Unit 1:
Artificial Intelligence and Its Issues

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What is Artificial Intelligence?

- 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**

- According to the father of Artificial Intelligence, John McCarthy-

“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

- AI is accomplished by studying
  - **How human brain thinks**
  - **How humans learn, decide, and work** while trying to solve a problem, and
  - Then using the **outcomes** of this study as a basis of developing intelligent software and systems

Importance of Artificial Intelligence

1 **Improved Efficiency**

AI can automate and optimize various processes, leading to increased productivity and cost savings.

2 **Expanded Capabilities**

AI systems can tackle complex problems and make decisions beyond human limitations.

3 **Innovative Solutions**

AI enables the development of groundbreaking technologies and applications that can transform industries.

4 **Enhanced Decision-Making**

AI-powered data analysis and predictive models can provide valuable insights to support informed decision-making.

Applications of AI

- Problem solving
- Search and control strategies
- Speech recognition
- Natural language understanding, computer vision, expert systems, etc.

Applications of AI - Examples

- Autonomous planning and scheduling (Ticket booking)
- Decision making (To buy a stock?)
- Machine learning, adaptive methods (Recommendation systems)
- Biologically inspired algorithms
- Game playing (Chess)
- Autonomous control, robotics (Driverless car)
- Natural language processing (Chatbot, Sentiment Analysis, +ve/-ve)

Applications of Artificial Intelligence

Healthcare

AI is transforming healthcare through advanced medical imaging analysis, drug discovery, and personalized treatment recommendations.

Transportation

Self-driving vehicles, traffic optimization, and predictive maintenance are just a few of the AI-powered innovations in transportation.

Finance

AI is used in financial services for fraud detection, risk management, and personalized investment recommendations.

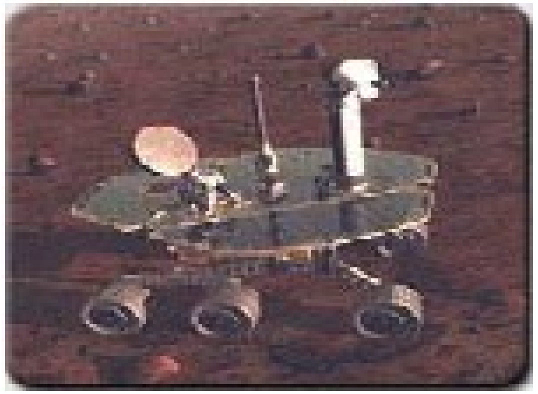
Examples of AI-Artificial Intelligence

- 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

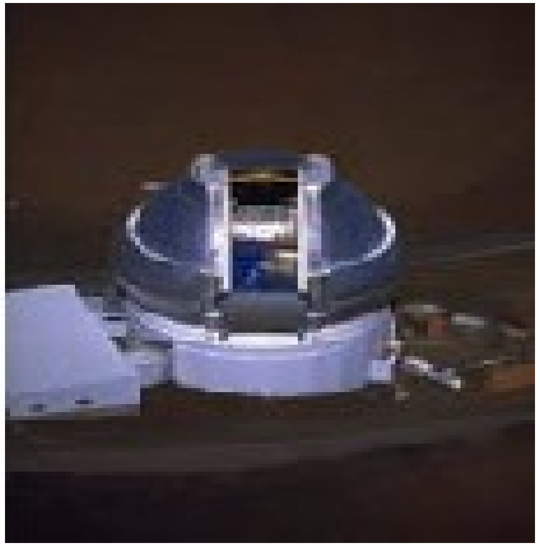
AI Applications

- Autonomous Planning & Scheduling:
  - Autonomous rovers.



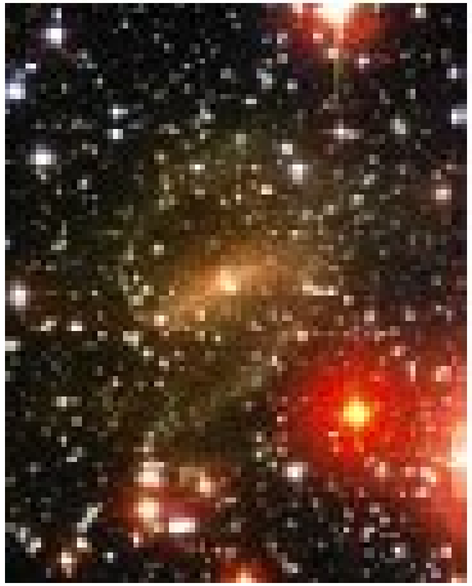
AI Applications

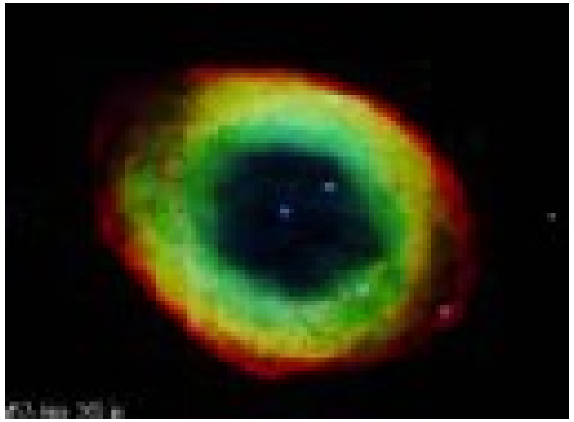
- Autonomous Planning & Scheduling:
  - Telescope scheduling

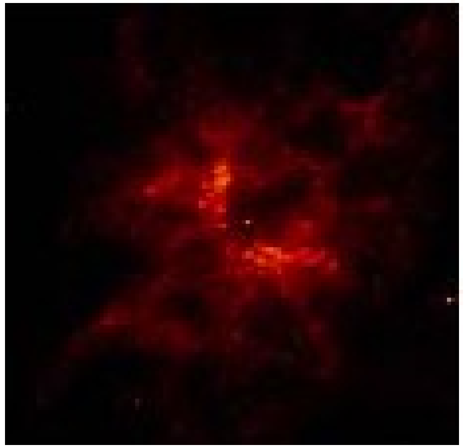


AI Applications

- Autonomous Planning & Scheduling:
  - Analysis of data:

