D. Y. Patil International University, Akurdi, Pune. Pincode : 411044

Introduction to Intelligent Systems (IIS)

Topic : Intelligent Reasoning Systems

Teaching Assistant: Mr. Yash More

COURSE OBJECTIVES :

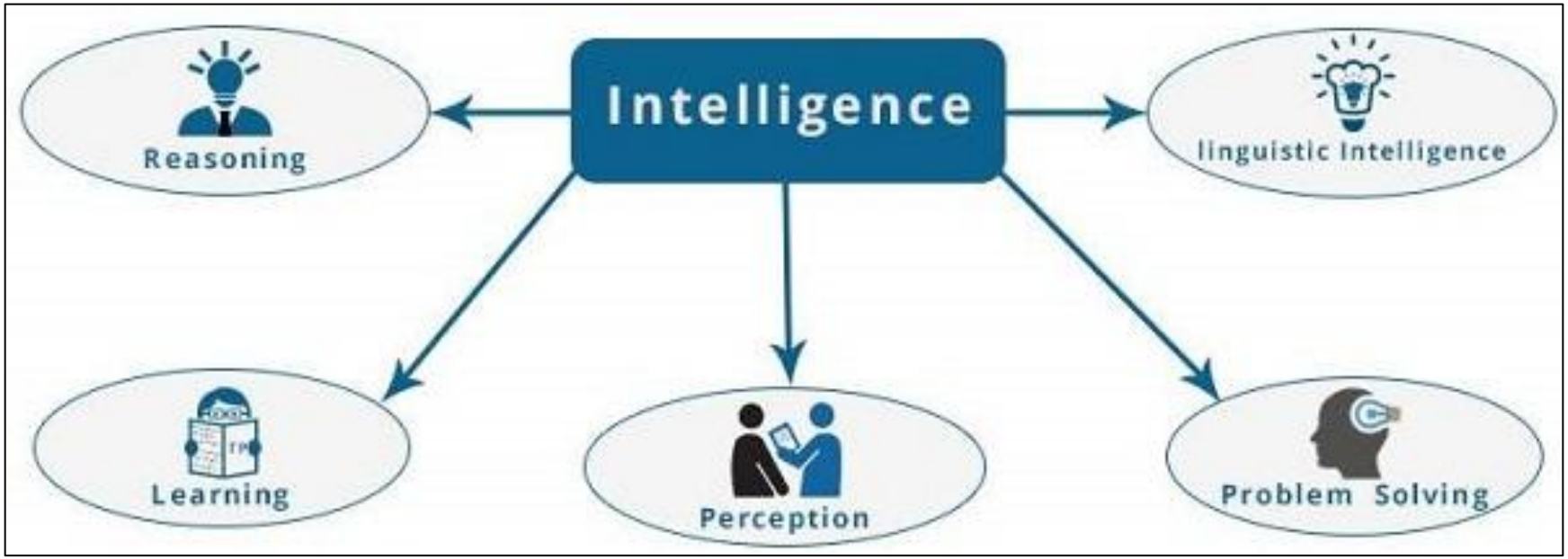
- **Upon successful completion of this course, students will be able to:**
- **Evolutions of intelligent systems.**
- **How to build an Intelligent Systems to solve problems by computational reasoning using captured domain knowledge and data.**
- **Intelligent Systems that will help to control the advanced robotic systems.**
- **The skills and techniques required to build Intelligent Sensing Systems that are able to make decisions based on real world data.**
- **To develop the ability to implement a particularly intelligent system of choice.**

Topic 2 :

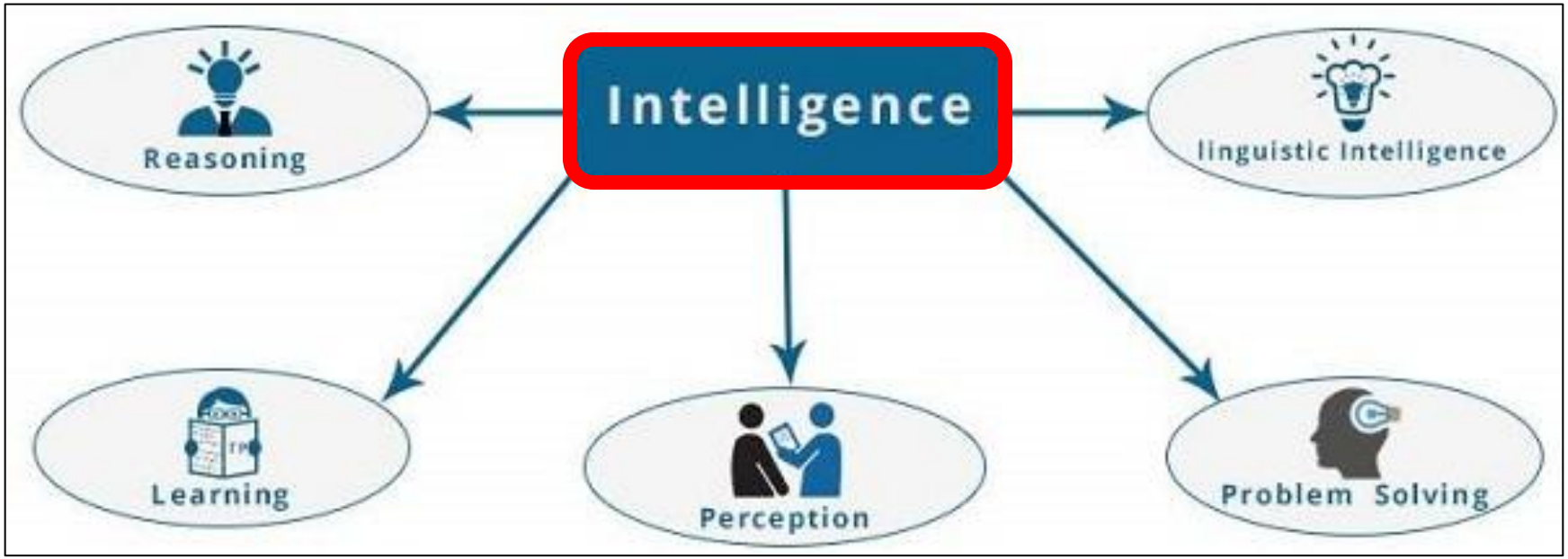
Intelligent Reasoning Systems:

- History of Intelligence Reasoning Systems
- A Spectrum of Intelligent Behavior
- Knowledge-Based Systems
- The Architecture of Knowledge-Based System:
- Knowledge-Based System: Knowledge Base
- Knowledge-Based System: Inference system
- Types of Reasoning System
- Machine Reasoning
- Machine Learning vs. Machine Reasoning:
- Natural Language Processing (NLP)

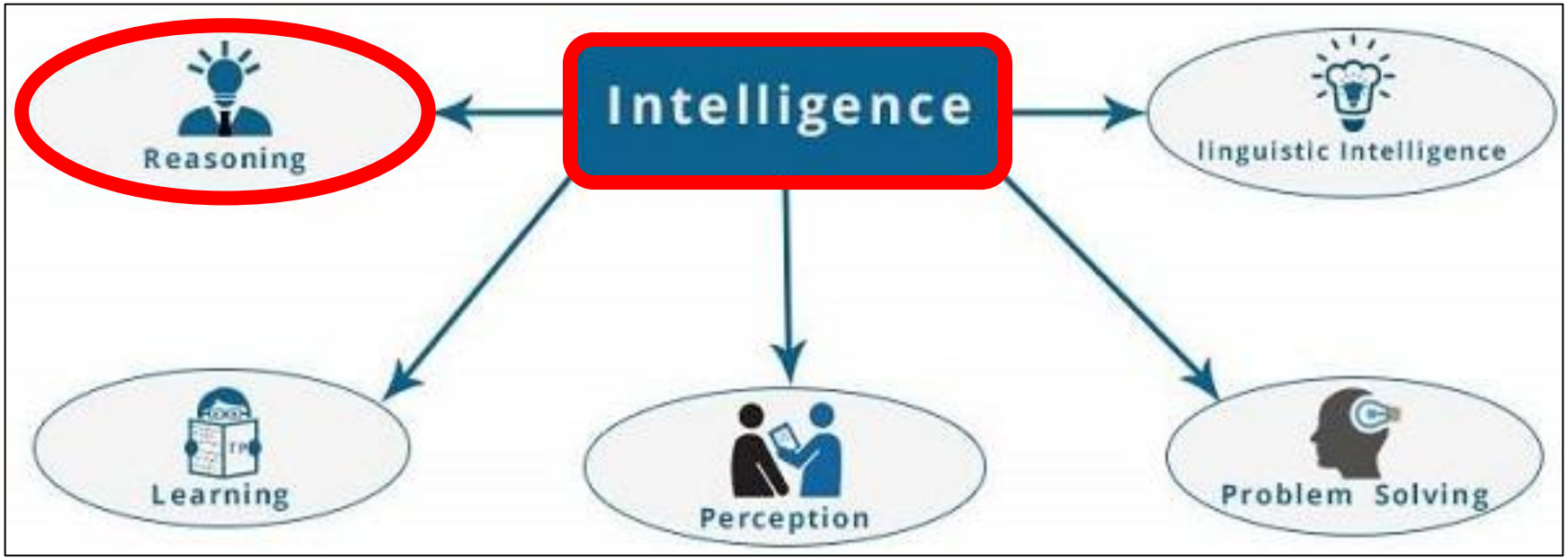
What is Intelligence Composed of ?



What is Intelligence Composed of ?



What is Intelligence Composed of ?



Intelligent Reasoning Systems:

Intelligent Reasoning Systems (IRS) are a type of artificial intelligence that can make decisions and solve problems based on a set of rules and knowledge.

These systems are designed to mimic human reasoning and decision-making processes.

They can handle complex problems, adapt to new situations, and learn from experience. However, they can be computationally expensive and may require large amounts of data and processing power.

- **Advantages:** IRS can handle complex problems, adapt to new situations, and learn from experience.
- **Disadvantages:** IRS can be computationally expensive and may require large amounts of data and processing power.

Intelligent Reasoning Systems:

Intelligent Reasoning Systems (IRS) are a type of artificial intelligence that can **make decisions and solve problems based** on a set of rules and knowledge.

These systems are designed to **mimic human reasoning and decision-making processes**.

They can handle **complex problems, adapt to new situations, and learn from experience**. However, they can be computationally expensive and may require large amounts of data and processing power.

