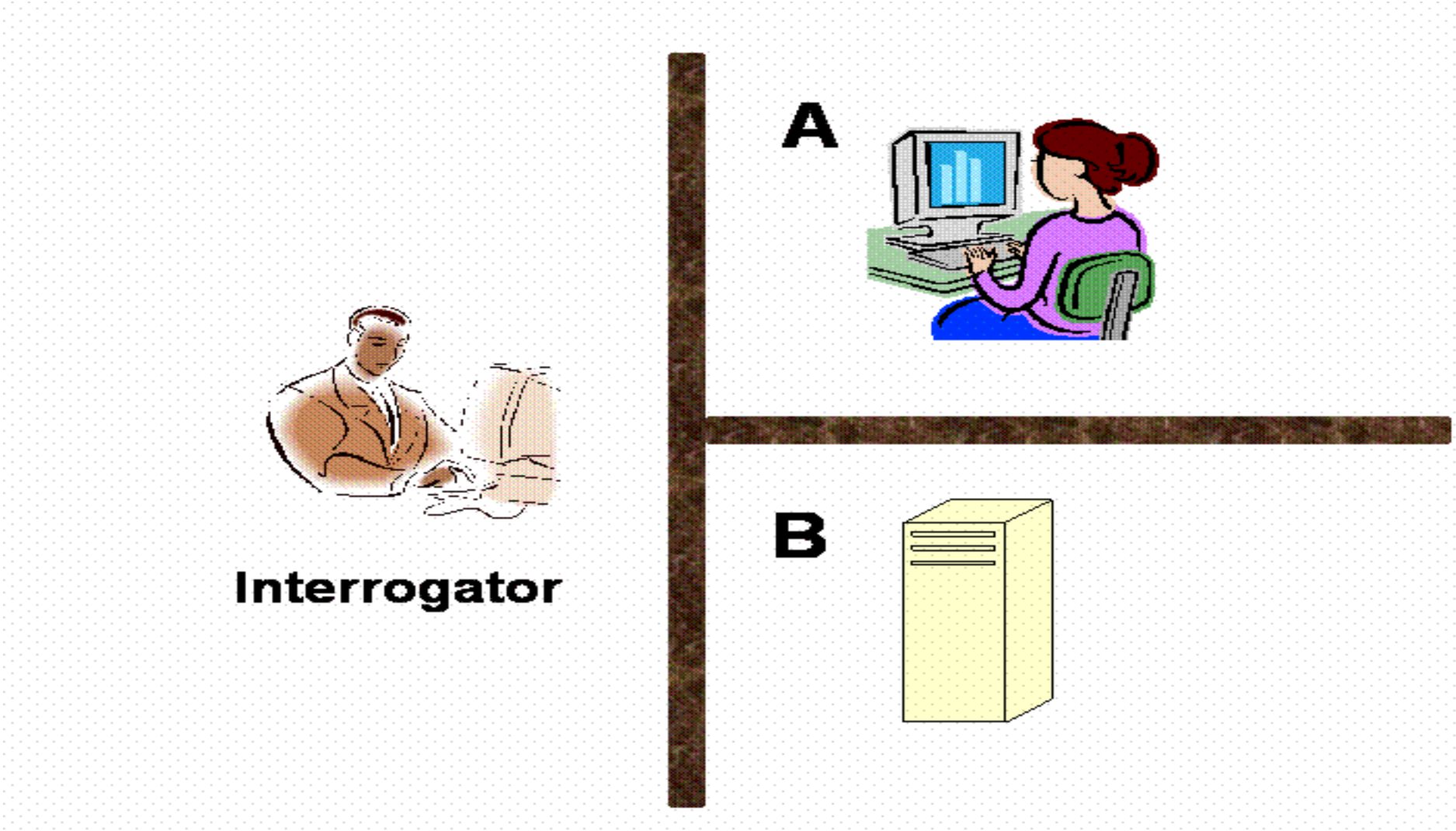
Approaches of AI

Systems that think like humans	Systems that think rationally
Systems that act like humans	Systems that act rationally

Scope and view of Artificial Intelligence

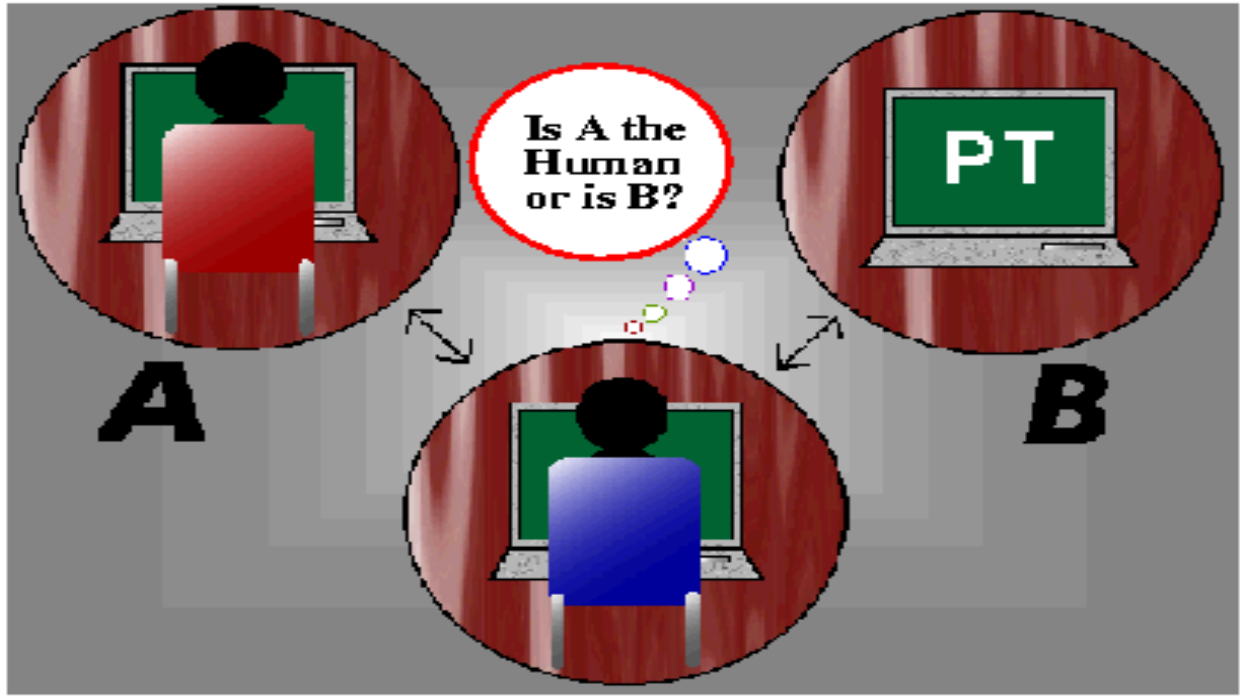
1. One view is that artificial intelligence is about designing systems that are as intelligent as humans. (emulate the human thought process)
2. The second approach is best embodied by the concept of the Turing Test. (Alan Turing, 1912)
3. Logic and laws of thought deals with studies of ideal or rational thought process and inference.
   - Knowledge representation
4. The fourth view of AI is that it is the study of rational agents. This view deals with building machines that act rationally (sensibly/logically).

Turing Test (The Imitation Game)



Turing Test : Acting Humanly

- Turing test: ultimate test for acting humanly
  - Computer and human both interrogated by judge
  - Computer passes test if judge can't tell the difference



Turing test

- In 1950, Alan Turing Proposed the following method for determining whether a machine can think. His method has since become known as the Turing Test.
- To conduct this Test, we need two people and the machine to be evaluated. One person plays the role of the interrogator, who is in a separate room from the computer and the other person.
- The interrogator can ask questions of either the person or the computer by typing questions and receiving types responses. However interrogator knows them only as A and B and aims to determine which is the person and which is the machine.
- The goal of the machine is to fool the interrogator into believing that it is the person. If the machine is succeeds at this, then we will conclude that the machine can think.

Typical AI problems

- "common-place" tasks (*These tasks are done routinely by people and some other animals*)
  - *Recognizing people, objects.*
  - Communicating (through *natural language).*
  - *Navigating around obstacles on the streets*
- "expert tasks" (*can only be performed by skilled specialists*)
  - Medical diagnosis
  - Mathematical problem solving
  - Playing games like chess

- Which of these tasks are easy and which ones are hard?
  - Computer system can perform sophisticated tasks like medical diagnosis, performing symbolic integration, proving theorems and playing chess
  - It has proved to be very hard to make computer systems perform many routine tasks that all humans and a lot of animals can do.

Intelligent behavior

- What constitutes intelligent behavior?
- Some of these tasks and applications are:
  - Perception involving image recognition and computer vision
  - Reasoning
  - Learning
  - Understanding language involving natural language processing, speech processing
  - Solving problems
  - Robotics

Which of these exhibits intelligence?

- You beat somebody at chess.
- You prove a mathematical theorem using a set of known axioms.
- You need to buy some supplies, meet three different colleagues, return books to the library, and exercise. You plan your day in such a way that everything is achieved in an efficient manner.
- You are a lawyer who is asked to defend someone. You recall three similar cases in which the defendant was guilty, and you turn down the potential client.
- A stranger passing you on the street notices your watch and asks, “Can you tell me the time?” You say, “It is 3:00.”
- You are told to find a large Phillips screwdriver in a cluttered workroom. You enter the room (you have never been there before), search without falling over objects, and eventually find the screwdriver.

Which of these exhibits intelligence?

- You are a six-month-old infant. You can produce sounds with your vocal organs, and you can hear speech sounds around you, but you do not know how to make the sounds you are hearing. In the next year, you figure out what the sounds of your parents' language are and how to make them.
- You are a one-year-old child learning Arabic. You hear strings of sounds and figure out that they are associated with particular meanings in the world. Within two years, you learn how to segment the strings into meaningful parts and produce your own words and sentences.
- Someone taps a rhythm, and you are able to beat along with it and to continue it even after it stops.
- You are some sort of primitive invertebrate. You know nothing about how to move about in your world, only that you need to find food and keep from bumping into walls. After lots of reinforcement and punishment, you get around just fine.

Practical Impact of AI

- AI components are embedded in numerous devices
  - Copy machines (for automatic copy quality improvement)
  - Identifying credit card fraud
  - Advising doctors
  - Recognizing speech
  - Helping complex planning tasks
  - Game playing
  - ….

What can AI systems do

- Today's AI systems have been able to achieve limited success in some of these tasks
  - In Computer vision, the systems are capable of face recognition
  - In Robotics, we have been able to make vehicles that are mostly autonomous.
  - In Natural language processing, we have systems that are capable of simple machine translation.
  - Today's Expert systems can carry out medical diagnosis in a narrow domain
  - Speech understanding systems are capable of recognizing several thousand words
  - Planning and scheduling systems
  - The Learning systems are capable of doing text categorization into about a 1000 topics
  - In Games, AI systems can play at the Grand Master level in chess (world champion), checkers, etc.