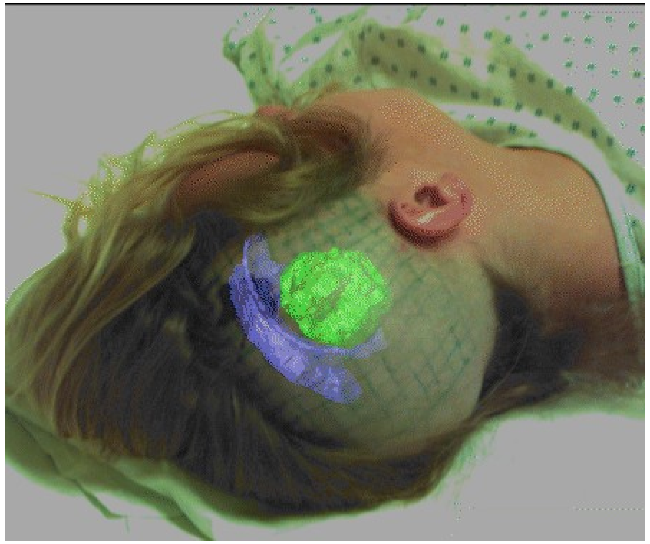


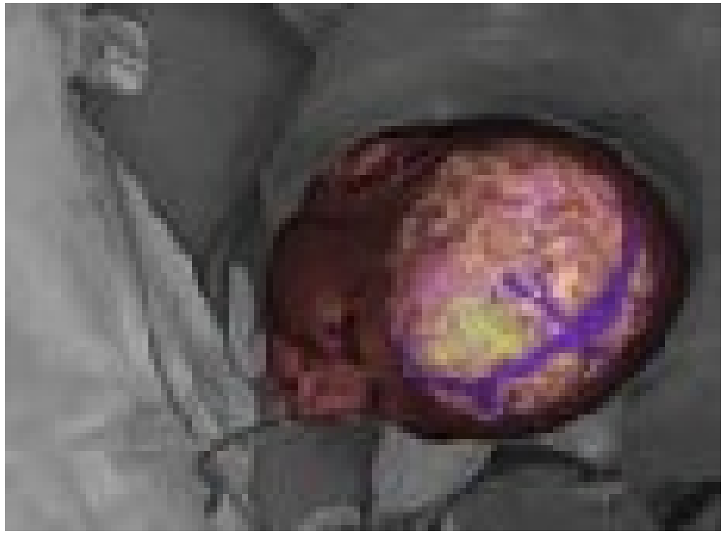




AI Applications

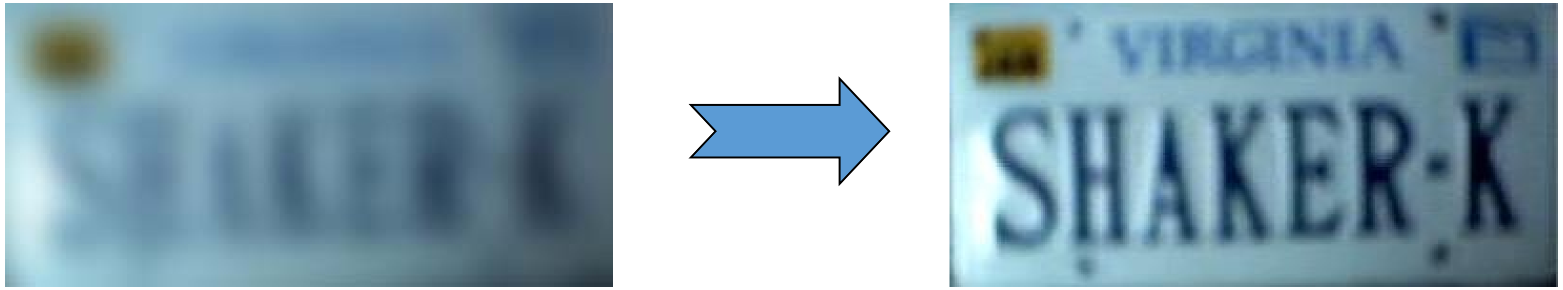
- **Medicine**:
    - Image guided surgery