- **Advantages:** IRS can handle complex problems, adapt to new situations, and learn from experience.
- **Disadvantages:** IRS can be computationally expensive and may require large amounts of data and processing power.

- Reasoning systems come in **two modes:**
  - **Interactive systems** interface with the user to ask clarifying questions or otherwise allow the user to guide the reasoning process.
  - **Batch-processing systems** take in all the available information at once and generate the best answer possible without user feedback or guidance.

- Reasoning systems come in two modes:
  - **Interactive systems** interface with the user to ask clarifying questions or otherwise allow the user to guide the reasoning process.
  - **Batch-processing systems** take in all the available information at once and generate the best answer possible without user feedback or guidance.

- Reasoning systems have a wide field of application that includes

  scheduling, business rule processing, problem solving, complex event processing, intrusion detection, predictive analytics, robotics, computer vision, and natural language processing.

History of Intelligence Reasoning Systems:

- The first reasoning systems were theorem provers, systems that represent axioms and statements in First Order Logic.
- Another early type of reasoning system were general problem solvers.
- These were systems such as the General Problem Solver designed by Newell and Simon.
- General problem solvers attempted to provide a generic planning engine that could represent and solve structured problems.
- They worked by decomposing problems into smaller more manageable sub-problems, solving each sub-problem and assembling the partial answers into one final answer.

A Spectrum of Intelligent Behavior:

- A Spectrum of Intelligent Behavior refers to the range of intelligent behaviors that can be observed in various systems, from simple reactive systems to complex cognitive systems.
- This spectrum can be categorized into three types of intelligent behavior:

  Reactive, Deliberative, and Adaptive, explained as follows.

A Spectrum of Intelligent Behavior:

- A Spectrum of Intelligent Behavior refers to the range of intelligent behaviors that can be observed in various systems, from simple reactive systems to complex cognitive systems.
- This spectrum can be categorized into three types of intelligent behavior:

  Reactive, Deliberative, and Adaptive, explained as follows.

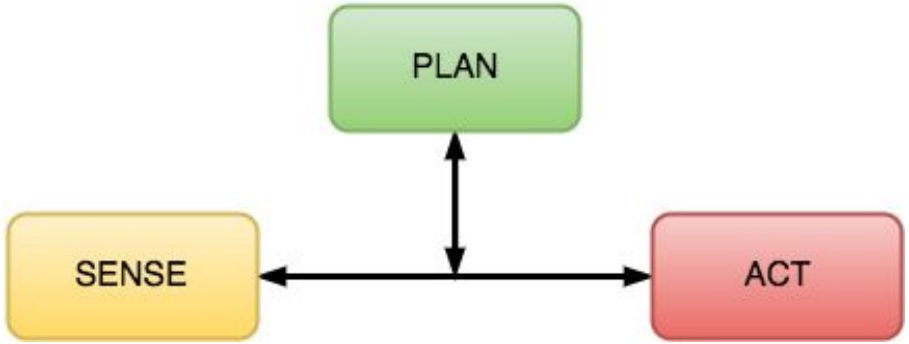
  - **Reactive Systems:** Systems that respond to their environment in real-time, without considering the past or future.
  - **Deliberative Systems:** Systems that consider past experiences and future consequences before making decisions.

A Spectrum of Intelligent Behavior:

- A Spectrum of Intelligent Behavior refers to the range of intelligent behaviors that can be observed in various systems, from simple reactive systems to complex cognitive systems.
- This spectrum can be categorized into three types of intelligent behavior:

  Reactive, Deliberative, and Adaptive, explained as follows.

  - **Reactive Systems:** Systems that respond to their environment in real-time, without considering the past or future.
  - **Deliberative Systems:** Systems that consider past experiences and future consequences before making decisions.

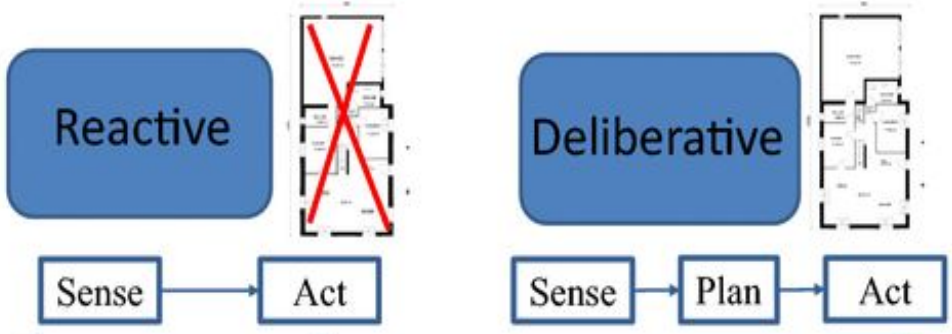


A Spectrum of Intelligent Behavior:

- A Spectrum of Intelligent Behavior refers to the range of intelligent behaviors that can be observed in various systems, from simple reactive systems to complex cognitive systems.
- This spectrum can be categorized into three types of intelligent behavior:

  Reactive, Deliberative, and Adaptive, explained as follows.

  - **Reactive Systems:** Systems that respond to their environment in real-time, without considering the past or future.
  - **Deliberative Systems:** Systems that consider past experiences and future consequences before making decisions.