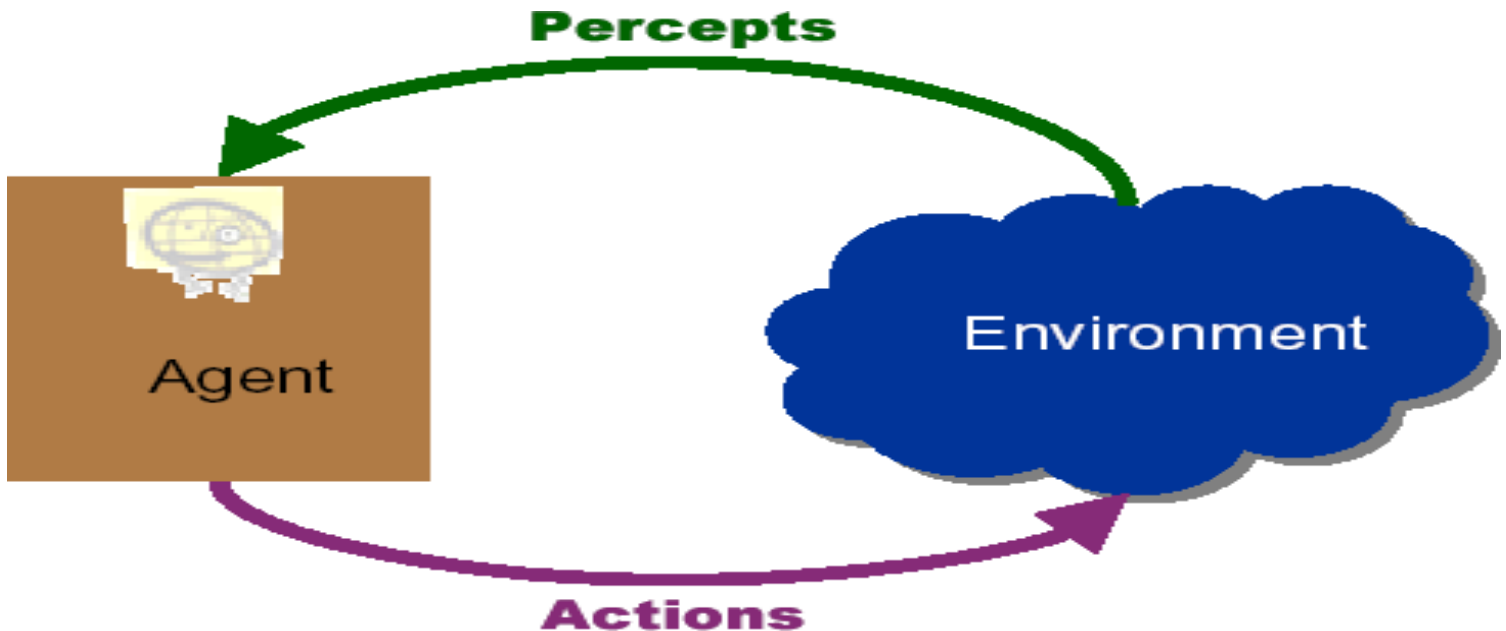
Introduction to Agent

Agents

- Agents in Artificial Intelligence are the associated concepts that the AI technologies work upon.
- The AI software or AI-enabled devices with sensors generally captures the information from the environment setup and process the data for further actions.
- There are mainly two ways the agents interact with the environment, such as perception and action. The perception is only passive for capturing the information without changing the actual environment, whereas action is the active form of interaction by changing the actual environment.
- AI technologies such as virtual assistance chat boats, AI-enabled devices to work based on the previous persecution data processing and learning for the actions.

What is an Agent

- An Agent is anything that takes actions according to the information that it gains from the environment. A human agent has sensory organs to sense the environment and the body parts to act while a robot agent has sensors to perceive the environment.
- An agent acts in an environment
- An agent perceives its environment through sensors.



How does the Agent Interact with the Environment?

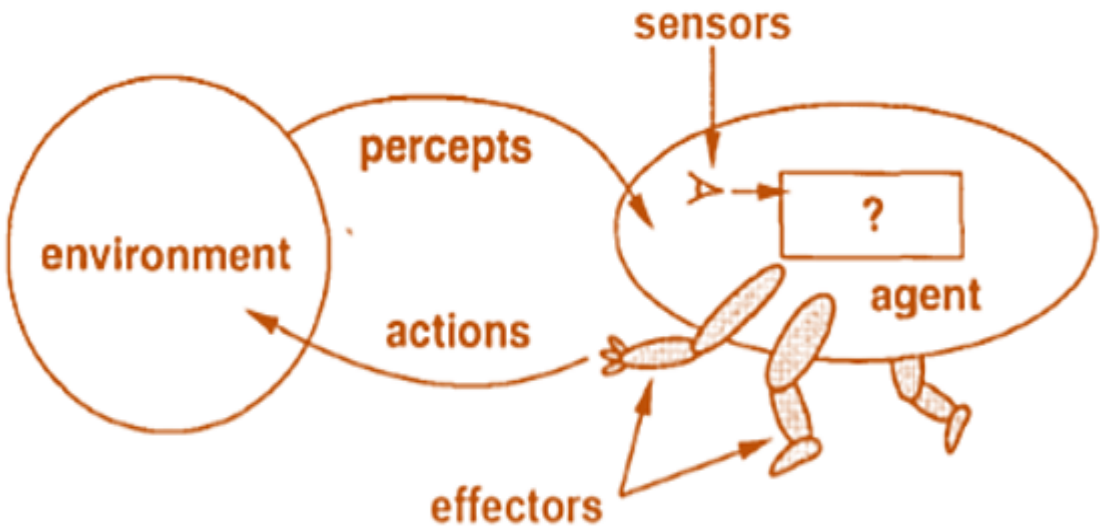
- The agents interact with the environment in two ways:

➢ Perception: Perception is a passive interaction, where the agent gains information about the environment without changing the environment. The sensors of the robot help it to gain information about the surroundings without affecting the surrounding. Hence, gaining information through sensors is called perception.

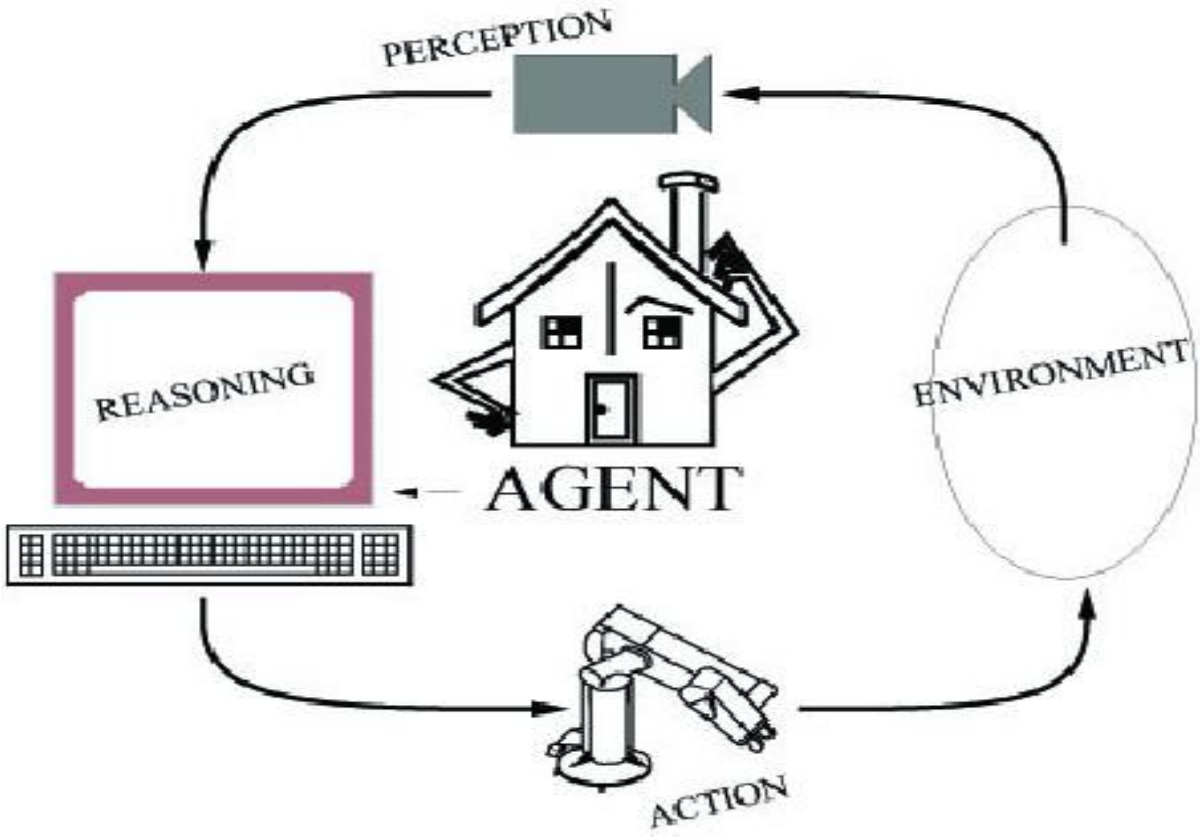
➢ Action: Action is an active interaction where the environment is changed. When the robot moves an obstacle using its arm, it is called an action as the environment is changed. The arm of the robot is called an “Effector” as it performs the action.

How does the Agent Interact with the Environment?

- The interaction of the Agent with the Environment is through Sensors and Effectors.
- Consider the example of a chatbot which is a virtual assistant. When it reads and understands the meaning of a user's messages, it is called perception. And when it replies to the user after analyzing the user's message, it is called the action.



How does the Agent Interact with the Environment?



An agent perceives its environment through sensors and acts on the environment through actuators.

Human: sensors are eyes, ears, actuators (effectors) are hands, legs, mouth.

Robot: sensors are cameras, sonar, lasers, ladar, bump, effectors are grippers, manipulators, motors

The agent's behavior is described by its function that maps percept to action.