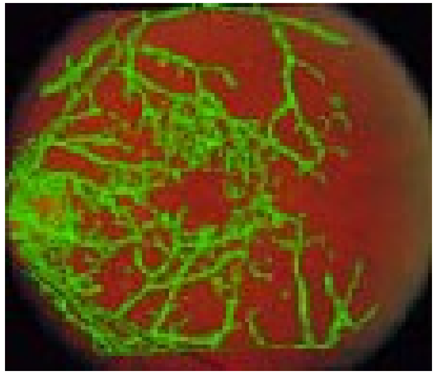


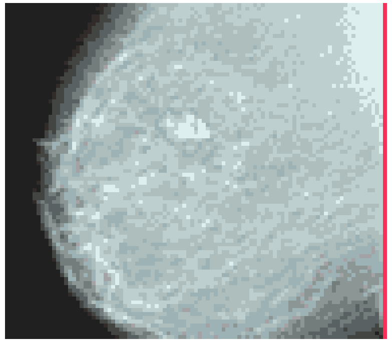


AI Applications

- **Medicine**:
  - Image analysis and enhancement





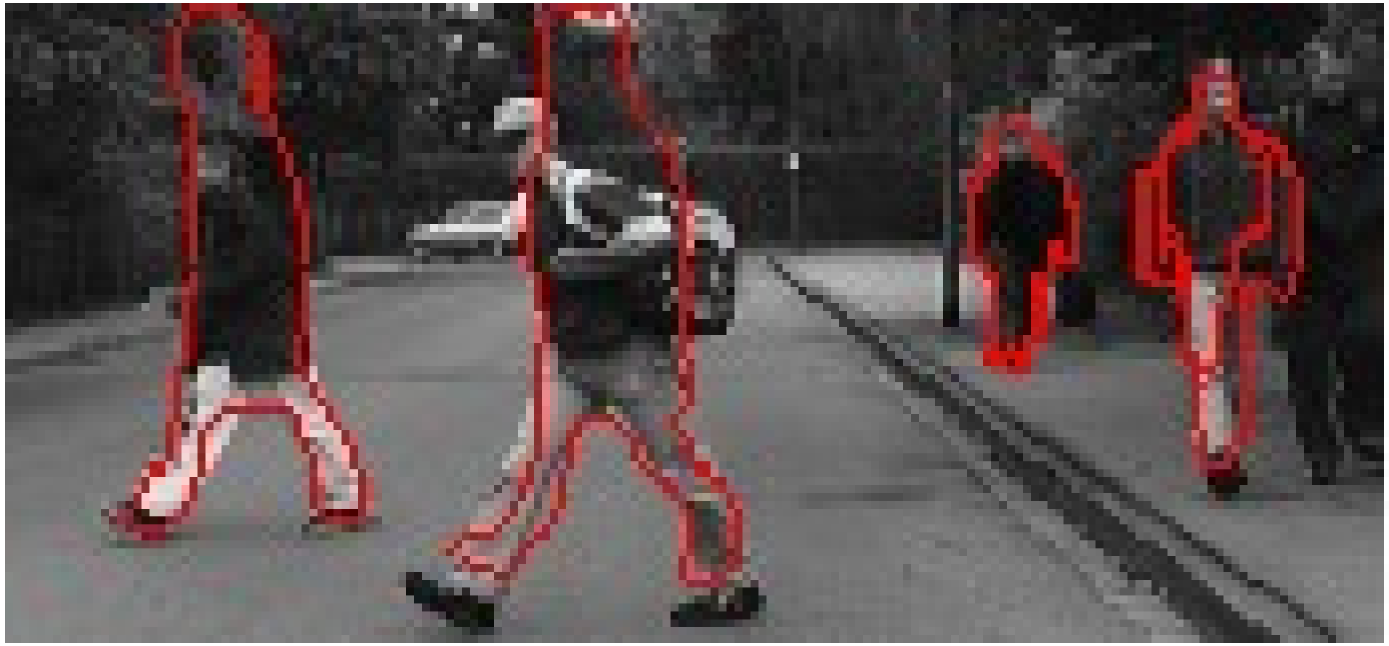


AI Applications

- **Transportation**:
  - **Autonomous vehicle control:**

AI Applications

- **Transportation**:
  - **Pedestrian detection:**

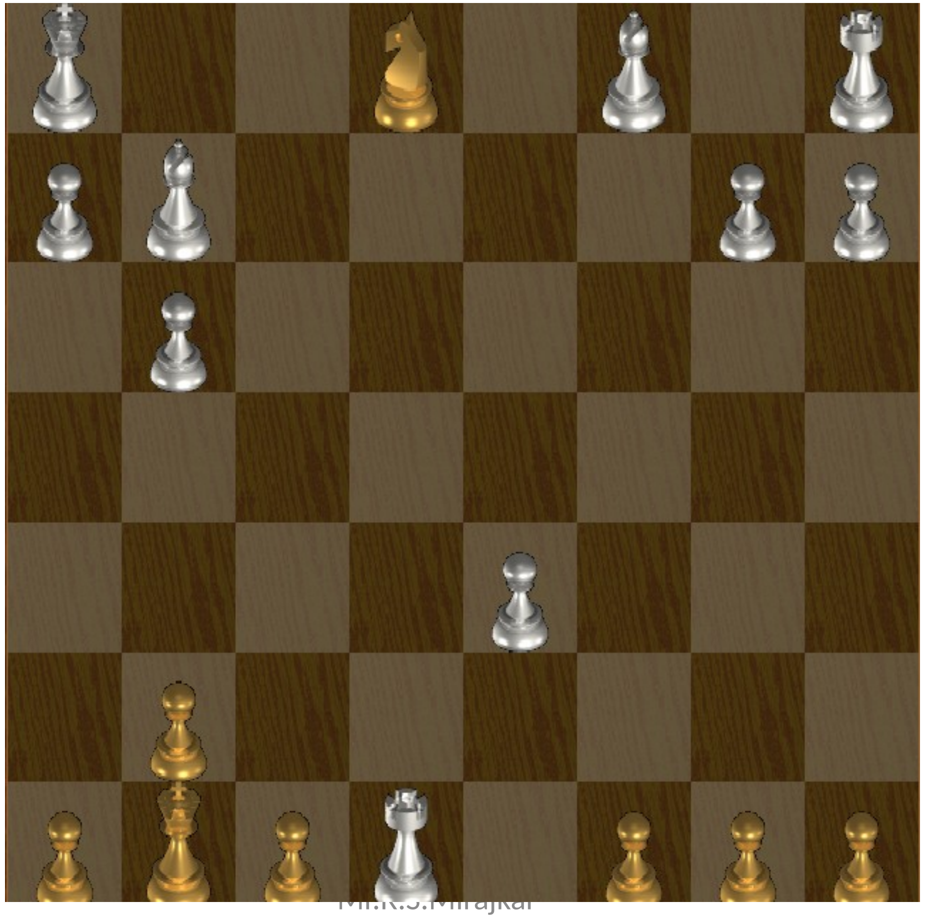


AI Applications

Games:

AI Applications

- **Games**:



AI Applications

- **Robotic toys**:

AI Applications

Other application areas:

- **Bioinformatics:**
  - Gene expression data analysis
  - Prediction of protein structure
- **Text classification, document sortin**g:
  - Web pages, e-mails
  - Articles in the news
- **Video, Image classification**

Search —

- Artificial Intelligence programs often examine large numbers of possibilities

- **For Example-** Moves in a chess game and inferences by a theorem proving program.

- Discoveries are frequently made about how to do this more efficiently in various domains.

Agent

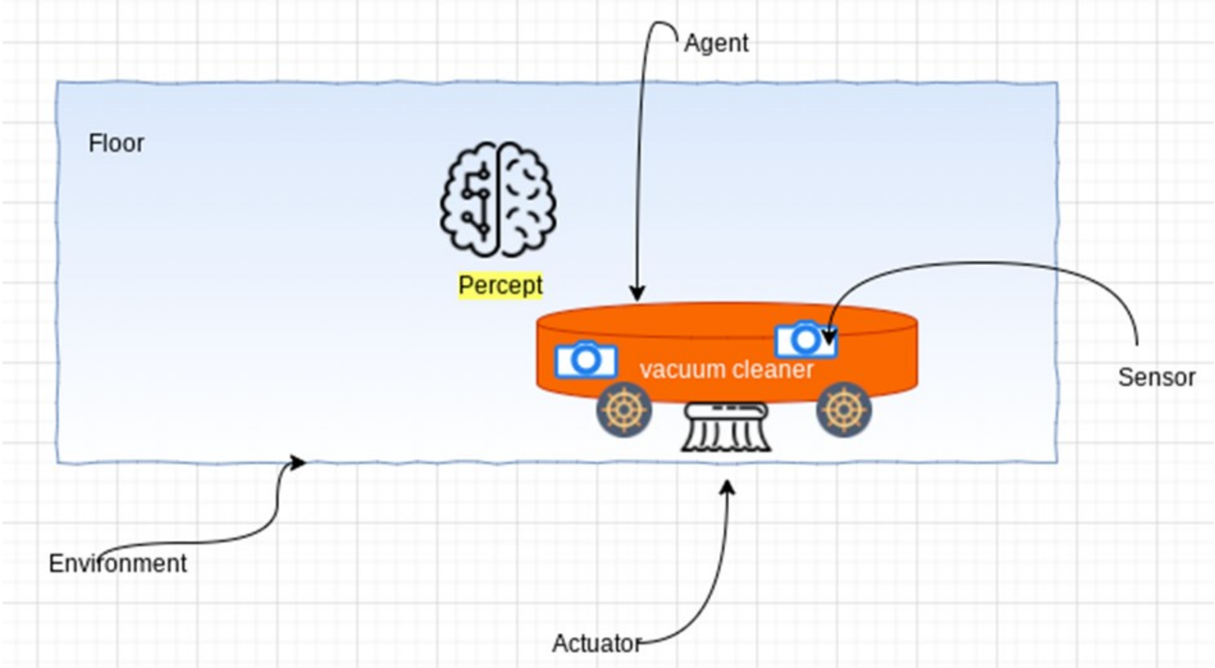
- An agent is anything that can be **ENVIRONMENT** viewed as **perceiving its environment** through sensors and SENSOR acting upon that environment through actuators

RATIONAL AGENT

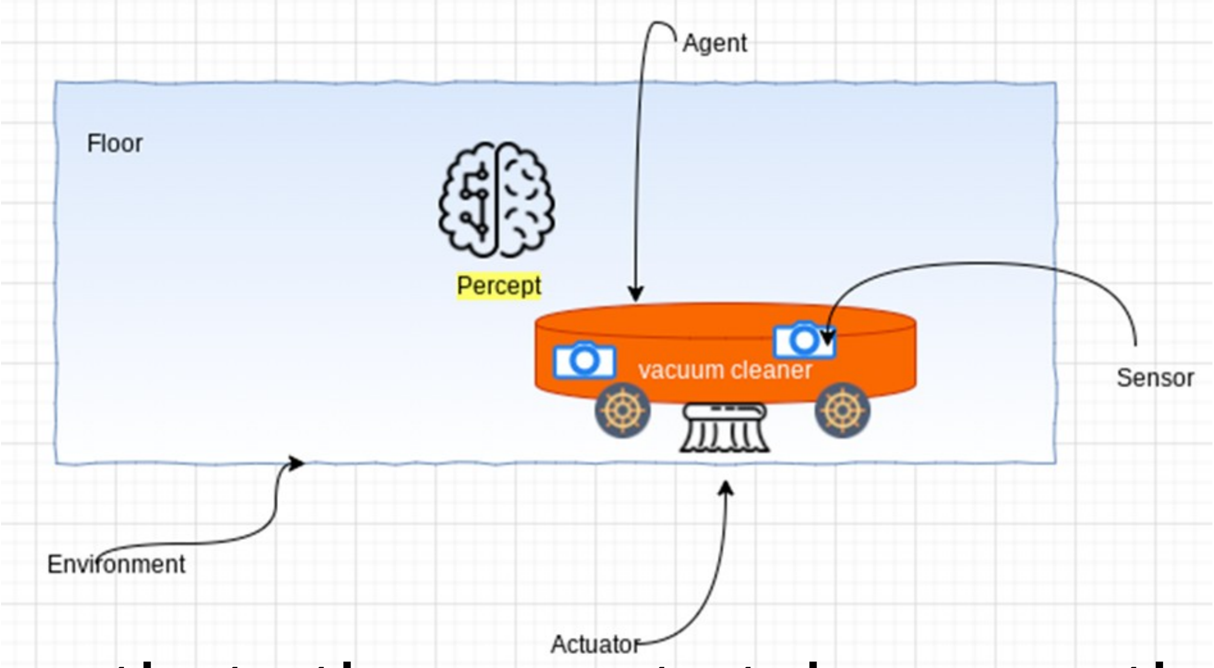
- A rational agent is one AGENT that does the right thing
- Conceptually speaking, every entry in the table for the agent function is filled out correctly.
- Obviously, doing the right thing is better than doing the wrong thing, but what does it mean to do the right thing?