A Spectrum of Intelligent Behavior:

- A Spectrum of Intelligent Behavior refers to the range of intelligent behaviors that can be observed in various systems, from simple reactive systems to complex cognitive systems.
- This spectrum can be categorized into three types of intelligent behavior:

  Reactive, Deliberative, and Adaptive, explained as follows.

  - **Reactive Systems:** Systems that respond to their environment in real-time, without considering the past or future.
  - **Deliberative Systems:** Systems that consider past experiences and future consequences before making decisions.
  - **Adaptive Systems:** Systems that learn from their environment and adapt their behavior over time.

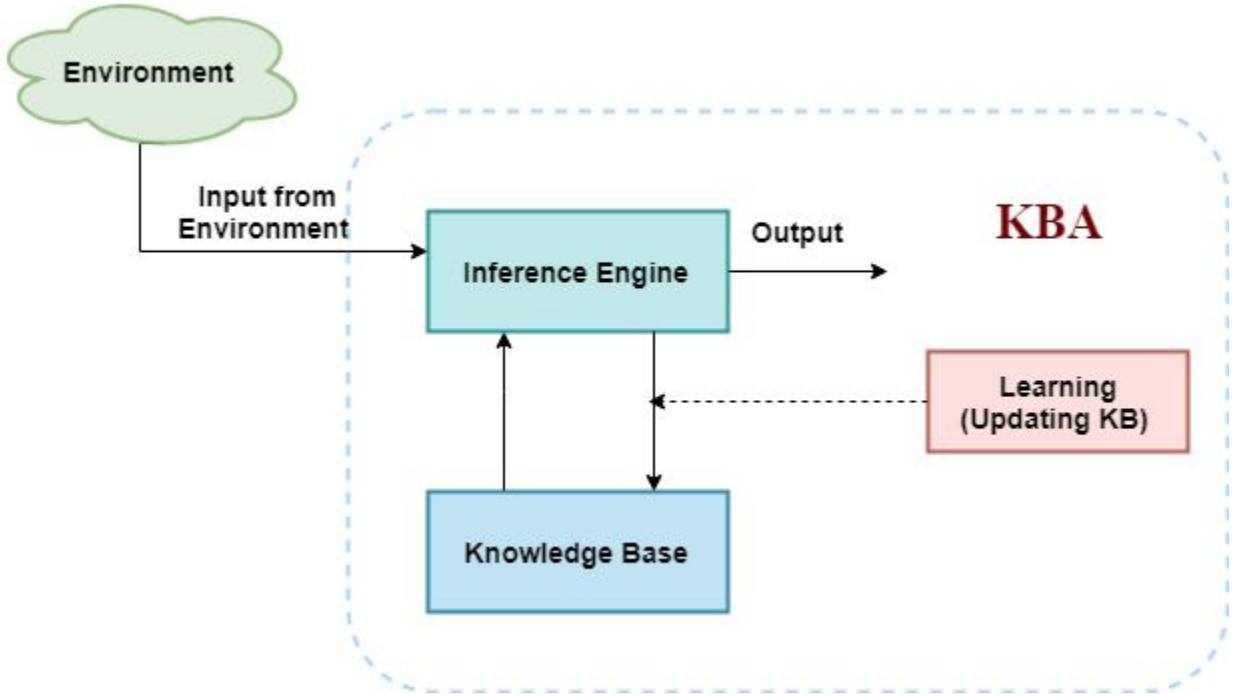
Knowledge-Based Systems:

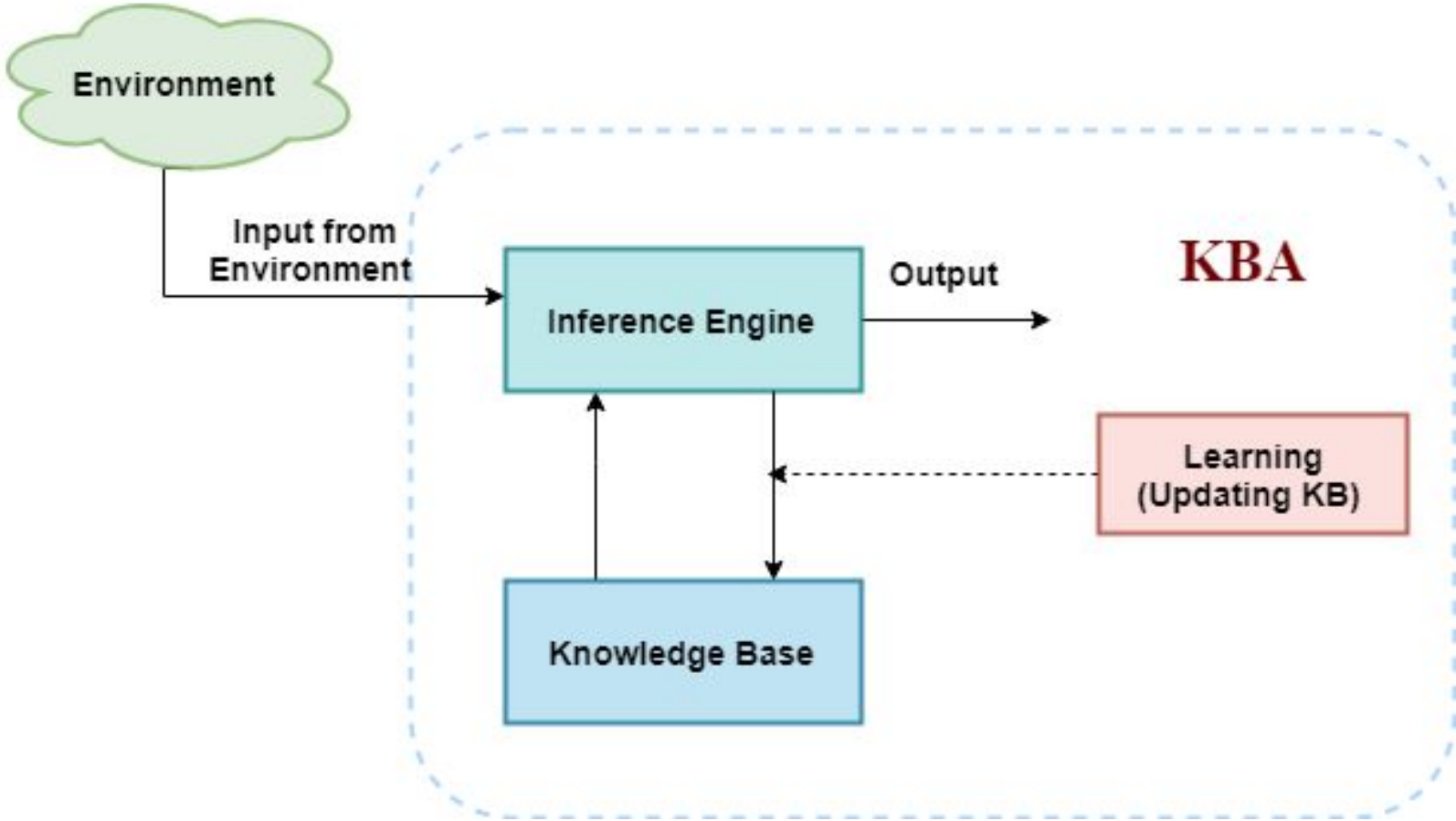
- Knowledge-based System are those systems who have the capability of maintaining an **internal state of knowledge, reason over that knowledge, update their knowledge after observations and take actions.**

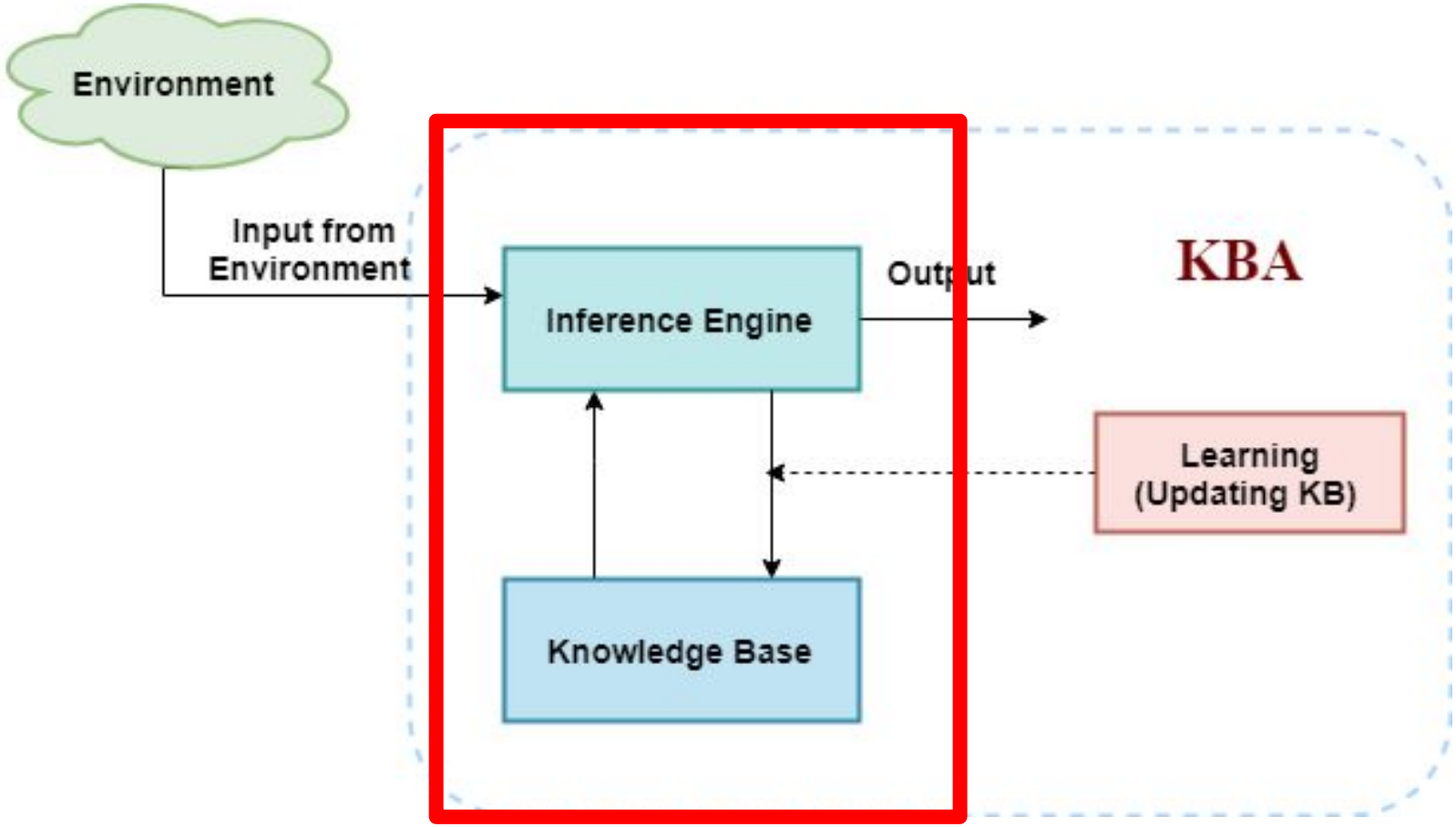
- These systems can represent the world with some formal representation and act intelligently.