Examples of Agents

- Humans : They have eyes, ears, skin, taste buds, etc. for sensors; and hands, fingers, legs, mouth for effectors.
- Robots : Robots may have camera, sonar, infrared, bumper, etc. for sensors. They can have grippers, wheels, lights, speakers, etc. for actuators.
- Software agents (softbots): have some functions as sensors and some functions as actuators.
- Expert systems
- Autonomous spacecrafts

PEAS

- Use PEAS to describe task environment
  - Performance measure
  - Environment
  - Actuators
  - Sensors
- Example: Taxi driver
  - Performance measure: safe, fast, comfortable (maximize profits)
  - Environment: roads, other traffic, pedestrians, customers
  - Actuators: steering, accelerator, brake, signal, horn
  - Sensors: cameras, sonar, speedometer, GPS, odometer, accelerometer, engine sensors

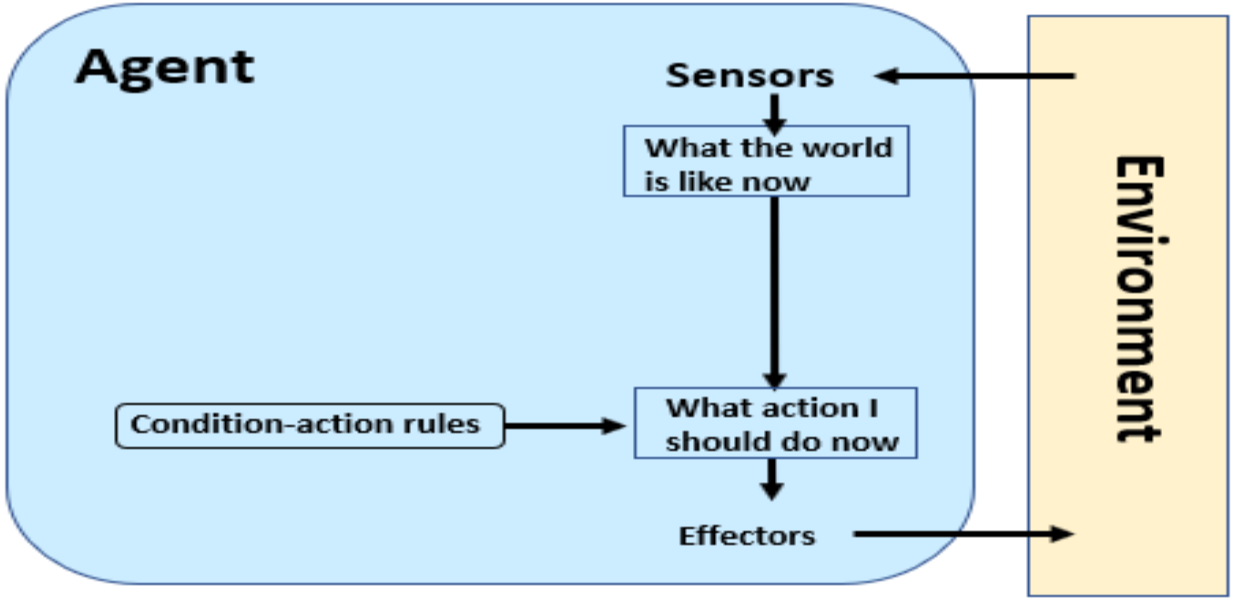
Agent Types

- Depending on the problem statement and ability to perceive the agents can be categorized into 5 categories.

- **Simple Reflex agent**: works on current perception
- **Reflex Agent With State**: represents the current state based on history.
- **Goal-based agents**: They are proactive agents and works on planning and searching.
- **Utility-based agents**: Have extra component of utility measurement over goal-based agent
- **Learning agent**: able to learn and adapt the new decision-making capabilities based on experience.

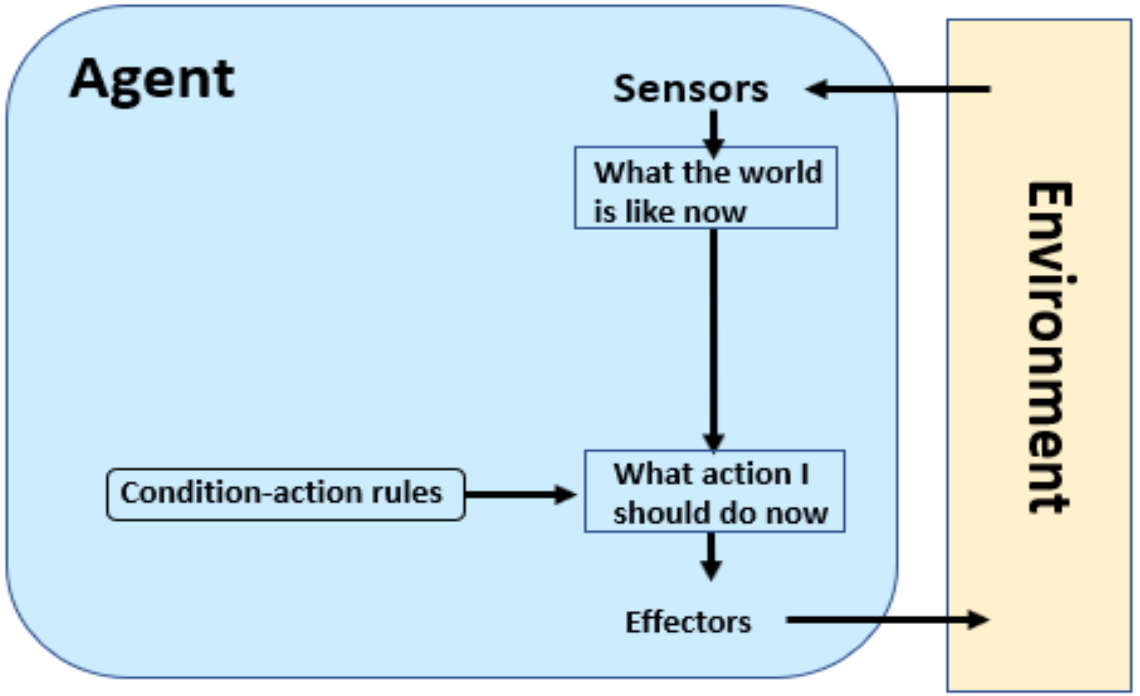
Reflex Agent

- Reflex Agent works similar to our body's reflex action (e.g. when we immediately lift our finger when it touches the tip of the flame). Just as the prompt response of our body based on the current situation, the **agent also responds based on the current environment irrespective of the past state of the environment.** The reflex agent can work properly only if the decisions to be made are based on the **current percept**.



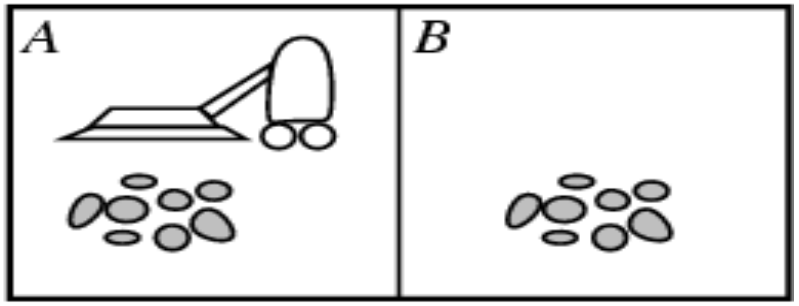
Simple Reflex Agent

- Use simple “if then” rules
- Can be short sighted




```
SimpleReflexAgent(percept)
  state  = InterpretInput(percept)
  rule   = RuleMatch(state, rules)
  action = RuleAction(rule)
  Return action
```

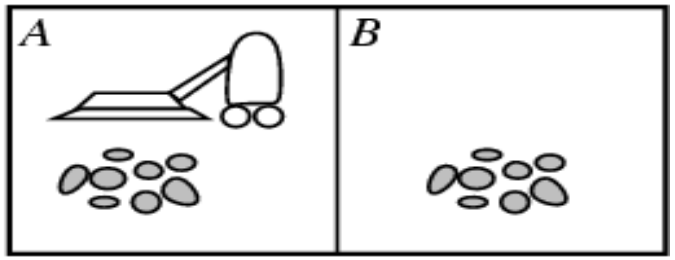
Example: Vacuum Agent



- Performance?
  - 1 point for each square cleaned in time T?
  - #clean squares per time step - #moves per time step?
- Environment: Two rooms that can be dirty or clean
- Agent: A robotic vacuum cleaner
- Actions: left, right, suck, idle
- Percepts: location and contents
  - [A, dirty]

Reflex Vacuum Agent

- If status=Dirty then return Suck
  else if location=A then return Right
  else if location=B then right Left

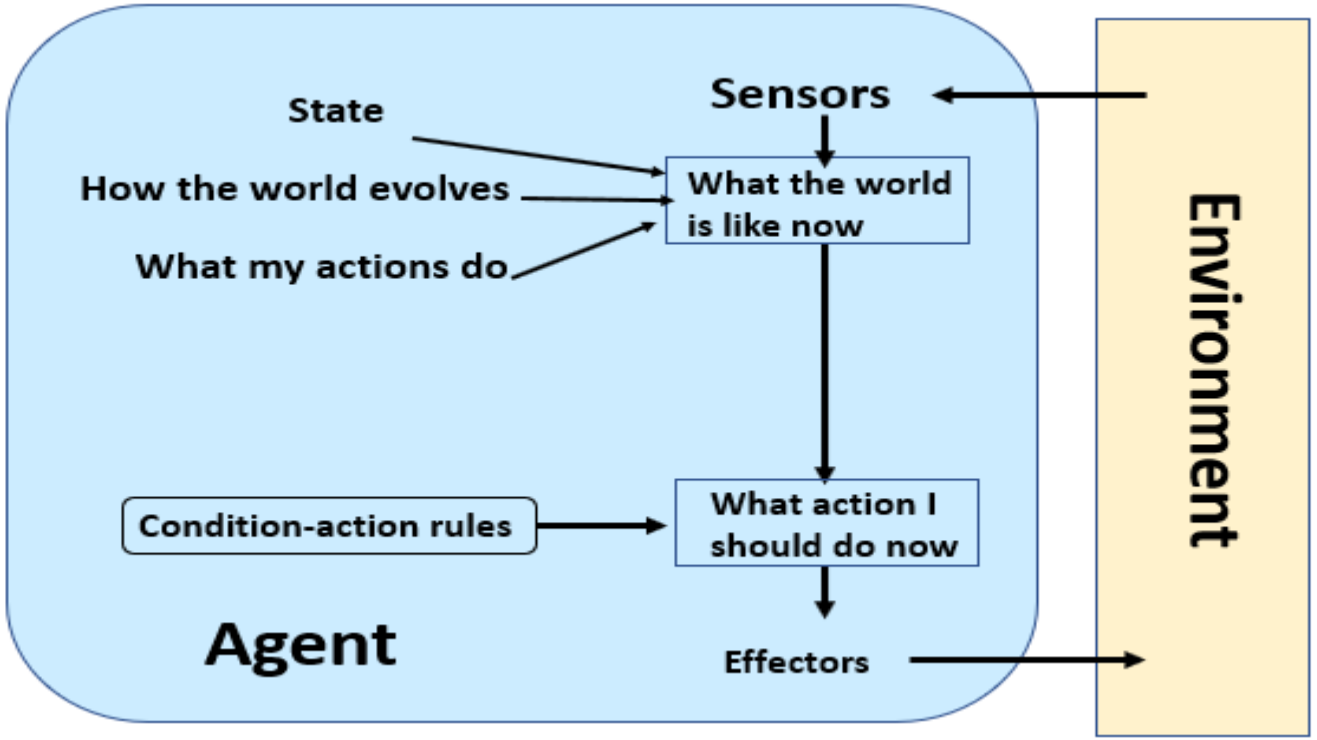


Reflex Agent With State

- These are the **agents with memory**. It stores the information about the **previous state, the current state and performs the action accordingly**.
- Just as while driving, if the driver wants to change the lane, he looks into the mirror to know the present position of vehicles behind him. While looking in front, he can only see the vehicles in front, and as he already has the information on the position of vehicles behind him (from the mirror a moment ago), he can safely change the lane. The previous and the current state get updated quickly for deciding the action.