Agent in an Environment

- A **Rational agent** is any piece of software, hardware or a combination of the two which can interact with the environment with actuators after perceiving the environment with sensors.



- Vacuum cleaner as a **Rational agent**.
- **Environment** as the floor which it is trying to clean.
- It has **sensors** like Camera's or dirt sensors which try to sense the environment.
- It has the brushes and the suction pumps as **actuators** which take action.
- **Percept** is the agent's perceptual inputs at any given point of time.



- The action that the agent takes on the basis of the perceptual input is defined by the **agent function**.
- Hence, before an agent is put into the environment, a Percept sequence and the corresponding actions are fed into the agent.
- This allows it to take action on the basis of the inputs.

Agent in an Environment

Percept Sequence	Action
Area1 Dirty	Clean
Area1 Clean	Move to Area2
Area2 Clean	Move to Area1
Area2 Dirty	Clean

What is rational at any given time depends on four things:

- The performance measure that defines the criterion of success.
- The agent's prior knowledge of the environment.
- The actions that the agent can perform.
- The agent's percept sequence to date.

- **DEFINITION OF A RATIONAL AGENT**

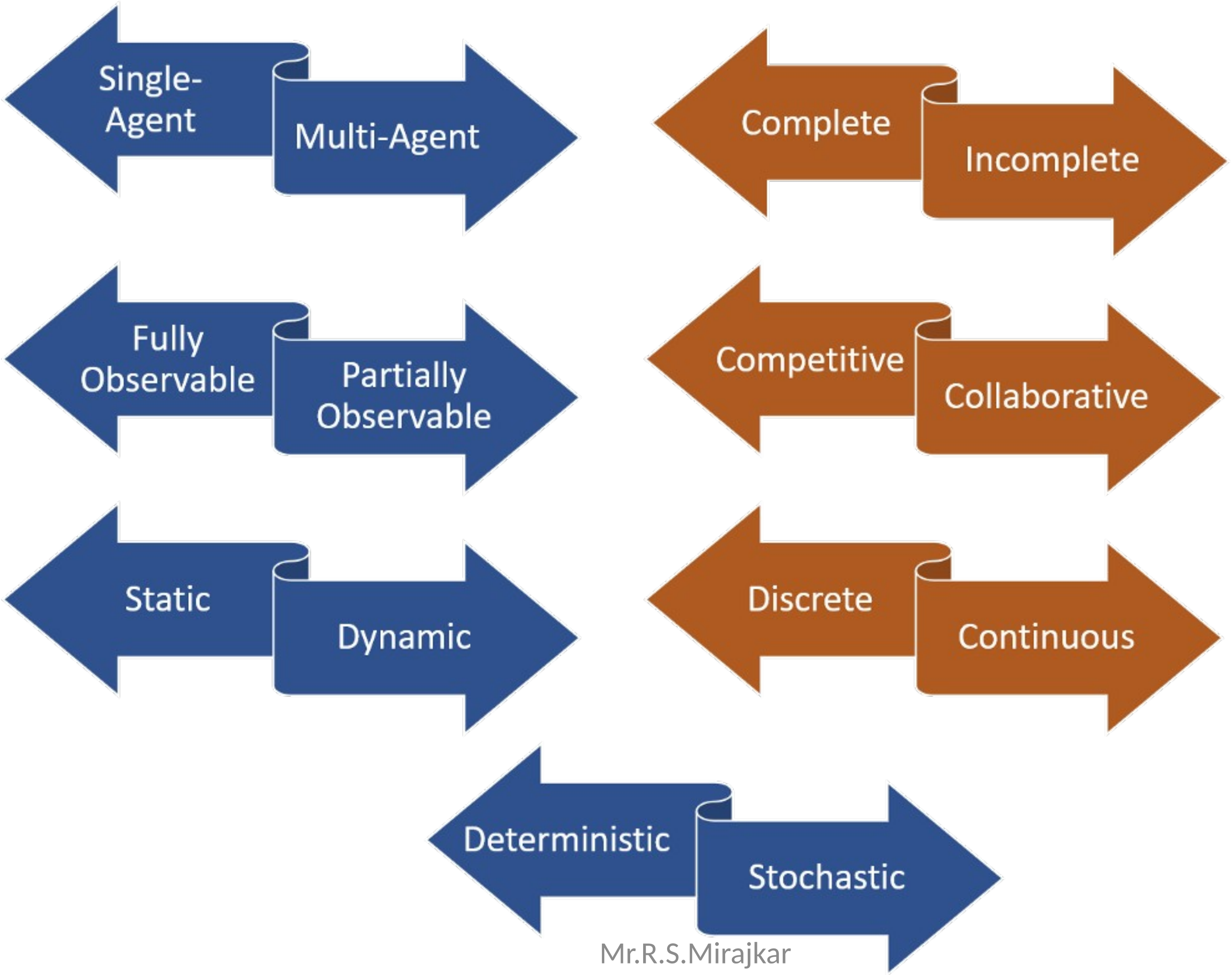
For each possible percept sequence, a rational agent should select an action that is expected to **maximize its performance measure**, given the evidence provided by the **percept sequence** and whatever **built-in knowledge** the agent has.

PEAS (Performance, Environment, Actuators, Sensors)

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

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

Classification of AI systems with respect to environment



1 - Single Agent vs. Multi-Agent

- Number of agents involved.

- The vast majority of AI models today focus on environments involving a single agent but there is an increasing expansion in multi-agent settings.

- The introduction of multiple agents in an AI problem raises challenges such as **collaborative or competitive dynamics** which are not present in single-agent environments.

2.Complete vs. Incomplete

- **Complete AI environments** are those on which, at any given time, the agents have enough information to complete a branch of the problem.
- **Chess** is a classic example of a complete AI environment.

- **Poker,** on the other hand, is an **incomplete environments** as AI strategies can only anticipate many moves in advance and, instead, they focus on finding a good ‘balance at any given time.

3.Fully Observable vs. Partially Observable

- A fully observable AI environment has access to all required information to complete target task.
- **Image recognition** operates in fully observable domains.

- **Partially observable** environments such as the ones encountered in **self-driving vehicle** scenarios deal with partial information in order to solve AI problems.
- Partially observable environments often rely on statistic techniques to infer knowledge of the environment.

4.Competitive vs. Collaborative

- Competitive AI environments face AI agents against each other in order to optimize a specific outcome.
- **Game such as Chess** is example of competitive AI environments.
- Collaborative AI environments rely on the cooperation between multiple AI agents.
- Self-driving vehicles are cooperating to avoid collisions S
- **Smart home sensors interactions** are examples of collaborative AI environments.
- Many multi-agent environments such as **video games include both collaborative and competitive dynamics** which makes them particularly challenging from an AI perspective.

5. 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.
- **Dynamic AI environments** such as the **vision AI systems** in drones deal with data sources that change quite frequently.
- Dynamic AI environments often need to enable faster and more regular training of AI agents.