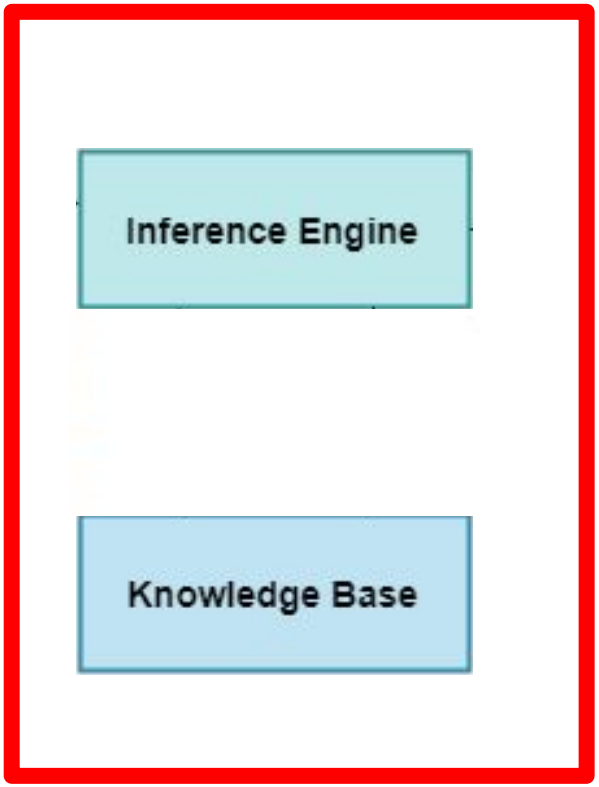
- **A knowledge-based Systems must able to do the following:**
    - System should be able to represent states, actions, etc.
    - System should be able to incorporate new perceptions.
    - System can update the internal representation of the world.
    - System can deduce the internal representation of the world.
    - System can deduce appropriate actions.

The Architecture of Knowledge-Based System:




Environment
Input from Environment
Inference Engine
Output
KBA
Learning (Updating KB)
Knowledge Base


Environment
Input from Environment
Inference Engine
Output
KBA
Learning (Updating KB)
Knowledge Base


Inference Engine
Knowledge Base

- Knowledge-based Systems are composed of two main parts:
    - Knowledge-base and
    - Inference system.

Knowledge-Based System: Knowledge Base

Knowledge base: Knowledge-base is a central component of a knowledge-based system, it is also known as 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?

Knowledge-base is required for updating knowledge for an system to learn with experiences and take action as per the knowledge.

Knowledge Base System Logics:

- It can be represented using various logics, such as:
    - **Propositional Logic:** A formal system for representing statements that can be either true or false.
    - **Predicate Logic:** A formal system for representing statements that can be either true or false, with the ability to quantify variables.
    - **First-Order Logic:** A formal system that allows for the representation of functions and predicates.

Knowledge Base System Logics:

- It can be represented using various logics, such as:
    - **Propositional Logic:** A formal system for representing statements that can be either **true or false.**
    - **Predicate Logic:** A formal system for representing statements that can be either **true or false, with the ability to quantify variables.**
    - **First-Order Logic:** A formal system that allows for the representation of **functions and predicates.**

Knowledge-Based System: Inference system

- Inference means deriving new sentences from old.
- Inference system allows us to add a new sentence to the knowledge base.
- A sentence is a proposition about the world. Inference system applies logical rules to the KB to deduce new information.

Knowledge-Based System: Inference system

- Inference means deriving **new sentences from old.**
- Inference system allows us to add a new sentence to the knowledge base.
- A sentence is a proposition about the world. Inference system applies logical rules to the KB to deduce new information.

Knowledge-Based System: Inference system

- Inference system generates new facts so that an agent can update the KB.
- An inference system works mainly in two rules which are given as:
  - **Forward chaining**
  - **Backward chaining**

Knowledge-Based System: Inference system

- Inference system generates new facts so that an agent can update the KB.

- An inference system works mainly in two rules which are given as:

    - **Forward chaining:** Which starts with known facts and maintain new facts.

    - **Backward chaining**

Knowledge-Based System: Inference system

- Inference system generates new facts so that an agent can update the KB.
- An inference system works mainly in two rules which are given as:
  - **Forward chaining:** Which starts with known facts and maintain new facts.
  - **Backward chaining:** Which starts with goals and works backward to determine what facts must be asserted to achieve those goals.