Reflex Agent With State

- Store previously-observed information
- Can reason about unobserved aspects of current state



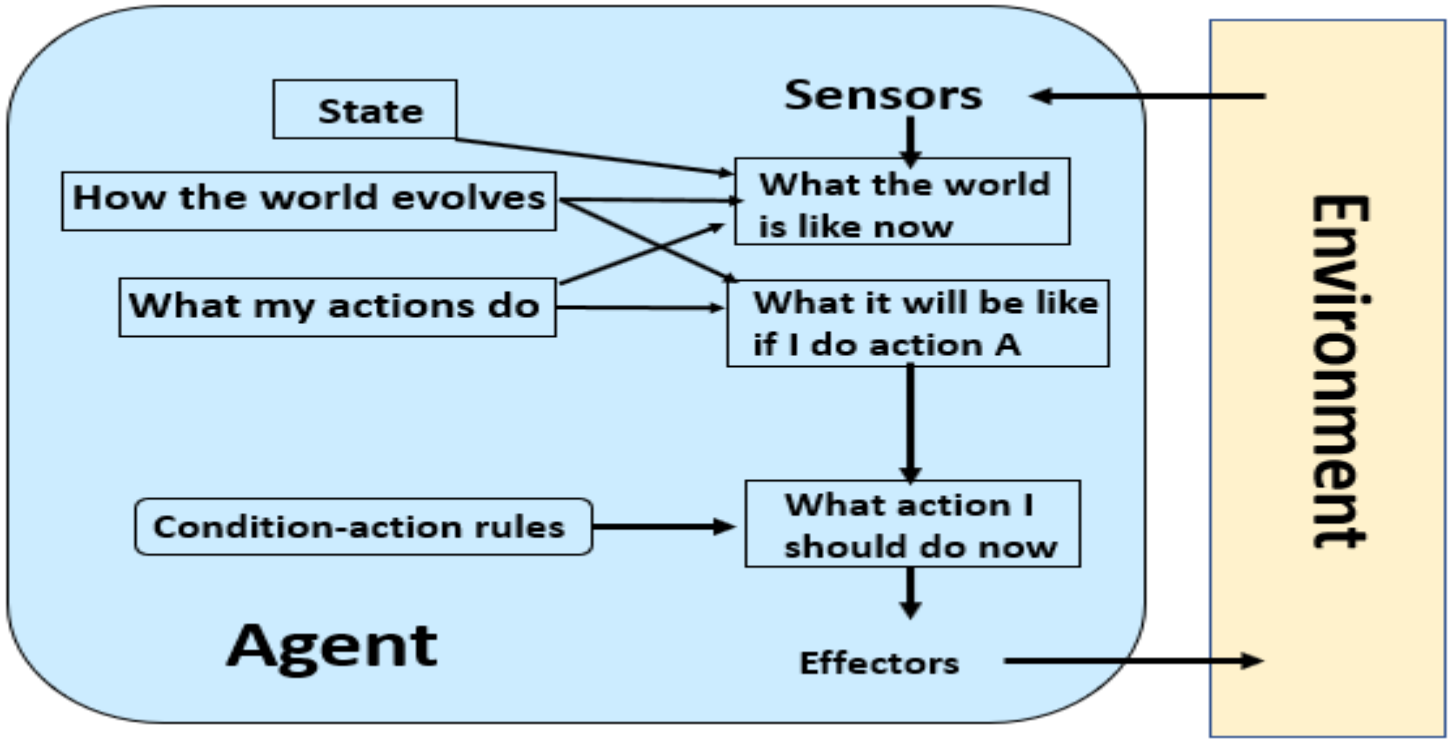

```
ReflexAgentWithState(percept)
  state  = UpdateDate(state,action,percept)
  rule   = RuleMatch(state, rules)
  action = RuleAction(rule)
  Return action
```

Goal-based Agents

- In some circumstances, just the information of the current state may not help in making the right decision**. If the goal is known, then the agent takes into account the goal information besides the current state information to make the right decision.**
- For, e.g., if the agent is a self-driving car and the goal is the destination, then the information of the route to the destination helps the car in deciding when to turn left or right.
- ‘Search’ and ‘planning’ are the two subfields of AI that help the agent achieve its goals. Though the goal-based agent may appear less efficient, yet it is flexible. Considering the same example mentioned above, if the destination changes then the agent will manipulate its actions accordingly. This will not be the case with the reflex agent as all the rules need to be rewritten with the change in goal.

Goal-Based Agents

- Goal reflects desires of agents
- May project actions to see if consistent with goals
- Takes time, world may change during reasoning

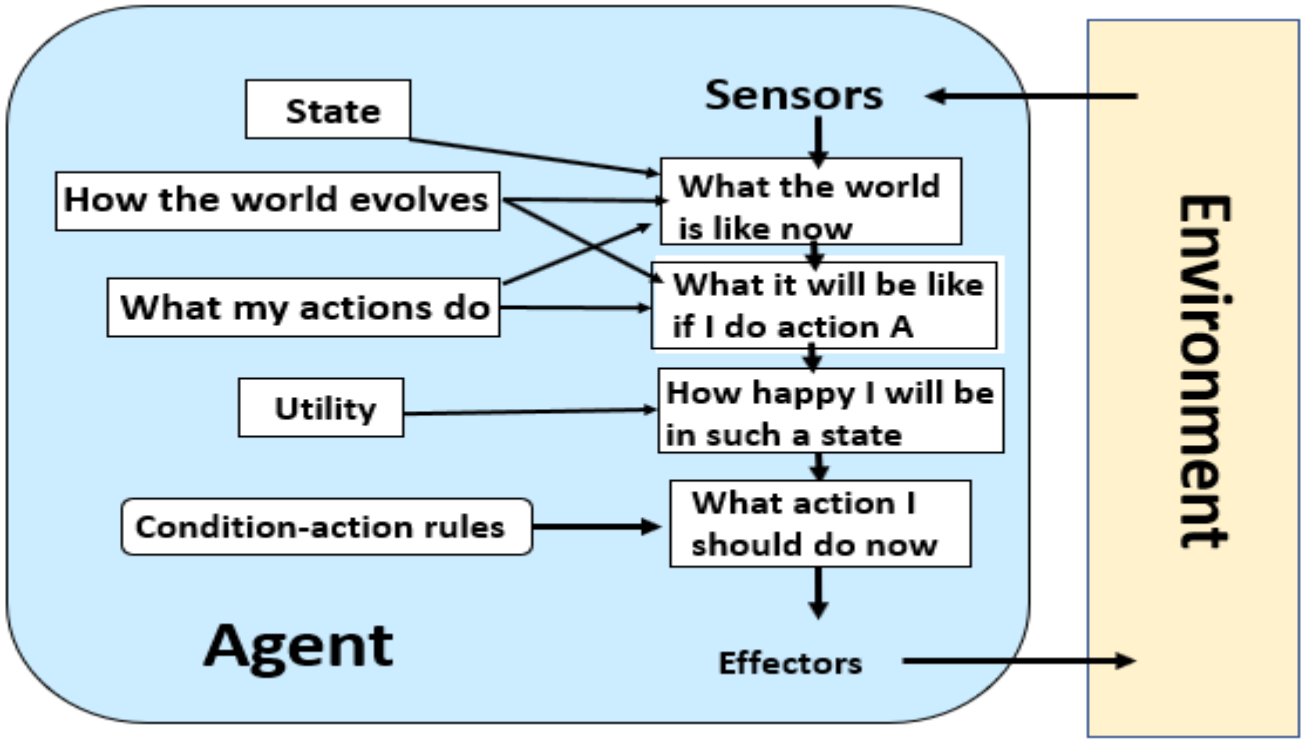


Utility Agents

- There can be many possible sequences to achieve the goal, but some will be better than others. Considering the same example mentioned above, **the destination is known**, but there are **multiple routes**. **Choosing an appropriate route** also matters to the overall success of the agent.
- There are many factors in deciding the route like the **shortest one**, the **comfortable one**, etc. The success depends on the utility of the agent-based on user preferences.
- The utility is a function that maps a state to a real number that describes the degree of happiness. The utility function specifies the appropriate trade-off in case the goals are conflicting.

Utility-Based Agents

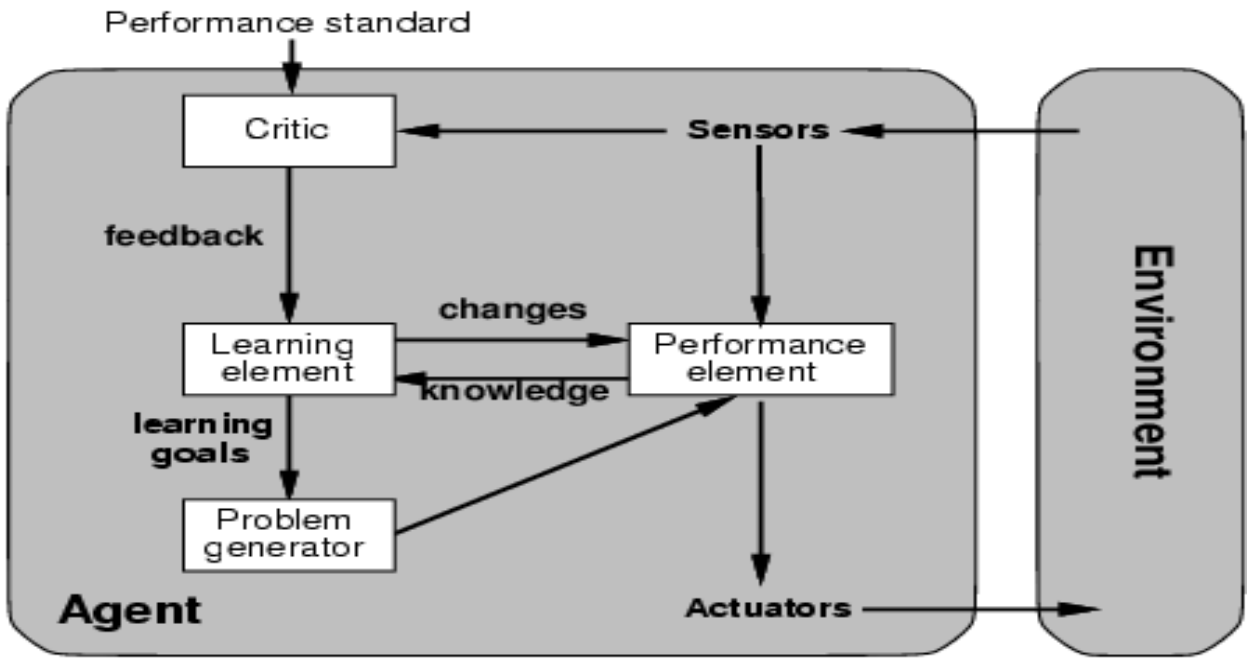
- Evaluation function to measure utility f(state) -> value
- Useful for evaluating competing goals