6. Discrete vs. Continuous

- Discrete AI environments are those on which a finite [although arbitrarily large] set of possibilities can drive the final outcome of the task.
- **Chess** is also classified as a discrete AI problem.
- Continuous AI environments rely on unknown and rapidly changing data sources.
- **Multi-player video games** are a classic example of continuous AI environments.

7 - Deterministic vs. Stochastic

- Deterministic AI environments are those on which the outcome can be **determined based on a specific state.**
- Most real world AI environments are not deterministic.
- Instead, they can be classified as **stochastic.**
- **Stochastic - Having a random probability distribution or pattern that may be analyzed statistically but may not be predicted precisely.**
- Self-driving vehicles are a one of the most extreme examples of stochastic AI environments but simpler settings can be found in simulation environments or even speech analysis models.

- **Knowledge base:** Central component of a knowledge-based agent, KB.
- It is a collection of sentences
- (here 'sentence' is a technical term and it is not identical to sentence in English).
- These sentences are expressed in a language which is called a **knowledge representation language**.
- The Knowledge-base of KBA stores fact about the world.

- **Why use a knowledge base?-** for updating knowledge for an agent to learn with experiences and take action as per the knowledge.

Knowledge-Based Agent in Artificial intelligence

- An **intelligent agent** needs **knowledge about the real world** for taking decisions and reasoning to act efficiently.
- Knowledge-based agents-
  1. Maintaining An Internal State Of Knowledge,
  2. Reason Over That Knowledge
  3. Update Their Knowledge After Observations And
  4. Take Actions.
- These agents can represent the world with some formal representation and act intelligently.

Knowledge-based agents are composed of two main parts:

- **Knowledge-base and Inference system.**

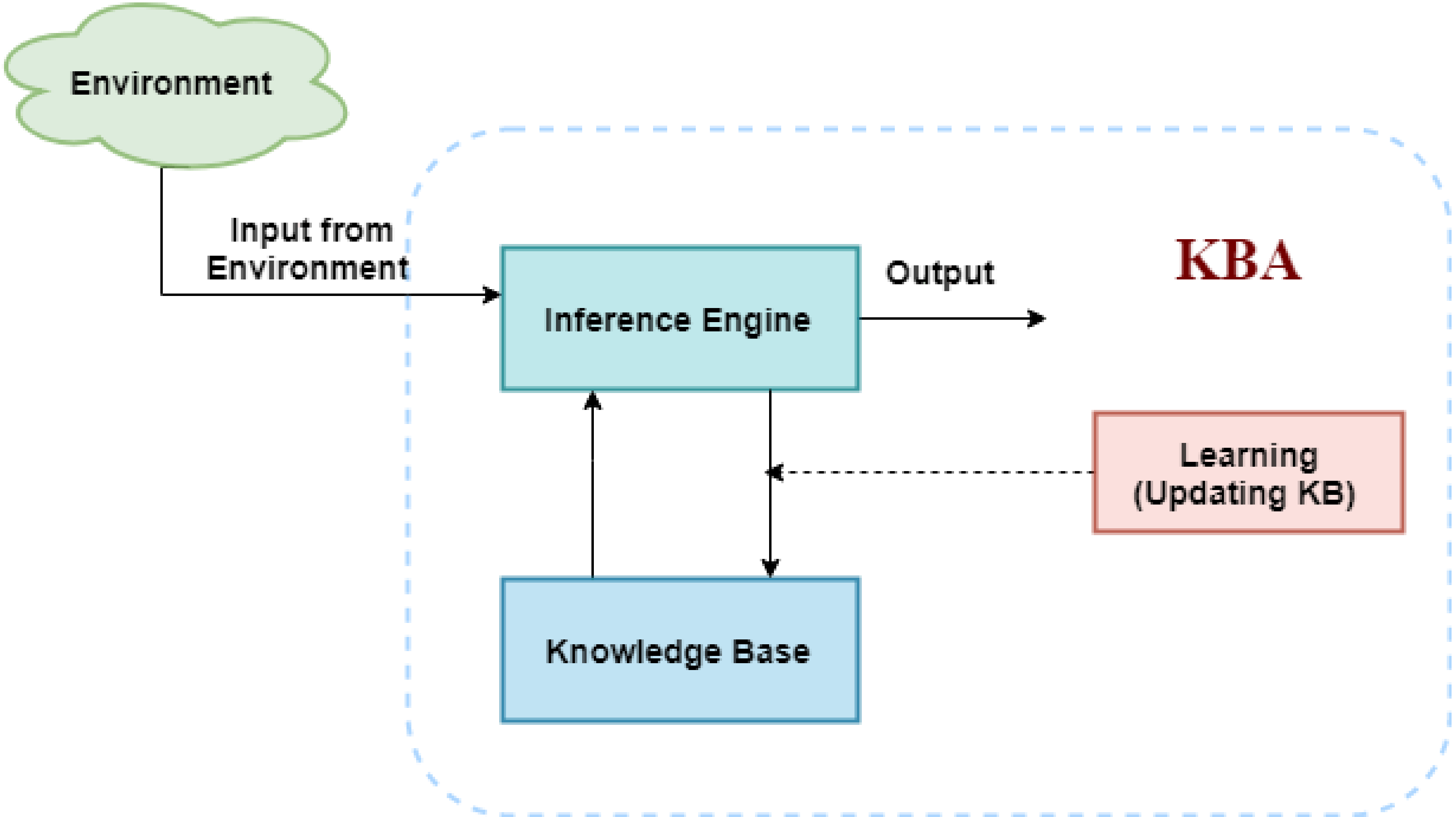
- A **knowledge-based agent** must able to do the following:

- An agent should be able to represent states, actions, etc.
- An agent should be able to incorporate new percepts
- An agent can update the internal representation of the world
- An agent can deduce the internal representation of the world
- An agent can deduce appropriate actions.

knowledge-based agent (KBA)

- It **take input from the environment** by perceiving the environment.
- The input is taken by the inference engine of the agent and which also communicate with KB to decide as per the knowledge store in KB.
- The **learning element of KBA** regularly updates the KB by learning new knowledge.

Architecture of knowledge-based agent:



Inference system

- **Inference** means deriving new sentences from old.
- Inference system allows us to add a new sentence to the knowledge base.
- Inference system applies logical rules to the KB to deduce new information.
- Inference system generates new facts so that an agent can update the KB.

Operations Performed by KBA

- Operations to **show the intelligent behavior**:
- **TELL:** This operation tells the knowledge base what it perceives from the environment.
- **ASK:** This operation asks the knowledge base what action it should perform.
- **Perform:** It performs the selected action.

A generic knowledge-based agent:

function KB-AGENT(percept):

persistent: KB, a knowledge base

t, a counter, initially 0, indicating time

TELL(KB, MAKE-PERCEPT-SENTENCE(percept, t))

Action = **ASK**(KB, MAKE-ACTION-QUERY(t))

TELL(KB, MAKE-ACTION-SENTENCE(action, t))

t = t + 1

return action

- The knowledge-based agent takes **percept as input** and returns an **action as output**.

1. It **asks KB what action** it should take
2. It **TELLS the KB that which action was chosen**.

- The **MAKE-PERCEPT-SENTENCE** generates a sentence as setting that the agent perceived the given percept at the given time.

- The **MAKE-ACTION-QUERY** generates a sentence to ask which action should be done at the current time.

- **Various levels of knowledge-based agent:**

1. **Knowledge level:**

- Knowledge level is the first level of knowledge-based agent, and in this level, we need to **specify what the agent knows, and what the agent goals are.**

- With these specifications, we can fix its behavior.

- **Example-** Suppose an automated taxi agent needs to go from a station A to station B, and he knows the way from A to B, so this comes at the knowledge level.