Types of Reasoning Systems:

1. **Deductive reasoning**
2. **Inductive reasoning**
3. **Abductive reasoning**
4. **Common Sense Reasoning**
5. **Monotonic Reasoning**
6. **Non-monotonic Reasoning**

(Note: Inductive and deductive reasoning are the forms of propositional logic, i.e. Ture or False)

Types of Reasoning Systems:

1. **Deductive reasoning:** Forming predictions from accessible knowledge, facts, and beliefs.
2. **Inductive reasoning**
3. **Abductive reasoning**
4. **Common Sense Reasoning**
5. **Monotonic Reasoning**
6. **Non-monotonic Reasoning**

(Note: Inductive and deductive reasoning are the forms of propositional logic, i.e. Ture or False)

Types of Reasoning Systems:

1. **Deductive reasoning:** Forming predictions from accessible knowledge, facts, and beliefs.
2. **Inductive reasoning:** Uses the process of generalization to arrive at a conclusion with a limited information.
3. **Abductive reasoning**
4. **Common Sense Reasoning**
5. **Monotonic Reasoning**
6. **Non-monotonic Reasoning**

(Note: Inductive and deductive reasoning are the forms of propositional logic, i.e. Ture or False)

Types of Reasoning Systems:

1. **Deductive reasoning:** Forming predictions from accessible knowledge, facts, and beliefs.
2. **Inductive reasoning:** Uses the process of generalization to arrive at a conclusion with a limited information.
3. **Abductive reasoning:** Begins with a single or several observations and then searches for the most plausible explanation or conclusion for the observation.
4. **Common Sense Reasoning**
5. **Monotonic Reasoning**
6. **Non-monotonic Reasoning**

(Note: Inductive and deductive reasoning are the forms of propositional logic, i.e. Ture or False)

Types of Reasoning Systems:

1. **Deductive reasoning:** Forming predictions from accessible knowledge, facts, and beliefs.
2. **Inductive reasoning:** Uses the process of generalization to arrive at a conclusion with a limited information.
3. **Abductive reasoning:** Begins with a single or several observations and then searches for the most plausible explanation or conclusion for the observation.
4. **Common Sense Reasoning:** Type of informal reasoning that can be learned through personal experience.
5. **Monotonic Reasoning**
6. **Non-monotonic Reasoning**

(Note: Inductive and deductive reasoning are the forms of propositional logic, i.e. Ture or False)

Types of Reasoning Systems:

1. **Deductive reasoning:** Forming predictions from accessible knowledge, facts, and beliefs.
2. **Inductive reasoning:** Uses the process of generalization to arrive at a conclusion with a limited information.
3. **Abductive reasoning:** Begins with a single or several observations and then searches for the most plausible explanation or conclusion for the observation.
4. **Common Sense Reasoning:** Type of informal reasoning that can be learned through personal experience.
5. **Monotonic Reasoning:** Once conclusion is reached, it will remain the same even if new information is added
6. **Non-monotonic Reasoning**

(Note: Inductive and deductive reasoning are the forms of propositional logic, i.e. Ture or False)

Types of Reasoning Systems:

1. **Deductive reasoning:** Forming predictions from accessible knowledge, facts, and beliefs.
2. **Inductive reasoning:** Uses the process of generalization to arrive at a conclusion with a limited information.
3. **Abductive reasoning:** Begins with a single or several observations and then searches for the most plausible explanation or conclusion for the observation.
4. **Common Sense Reasoning:** Type of informal reasoning that can be learned through personal experience.
5. **Monotonic Reasoning:** Once conclusion is reached, it will remain the same even if new information is added
6. **Non-monotonic Reasoning:** Conclusion may be changed if we add more information to our knowledge base.

(Note: Inductive and deductive reasoning are the forms of propositional logic, i.e. Ture or False)

Difference between Deductive and Inductive reasoning:

Basics for comparison	Deductive Reasoning	Inductive Reasoning
Definition	Deductive reasoning is a type of legitimate reasoning that involves deducing new information or conclusions from previously known facts and data.	Inductive reasoning relies on the generalization of certain facts or evidence to reach a conclusion.
Approach	A top-down approach is used in deductive reasoning.	Bottom-up reasoning is used in inductive reasoning.
Validity	Premises are the starting point for deductive reasoning.	The conclusion is where inductive reasoning begins.
Usage	Deductive reasoning is difficult to use since we need facts that must be true.	Because we need evidence rather than genuine facts, we can use inductive reasoning quickly and easily. It is frequently used in our daily lives.
Process	Theory→ hypothesis→ patterns → confirmation.	Observations-→patterns → hypothesis → Theory.
Argument	Arguments in deductive reasoning might be valid or invalid.	Arguments in inductive reasoning can be weak or strong.
Structure	Deductive reasoning progresses from broad to specific information.	From specific data to general facts, inductive reasoning is used.