Learning Agents

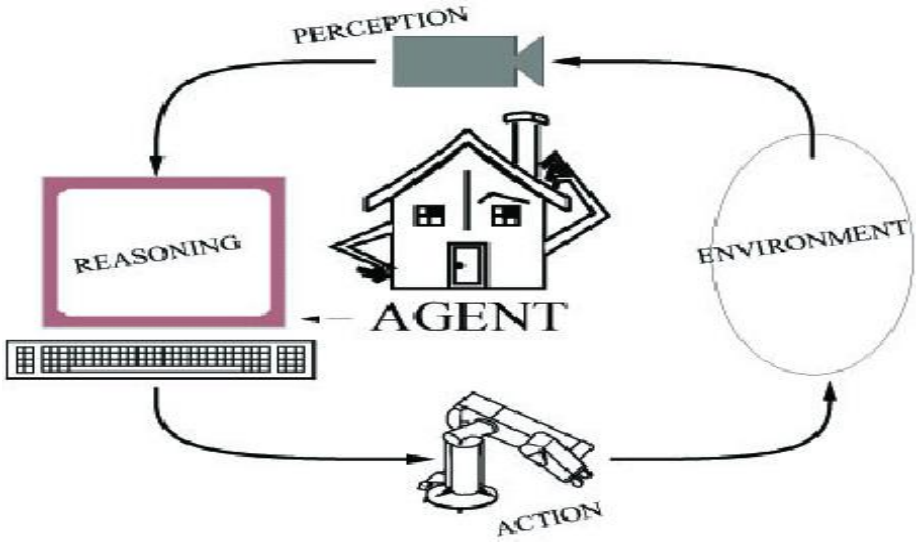
- This agent is capable of learning from the experience that is whatever the actions it has performed; it takes feedback and adapts accordingly.
- For a Learning agent to work the way, it has four components. First is the **learning element**, which learns from experience. Second is the **critic**, which is a feedback system about how well the agent is doing. The third is the **performance** element, which decides what external action should be taken. The last one is a **problem generator** which is a feedback agent that keeps history and makes new suggestions.

Learning Agents



Xavier mail delivery robot

- Performance: Completed tasks
- Environment: See for yourself
- Actuators: Wheeled robot actuation
- Sensors: Vision, sonar, dead reckoning
- Reasoning: Markov model induction, A* search, Bayes classification



Pathfinder Medical Diagnosis System

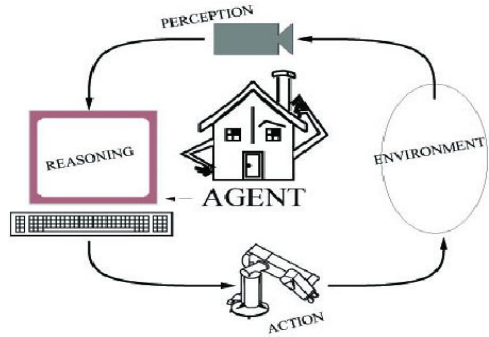
- Performance: Correct Hematopathology diagnosis
- Environment: Automate human diagnosis, partially observable, deterministic, episodic, static, continuous, single agent
- Actuators: Output diagnoses and further test suggestions
- Sensors: Input symptoms and test results
- Reasoning: Bayesian networks, Monte-Carlo simulations

Alvinn

- ALVINN (Autonomous Land Vehicle In a Neural Network) is a 3-layer back-propagation network designed for the task of road following. Currently ALVINN takes images from a camera and a laser range finder as input and produces as output the direction the vehicle should travel in order to follow the road.
- Performance: Stay in lane, on road, maintain speed
- Environment: Driving Hummer on and off road without manual control (Partially observable, stochastic, episodic, dynamic, continuous, single agent), Autonomous automobile
- Actuators: Speed, Steer
- Sensors: Stereo camera input
- Reasoning: Neural networks

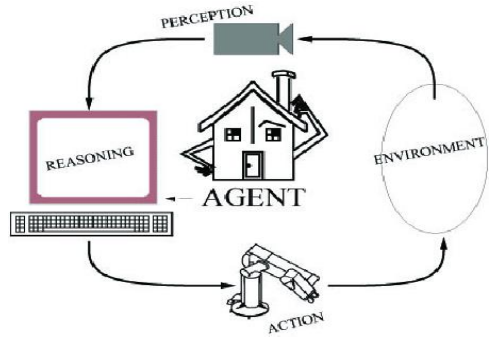
Robot Soccer

- Robot soccer competition
- Sensors: Camera image, messages from other players
- Reasoning: Planning, image processing
- Action: Robot 2D move or kick ball



Webcrawler Softbot

- Search web for items of interest
- Perception: Web pages
- Reasoning: Pattern matching
- Action: Select and traverse hyperlinks



Summary

- A goal of AI is to build intelligent agents that act so as to optimize performance.
- An agent perceives and acts in an environment, has an architecture, and is implemented by an agent program.
- An ideal agent always chooses the action which maximizes its expected performance, given its percept sequence so far.
- An autonomous agent uses its own experience rather than built-in knowledge of the environment by the designer.
- An agent program maps from percept to action and updates its internal state.
  - Reflex agents respond immediately to percepts.
  - Goal-based agents act in order to achieve their goal(s).
  - Utility-based agents maximize their own utility function.
- Representing knowledge is important for successful agent design.

Agent Environment

- Agent and Environment are two pillars in Artificial Intelligence, our aim is to build intellectual agents and work in an environment. If you consider broadly agent is the solution and environment is the problem.
- In simple terms, even starter or researcher can understand that and is defined **Agent as game and Environment as ground.**
- 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.
- Environment is the place where the agent is going to work. In general, Environment gives possible rewards, states, actions to the agents.

Agent Environment

- Before we start let us define few terms

➢ **Perception**: what agent see the environment.

➢ **Perception history**: It is the history of perception which comes in a specific period.

➢ **Actuators / Effectors** : A mechanism that puts something into action / Agents organs (hands and legs) that becomes active.

Examples

- Examples of Agent : It can be Program, Chatbot, Robot, Machine, Car, Players etc.
- Examples of Environment: It depends on the application for example- chess, maze, outer space etc.

Examples

- Examples of Agents and Environments are many due to their contexts, applications and necessity. Possible and well known agents and environments listed in the below diagram.
- **Agents ---------- Environments**

➢ Robot ----------→Room

➢ Chatbot----------> Chatting

➢ Vehicle----------→ Road

➢ Program---------→ Data and Rules

➢ Machine ----------→ Working Field

Types of Environment

- As per Russell and Norvig, an environment can have various features from the point of view of an agent:

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

Types of Environment

- **Fully observable Vs Partially Observable:**

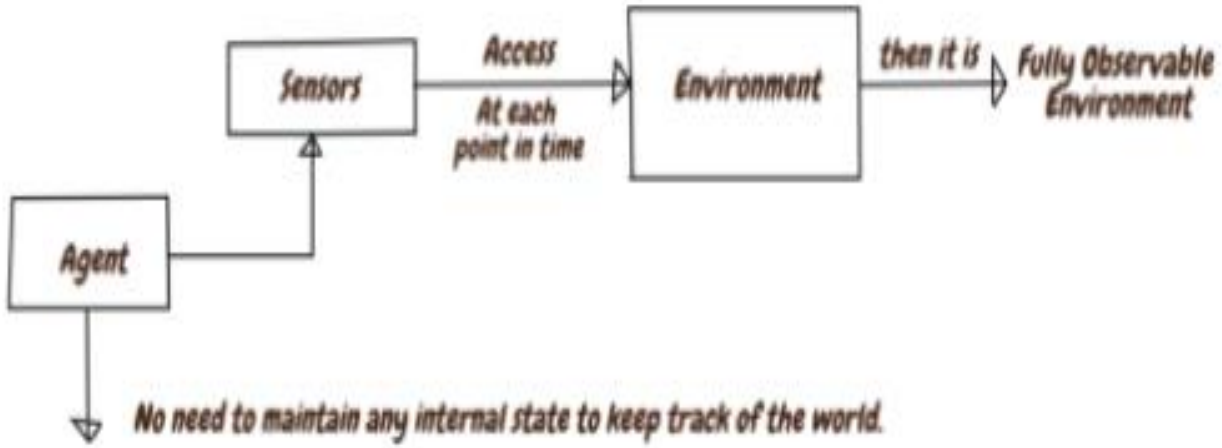
➢ If an agent sensor can sense or access the complete state of an environment at each point of time then it is **a fully observable** environment, else it is **partially observable**.

➢ An Environment is Partially Observable due to noise and inaccurate sensors or because parts of the state are simply missing from the sensor data.