Various levels of knowledge-based agent:

2. Logical level:

- At this level, we understand that **how the knowledge representation of knowledge is stored**.
- At this level, sentences are encoded into **different logics**.
- **At the logical level we can expect to the automated taxi agent to reach to the destination B.**

Various levels of knowledge-based agent:

3. Implementation level:

- Physical representation of logic and knowledge.
- At the implementation level agent perform actions as per logical and knowledge level.
- **At this level, an automated taxi agent actually implement his knowledge and logic so that he can reach to the destination.**

Types of knowledge

1. **Declarative Knowledge:**

- Declarative knowledge is to know about something.
- It includes concepts, facts, and objects.
- It is also called descriptive knowledge and expressed in declarative sentences.
- Example - Knowing paris is capital of france
- Example - Being aware that formula for area of rectangle is length times width

2. **Procedural Knowledge**

- It is also known as imperative(VIMP) knowledge.
- Procedural knowledge is a type of knowledge which is responsible for knowing how to do something.
- It can be directly applied to any task.
- It includes rules, strategies, procedures, agendas, etc.
- Examples – Knowing how to ride a bicycle, Understand steps to bake a cake, Being skilled in playing musical instruments like piano

3. **Meta-knowledge:**

- Knowledge about the other types of knowledge is called Meta-knowledge.
- Example - Understand certain ML Algorithms perform better with more training data

4. **Heuristic knowledge:**

- Heuristic knowledge is representing knowledge of some experts in a filed or subject.
- Heuristic knowledge is rules of thumb based on previous experiences, awareness of approaches, and which are good to work but not guaranteed.
- Example – Finding a shortest route to a destination in a city

5. **Structural knowledge:**

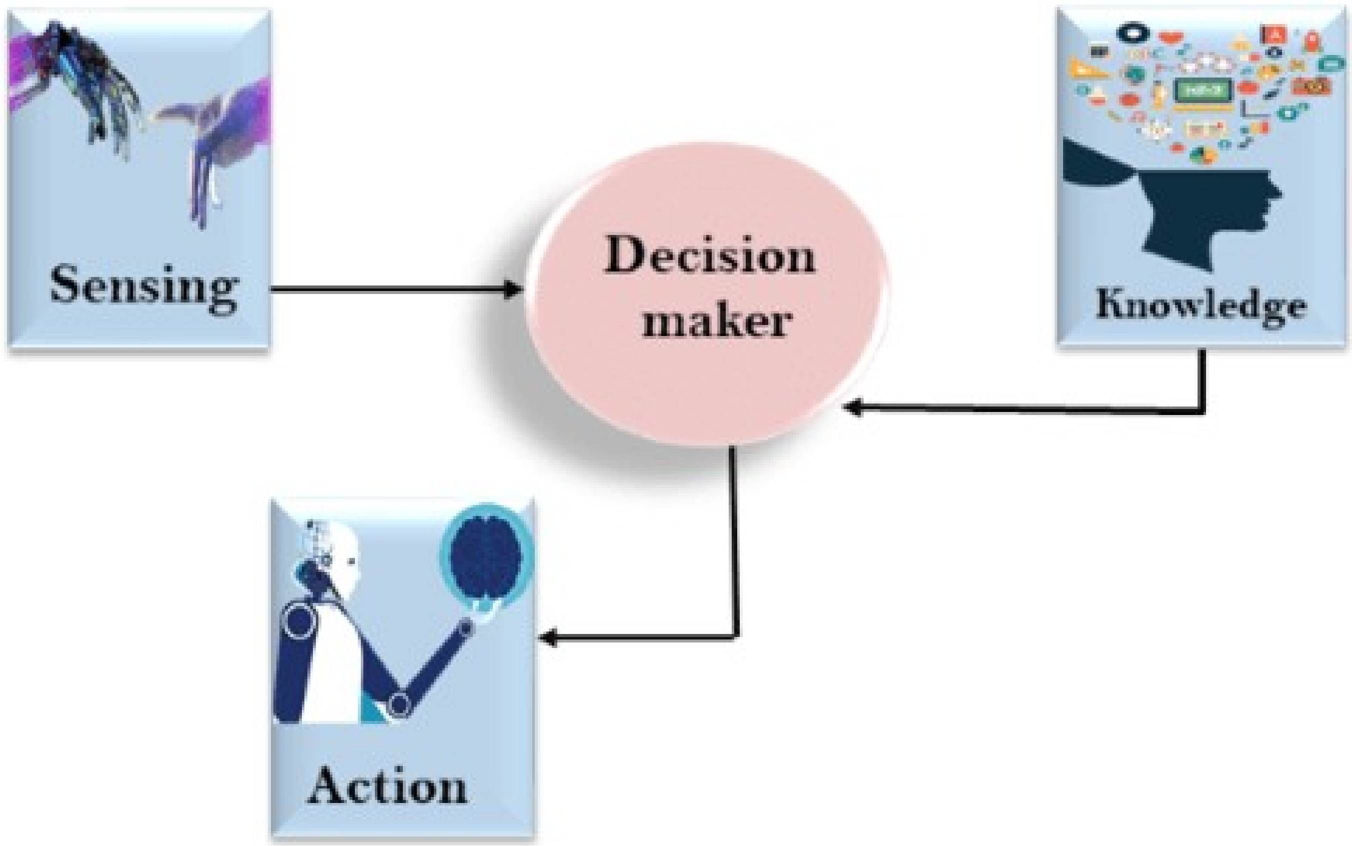
- Structural knowledge is basic knowledge to problem-solving.
- It describes relationships between various concepts such as kind of, part of, and grouping of something.
- It describes the relationship that exists between concepts or objects.

- Example – Understanding the hierarchical structure of a companys organizational chart.

The relation between knowledge and intelligence:

- Knowledge of real-worlds plays a vital role in intelligence and same for creating artificial intelligence.
- Knowledge plays an important role in demonstrating intelligent behavior in AI agents.
- An agent is only able to accurately act on some input when he has some knowledge or experience about that input.
- **Example**
- Let's suppose if you met some person who is speaking in a language which you don't know, then how you **will able to act on that.**
- The same thing applies to the **intelligent behavior** of the agents.