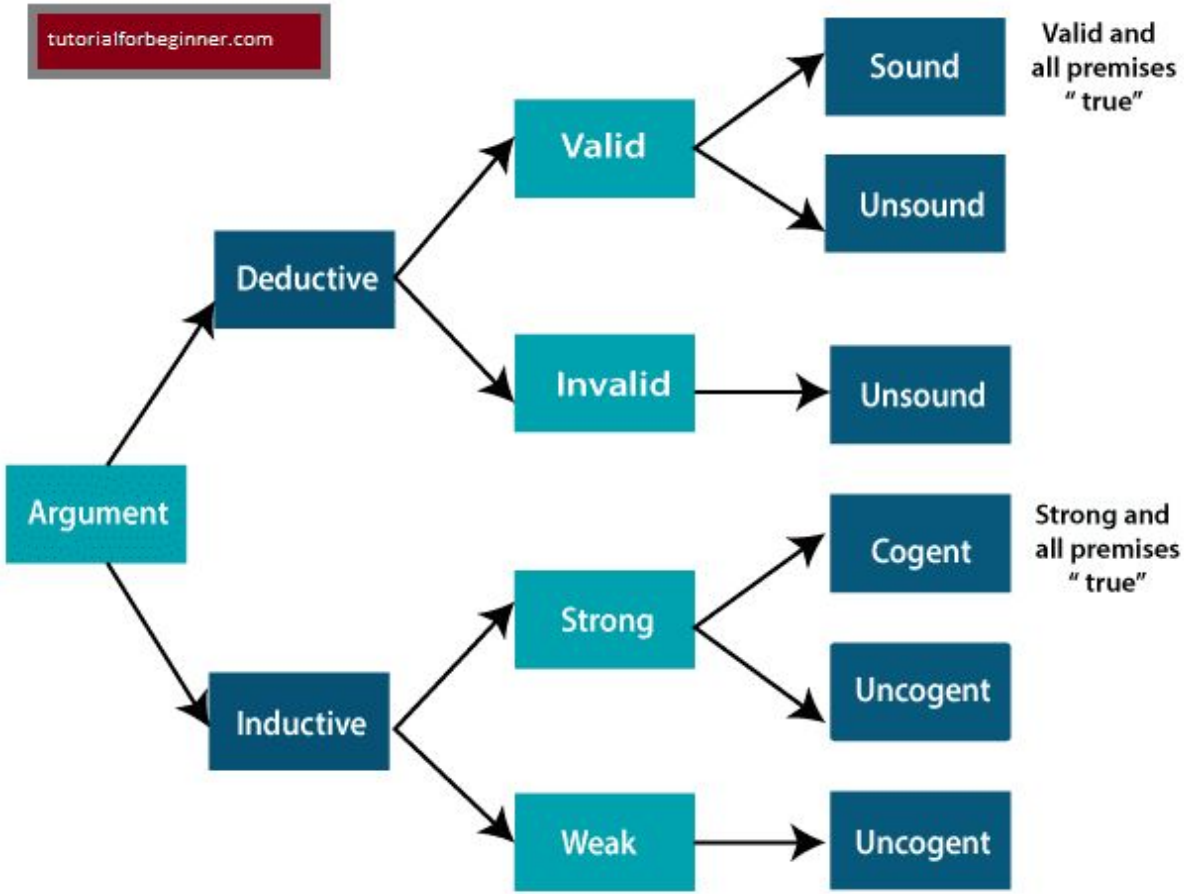


Fig : Representation of arguments, the distinctions between inductive and deductive reasoning can be demonstrated using the picture

Machine Reasoning:

- Machine Reasoning is a subfield of IRS that focuses on developing algorithms and techniques for automated reasoning.
- It can be used in various applications, such as:
    1. Planning: Developing plans to achieve a goal based on a set of constraints and available resources.
    2. Diagnosis: Identifying the cause of a problem based on a set of symptoms.
    3. Question Answering: Answering questions based on a set of facts and rules.

Machine Learning vs. Machine Reasoning:

Basics of comparision	Machine Learning	Machine Reasoning
Approach	Machine learning is based on the statistical identification of hidden patterns within a large amount of data	While machine reasoning is based on using facts and drawing conclusions from those facts
Understanding	Machine learning deals with pattern recognition	Machine reasoning deals with understanding relationships and drawing conclusions
Data representation	Machine learning uses quantitative data and statistical modeling	machine reasoning uses knowledge representations and logic-based reasoning
Objective vs. Subjective	Machine learning is more formulaic and objective	machine reasoning is more open-ended and intuitive
Adaptability	Machine learning is limited in its ability to adapt to new situations without human involvement	machine reasoning can make connections between facts, observations, and various areas of logic to make decisions

Natural Language Processing (NLP):

NLP is a subfield of IRS that focuses on developing algorithms and techniques for understanding and processing human language. It can be used in various applications, such as:

- **Speech Recognition:** Converting spoken language into text or other forms of data.
- **Text Analysis:** Analyzing text data to extract meaning and insights.
- **Machine Translation:** Translating text from one language to another.

References :

- Knowledge-based systems : *https://en.wikipedia.org/wiki/Knowledge-based_systems*
- Whats is Knowledge-based systems : *https://www.techtarget.com/searchcio/definition/knowledge-based-systems-KBS*
- 'Deduction' vs. 'Induction' vs. 'Abduction' : *https://www.merriam-webster.com/grammar/deduction-vs-induction-vs-abduction*
- Inference Engine in AI: *https://www.scaler.com/topics/artificial-intelligence-tutorial/inference-engine-in-ai/*
- Machine Reasoning: Technology, Dilemma and Future: *https://aclanthology.org/2020.emnlp-tutorials.1.pdf*
- What is Natural Language Processing (NLP)?: *https://aws.amazon.com/what-is/nlp/*
- Reasoning system: *https://en.wikipedia.org/wiki/Reasoning_system*

Thank You!!