➢ **Unobservable**: If the agent has no sensors at all then the Environment is Unobservable

Types of Environment

Fully Observable



Partially Observable

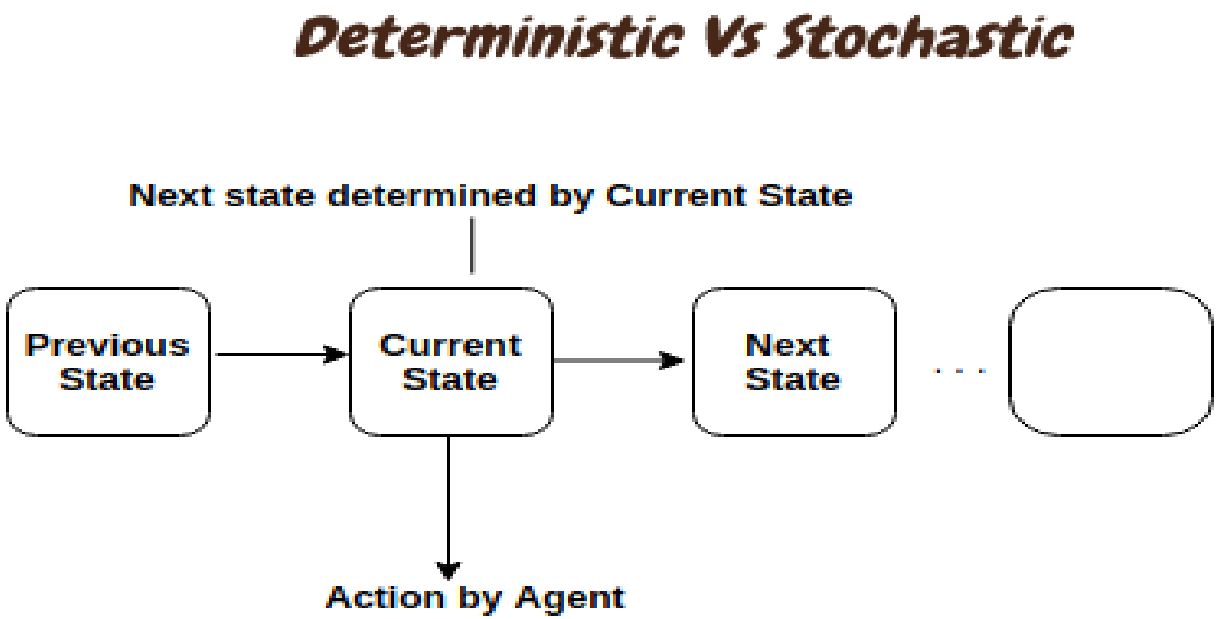
Types of Environment

- **Single Vs Multi Agent:** Only one agent participates in the environment is Single Agent. More than one agent interact the with the environment is Multi 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.

Types of Environment

- **Deterministic Vs Stochastic :** If the next state of the environment is completely determined by the current state & the action executed by the agent, then we say the environment is deterministic, otherwise it is stochastic.



Types of Environment

- **Deterministic Vs Stochastic:**

- Deterministic AI environments are those on which the outcome can be determined base on a specific state. In other words, deterministic environments ignore uncertainty. Most real world AI environments are not deterministic. Instead, they can be classified as stochastic. Tic Tac Toe game, chess is an example of Deterministic environment.
- A stochastic environment is random in nature and cannot be determined completely by an agent. For e.g., if agent kicks the ball in a particular direction, then the ball may or may not be stopped by other players in soccer game, self driving car, the growth of a bacterial population, an electric current fluctuating due to thermal noise or the movement of a gas molecule.
- In a deterministic, fully observable environment, agent does not need to worry about uncertainty.

Types of Environment

- **Uncertainty**: An environment is Uncertain if it is not fully observable or Not Deterministic.
- In a multi-agent environment, Uncertainty arises purely from the actions of other agents. In deterministic, actions of other agents unable to predict by any other agent (each agent).

Types of Environment

- **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. For e.g., An AI that looks at radiology images to determine if there is a sickness.

➢ However, in Sequential environment, an agent requires memory of past actions to determine the next best actions.

➢ In an episodic environment, each agent's performance is the result of a series of independent tasks performed. There is no link between the agent's performance and other different scenarios. In other words, the agent decides which action is best to take, it will only consider the task at hand and doesn't have to consider the effect it may have on future tasks.

- Examples:

➢ Episodic environment: mail sorting system

➢ Non-episodic environment: chess game

Types of Environment

- **Static Vs Dynamic:**

- Static AI environments rely on data-knowledge sources that **don't change frequently over time**. Speech analysis is a problem that operates on static AI environments.
- 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.

Types of Environment

- **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 game comes under discrete environment as there is a finite number of moves that can be performed.
- Continuous AI environments rely on unknown and rapidly changing data sources. Vision systems in drones or self-driving cars operate on continuous AI environments.

Types of Environment

- **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.
- **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.

Introduction to State Space Search

State space search

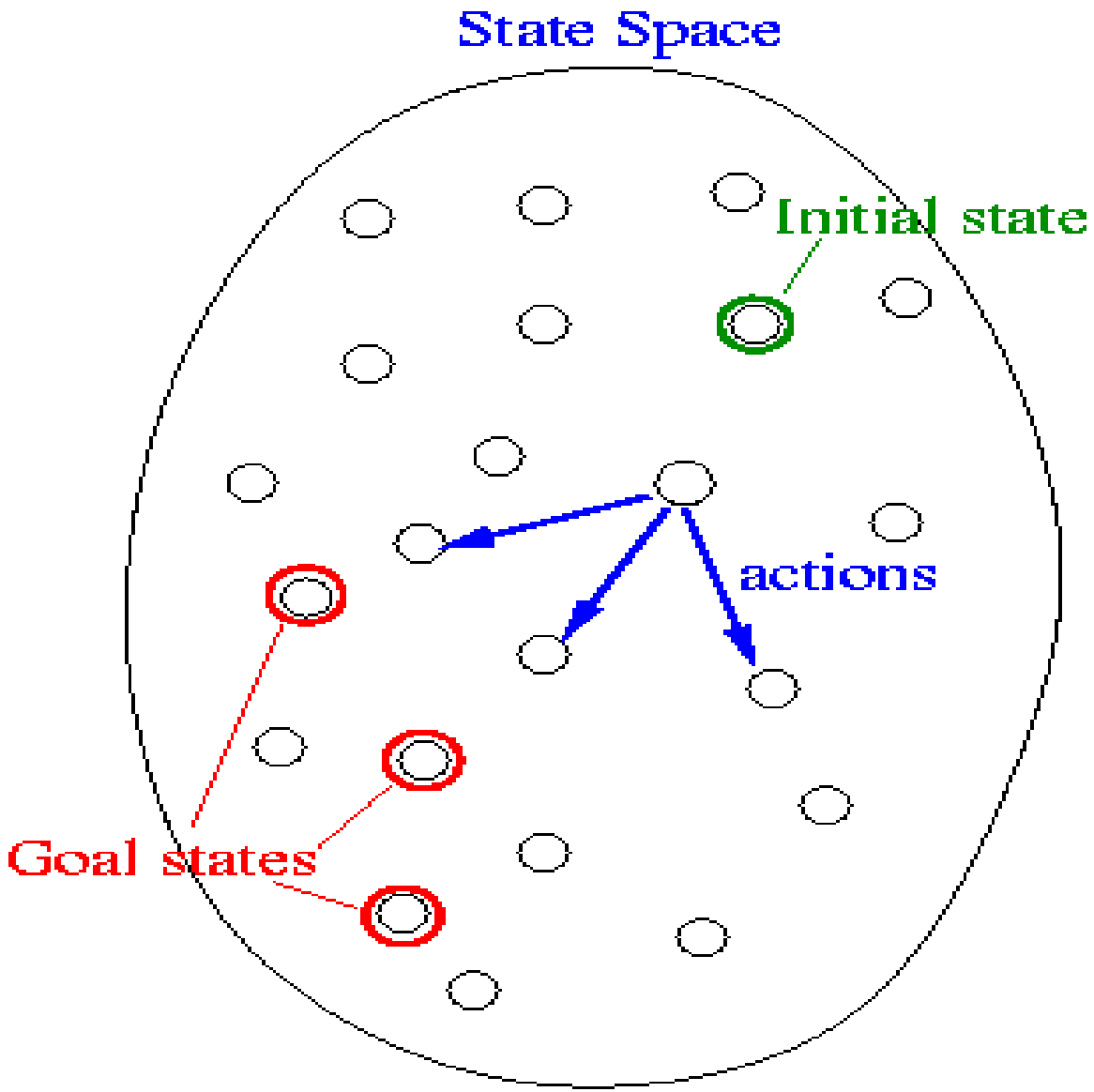
- Formulate a problem as a state space search by showing the legal problem states, the legal operators, and the initial and goal states
- A state is defined by the specification of the values of all attributes of interest in the world
- An operator changes one state into the other;
- The initial state is where you start
- The goal state is the partial description of the solution

Goal Directed Agent

- A goal directed agent needs to achieve certain goals.
- Such an agent selects its actions based on the goal it has.
- Few examples of goal directed agents
  - 15-puzzle:
  - to navigate a maze and reach the HOME position
- The agent must choose a sequence of actions to achieve the desired goal

Search Problem

- A search problem consists of the following:
  - S: the full set of states
  - s_0 : the initial state
  - A: S→Sis a set of operators
  - G is the set of final states. Note that G ⊆S
- Figure Shown in next slide


State Space
Initial state
actions
Goal states

Search Problem

- The search problem is to find a sequence of actions which transforms the agent from the initial state to a goal state $g \in G$.
- A search problem is represented by a 4-tuple $\{S, s_0, A, G\}$.
- This sequence of actions is called a solution plan (path from the initial state to a goal state)
- The cost of a path is a positive number.

Representation of search problems

- A search problem is represented using a directed graph.
  - The states are represented as nodes.
  - The allowed actions are represented as arcs.