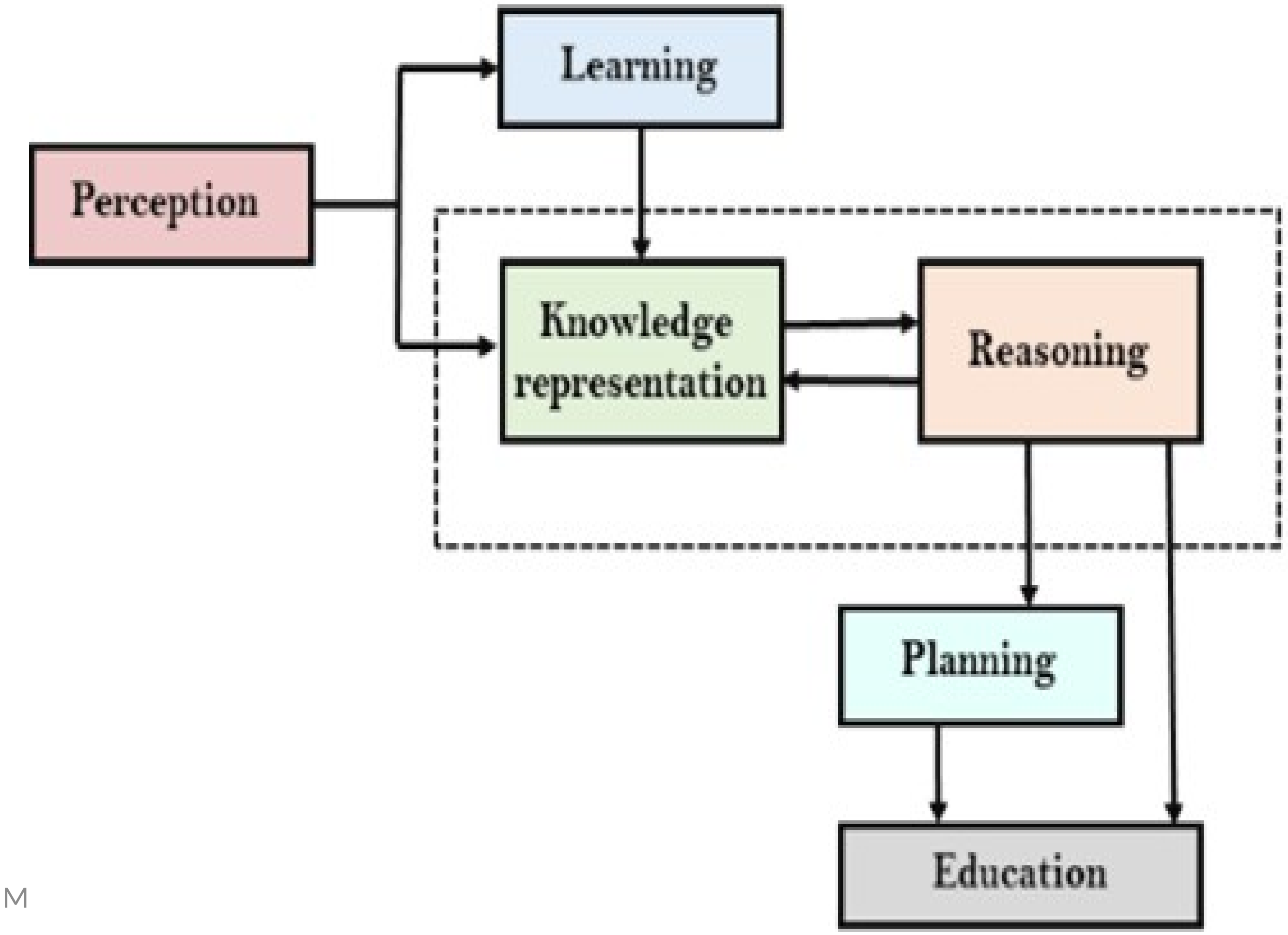
In diagram –
- There is one decision maker which act by sensing the environment and using knowledge.
- But if the knowledge part will not present then, it cannot display intelligent behavior.



AI knowledge cycle:

- Components for displaying intelligent behavior:

- Perception
- Learning
- Knowledge Representation
 & Reasoning
- Planning
- Execution



Approaches to knowledge representation:

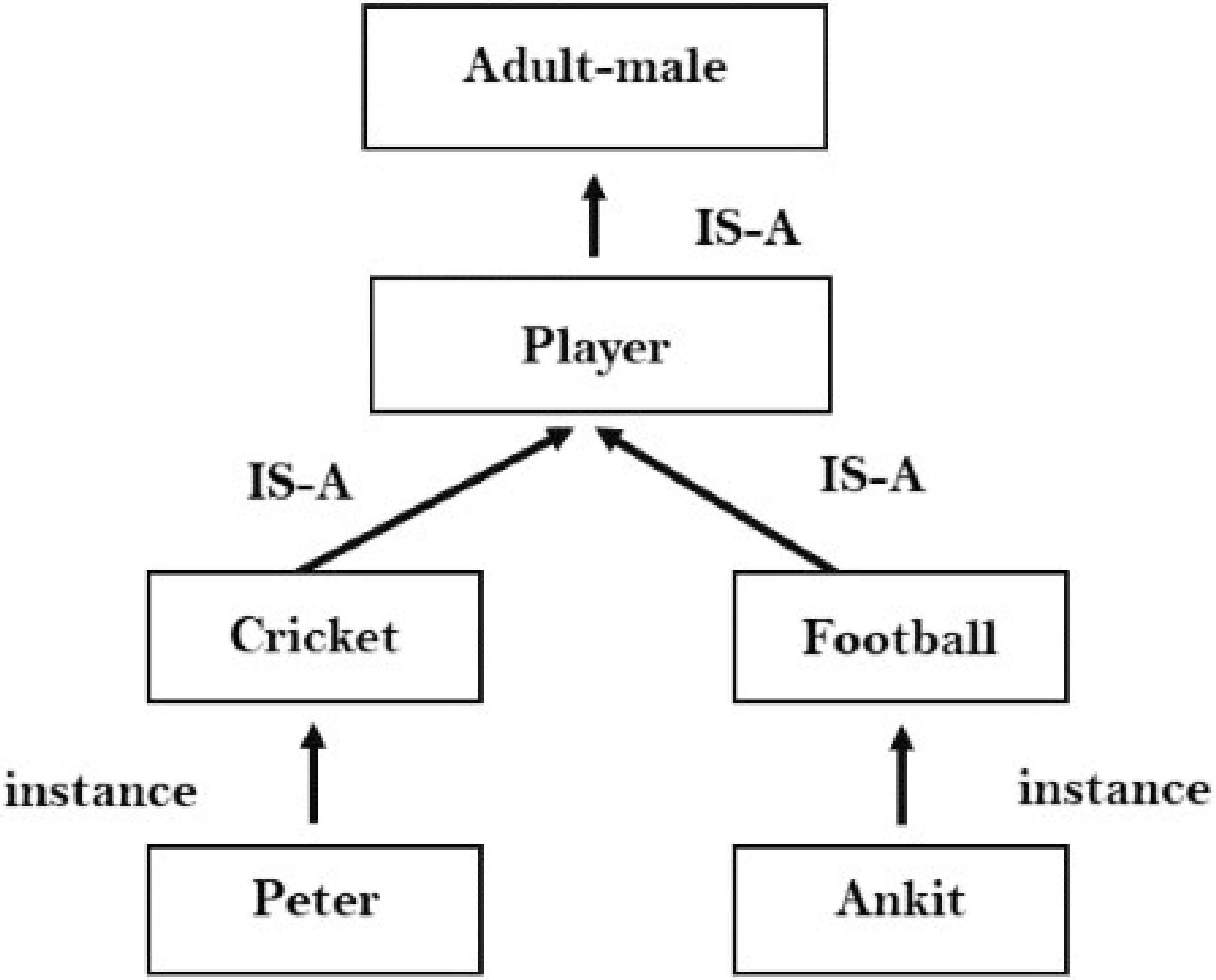
- **Simple Relational Knowledge:**
  - It is the simplest way of storing facts which uses the relational method, and each fact about a set of the object is set out systematically in columns.
  - This approach of knowledge representation is famous in database systems where the relationship between different entities is represented.
  - This approach has little opportunity for inference.

- **Example:** The following is the simple relational knowledge representation.

Player	Weight	Age
Player1	65	23
Player2	58	18
Player3	75	24

2. Inheritable knowledge:

- In the inheritable knowledge approach, all data must be stored into a hierarchy of classes.
- All classes should be arranged in a generalized form or a hierarchal manner.
- In this approach, we apply inheritance property.
- Elements inherit values from other members of a class.
- This approach contains inheritable knowledge which shows a relation between instance and class, and it is called instance relation.
- Every individual frame can represent the collection of attributes and its value.
- In this approach, objects and values are represented in Boxed nodes.
- We use Arrows which point from objects to their values.