Searching process

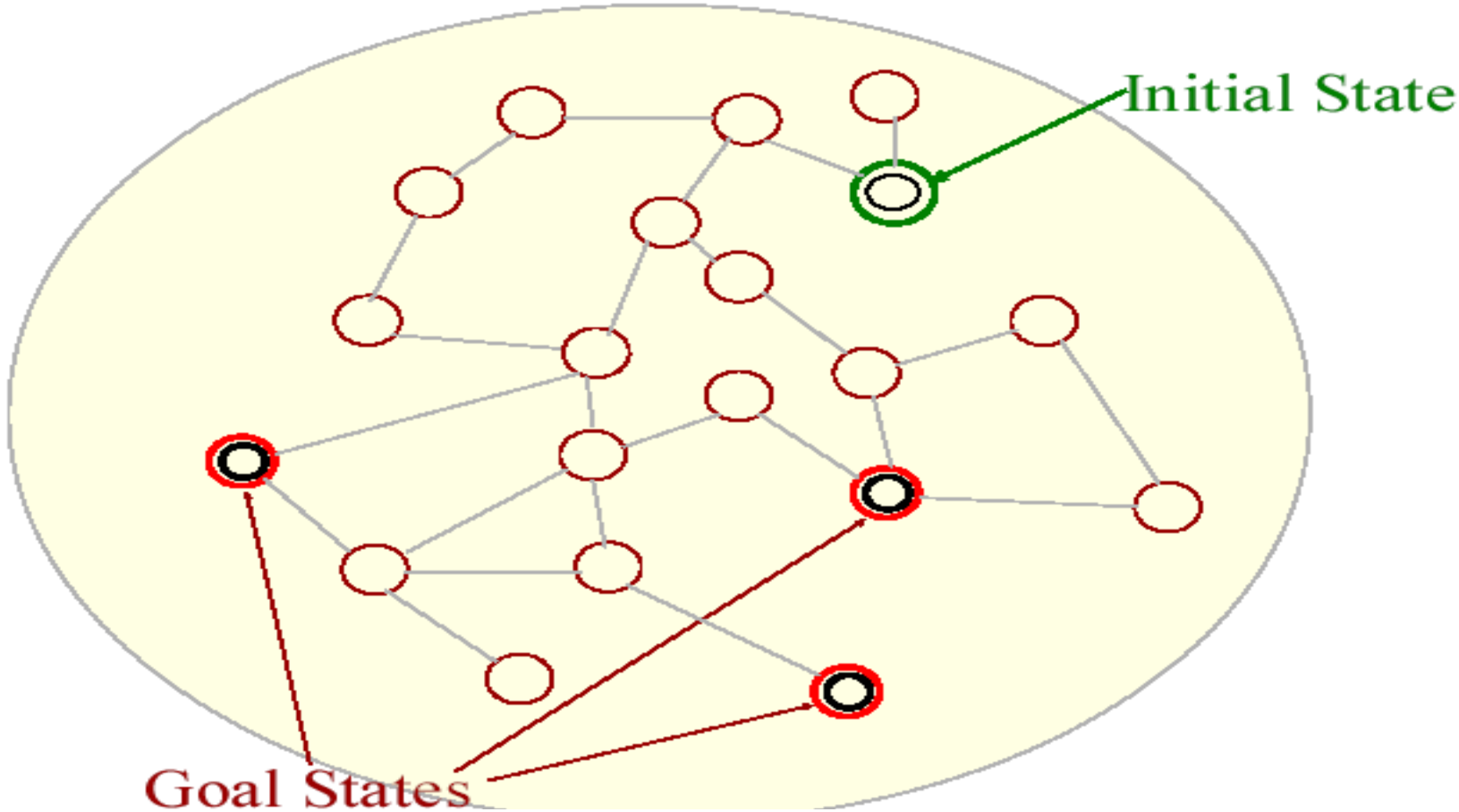
- The generic searching process

Do until a solution is found or the state space is exhausted.

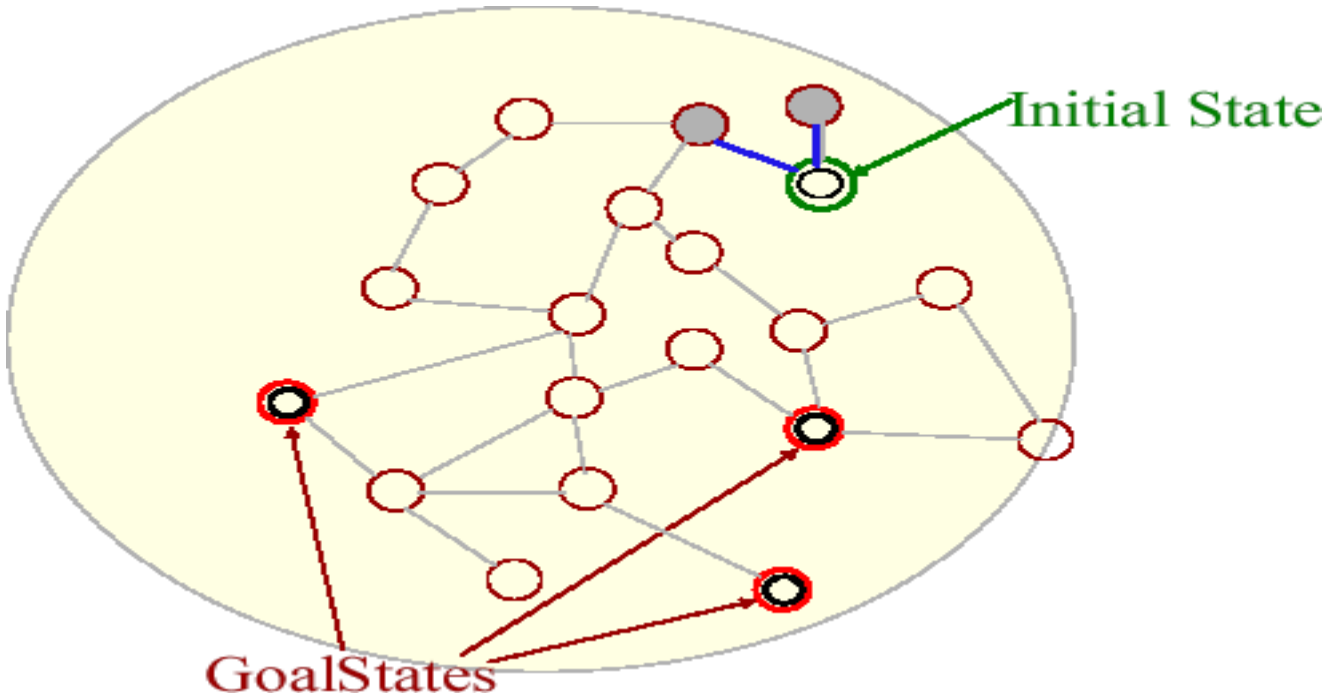
1. Check the current state
2. Execute allowable actions to find the successor states.
3. Pick one of the new states.
4. Check if the new state is a solution state

   If it is not, the new state becomes the current state and the process is repeated

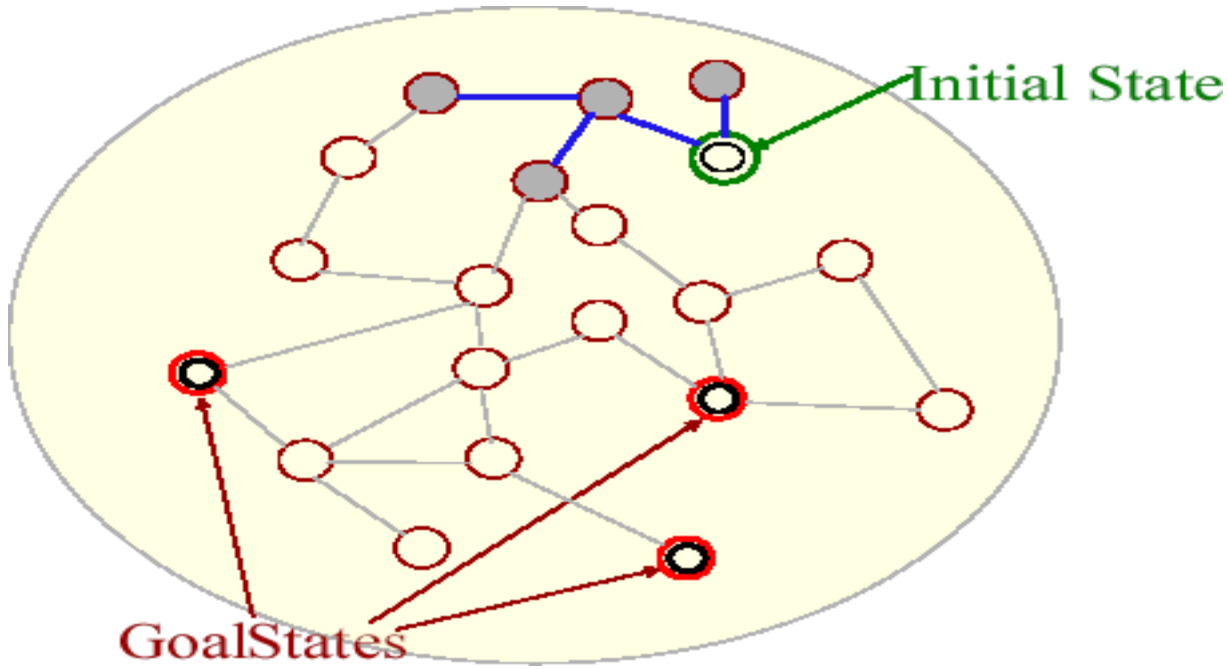
Illustration of a search process



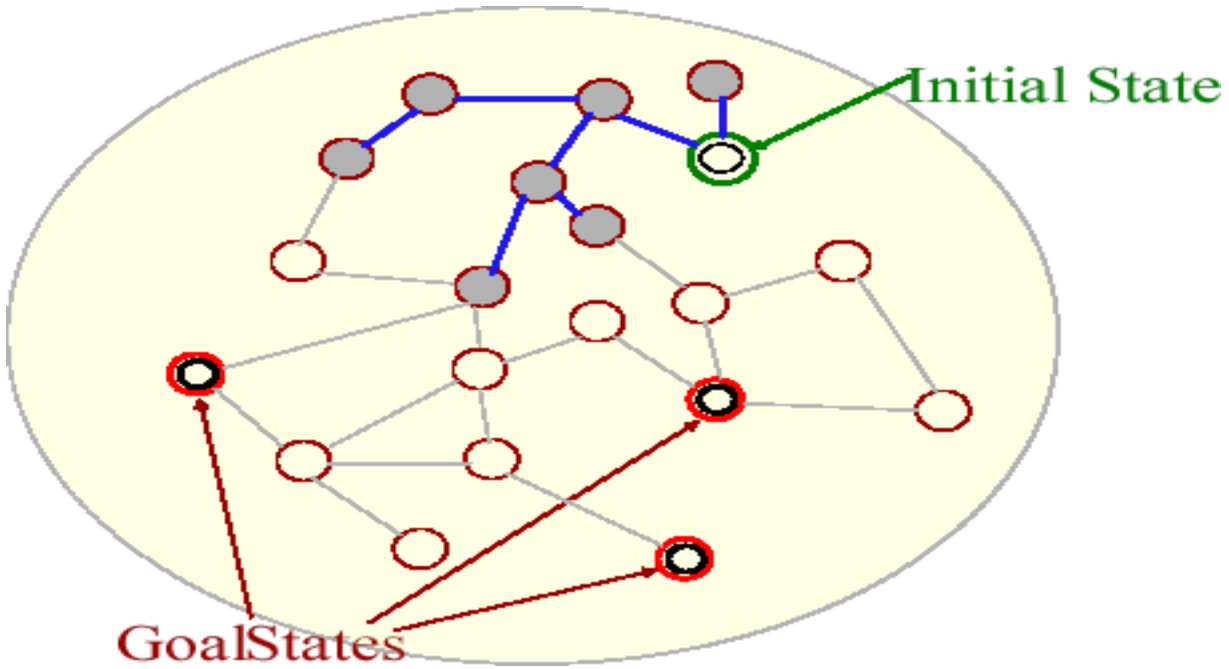
s_0 is the initial state.
The successor states are the adjacent states in the graph.
There are three goal states.



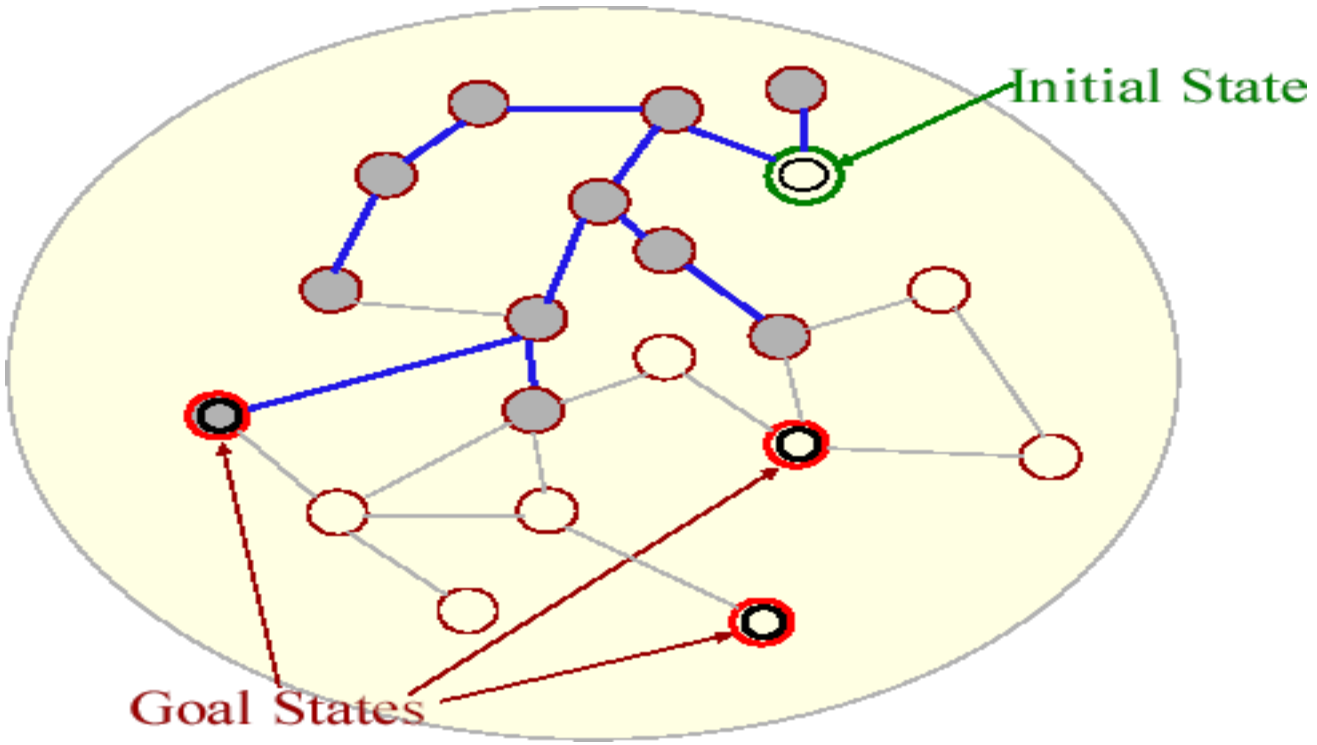
The two successor states of the initial state are generated.



The successors of these states are picked and their successors are generated.



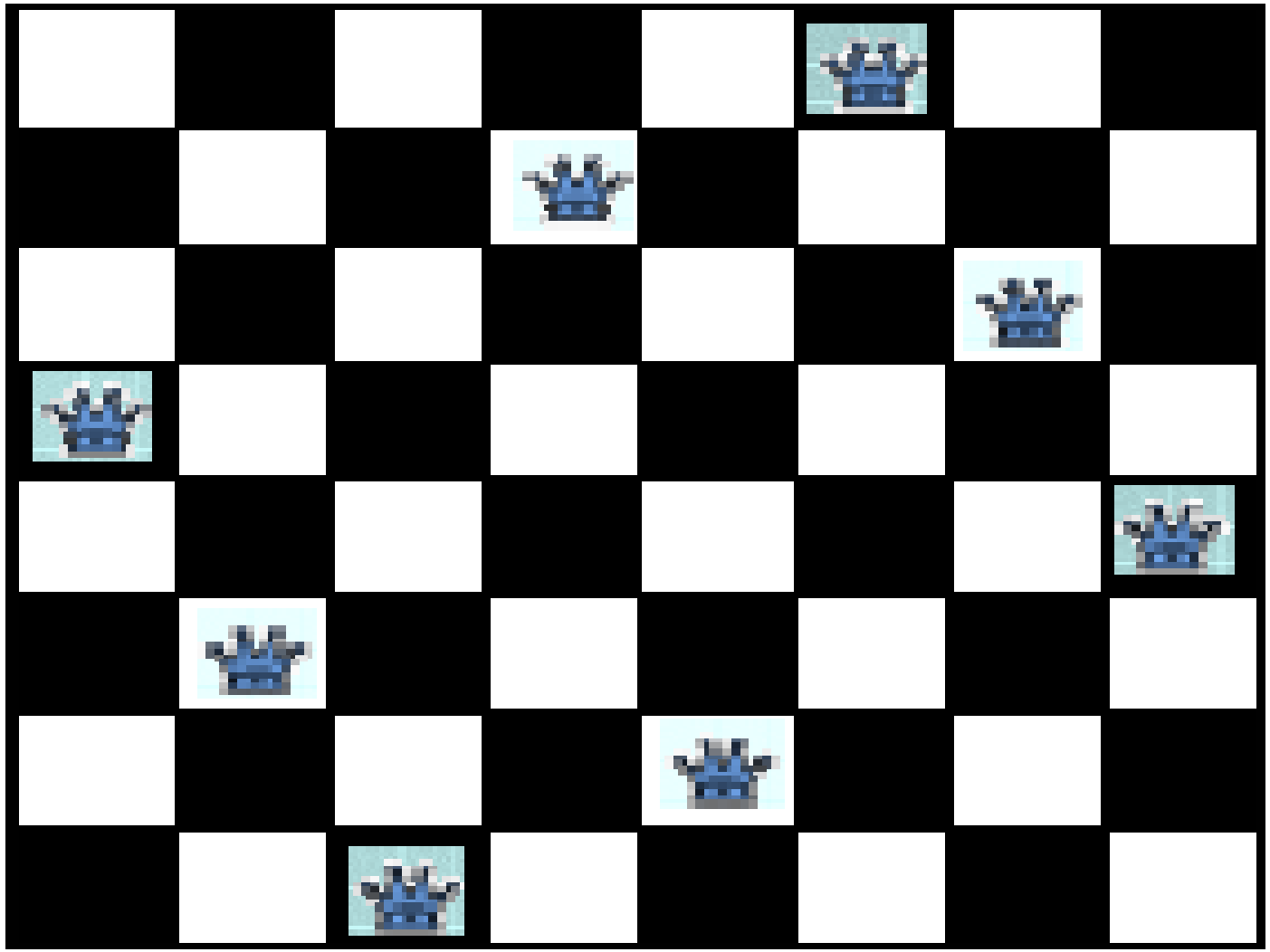
Successors of all these states are generated.



A goal state has been found.

8 queens problem

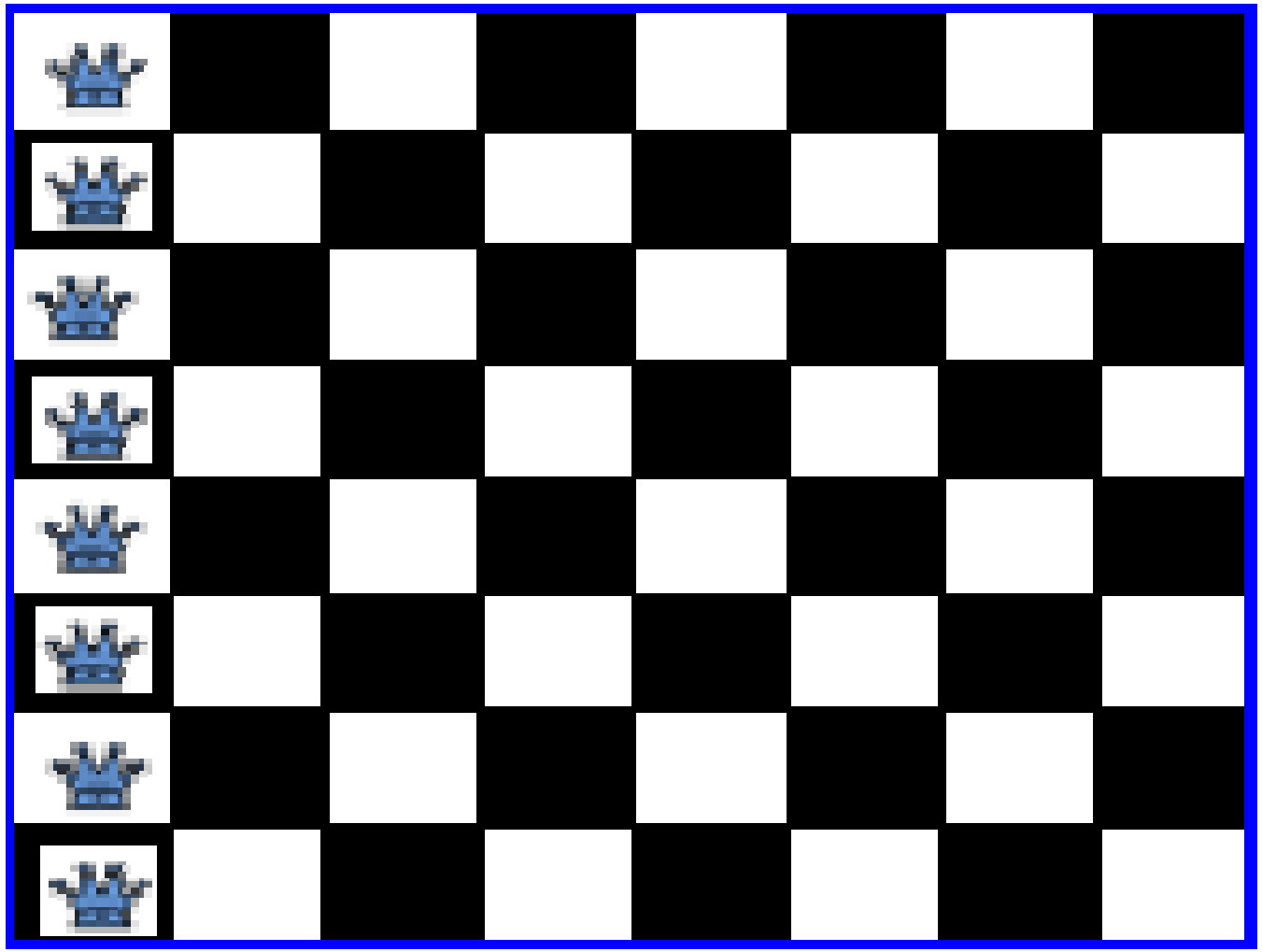
- The problem is to place 8 queens on a chessboard so that no two queens are in the same row, column or diagonal



- Is this state a solution? Yes

N queens problem formulation

- States: Any arrangement of 8 queens on the board
- Initial state: All queens are at column 1
- Successor function: Change the position of any one queen
- Goal test: 8 queens on the board, none are attacked



- If we consider moving the queen at column 1, it may move to any of the seven remaining columns.

Thank you.