Adult-male
IS-A
Player
IS-A
IS-A
Cricket
Football
instance
instance
Peter
Ankit

Inferential knowledge:

- Inferential knowledge approach represents knowledge in the form of formal logics.
- This approach can be used to derive more facts.
- It guaranteed correctness.
- Example:

Let's suppose there are two statements:

  - Marcus is a man
  - All men are mortal
  - Then it can represent as;

- man(Marcus) ∀x = man (x) ----------> mortal (x)s

Procedural knowledge:

- Procedural knowledge approach uses small programs and codes which describes how to do specific things, and how to proceed.
- In this approach, one important rule is used which is **If-Then rule.**
- We can easily represent heuristic or domain-specific knowledge using this approach.
- But it is not necessary that we can represent all cases in this approach.

Causes of uncertainty in AI

- Information occurred from unreliable sources.
- Experimental Errors
- Equipment fault
- Temperature variation
- Climate change.

Probabilistic reasoning:

- Probabilistic reasoning is a way of knowledge representation where we apply the concept of probability to indicate the uncertainty in knowledge.
- In probabilistic reasoning, we combine probability theory with logic to handle the uncertainty.

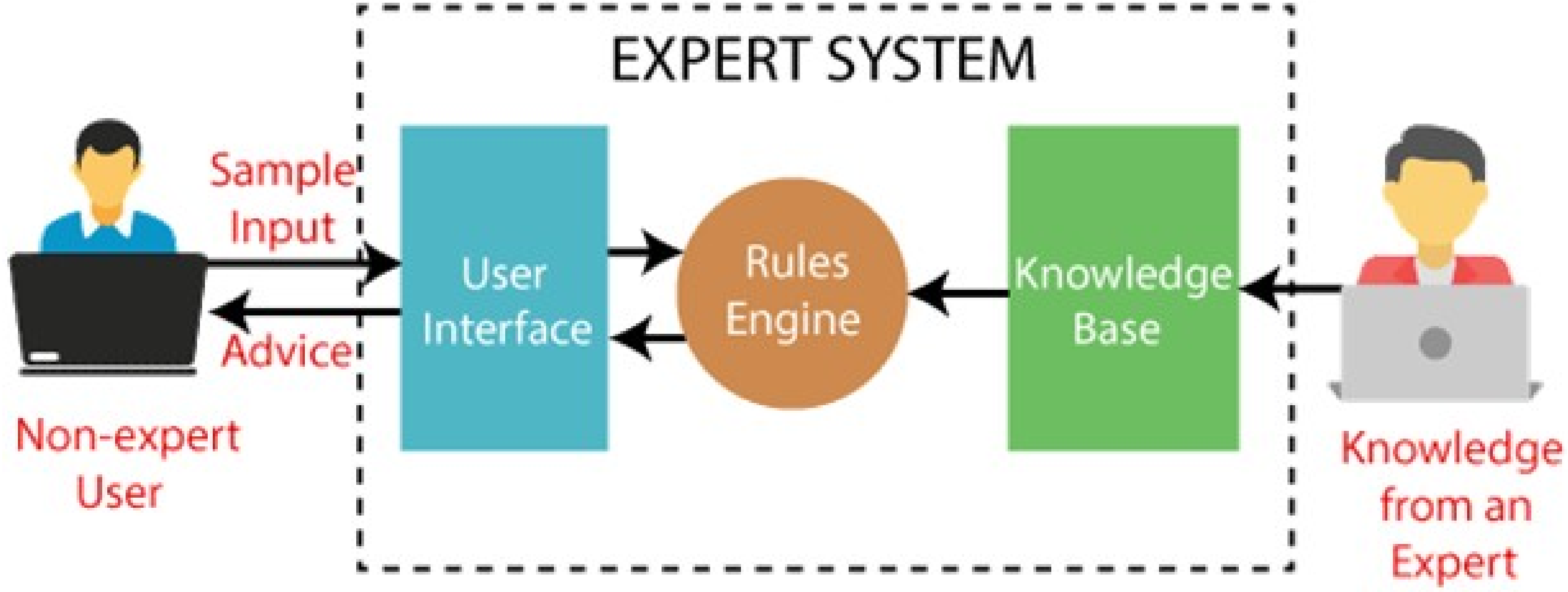
Need of probabilistic reasoning in AI:

- When there are unpredictable outcomes.
- When specifications or possibilities of predicates becomes too large to handle.
- When an unknown error occurs during an experiment.
- In probabilistic reasoning, there are two ways to solve problems with uncertain knowledge:
- **Bayes' rule**
- **Bayesian Statistics**

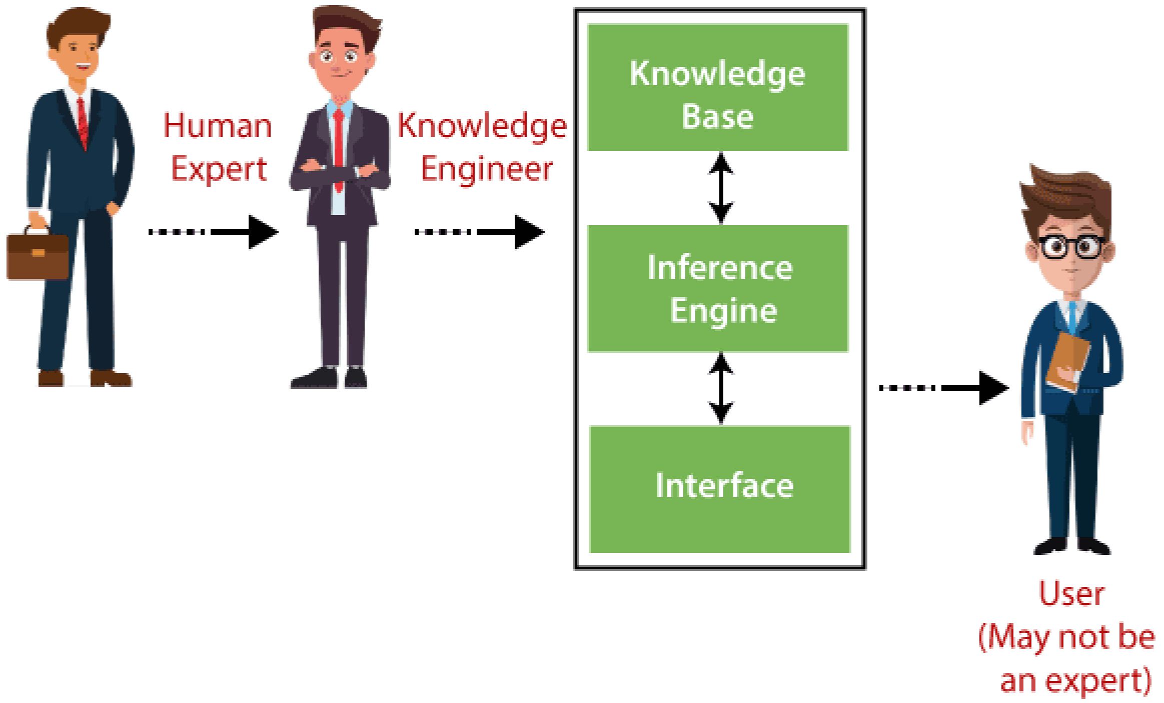
Expert System

- An expert system is a computer program that is designed to solve complex problems and to provide decision-making ability like a human expert.
- It performs this by extracting knowledge from its knowledge base using the reasoning and inference rules according to the user queries.

Expert System



Expert System



Tutorial No. 1

1. Name the elements of an agent and list down the characteristics of intelligent agent.
2. How would you quote PEAS description?
3. What is an agent?
4. What is AI? List the applications.
5. What is meant by Knowledge based system?
6. Explain components of knowledge based systems.
7. Write various levels of Knowledge based system.
8. Explain various approaches and properties of knowledge representation
9. Explain different types of environment.