Artificial Intelligence

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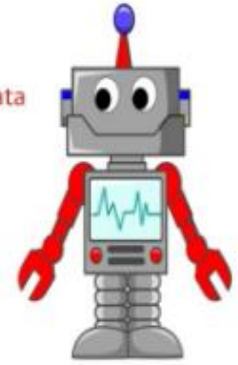


❑ Knowledge Representation

What is Knowledge Representation?

Humans are best at understanding, reasoning, and interpreting knowledge. Human knows things, which is knowledge and as per their knowledge they perform various actions in the real world. **But how machines do all these things comes under knowledge representation and reasoning**. Hence we can describe Knowledge representation as following:

- Knowledge representation and reasoning (KR, KRR) is the part of Artificial intelligence which is concerned with AI agents thinking and how thinking contributes to intelligent behavior of agents.
- It is responsible for representing information about the real world so that a computer can understand and can utilize this knowledge to solve the complex real world problems such as diagnosis a medical condition or communicating with humans in natural language.
- It is also a way which describes how we can represent knowledge in artificial intelligence. Knowledge representation is not just storing data into some database, but it also enables an intelligent machine to learn from that knowledge and experiences so that it can behave intelligently like a human.

What to Represent

Following are the kind of knowledge which needs to be represented in AI systems:

1. **Object:** All the facts about objects in our world domain. E.g., Guitars contains strings, A chair has a seat, back, and legs.
2. **Events:** Events are the actions which occur in our world.
3. **Performance:** It describe behavior which involves knowledge about how to do things.
4. **Meta-knowledge:** It is knowledge about what we know.
5. **Facts:** Facts are the truths about the real world and what we represent.
6. **Knowledge-Base:** The central component of the knowledge-based agents is the knowledge base. It is represented as KB. The Knowledgebase is a group of the Sentences (Here, sentences are used as a technical term and not identical with the English language).

Knowledge: Knowledge is awareness or familiarity gained by experiences of facts, data, and situations.

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.
   - It is simpler than procedural language.
2. **Procedural Knowledge**
   - It is also known as imperative 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.
   - Procedural knowledge depends on the task on which it can be applied.

Types of Knowledge

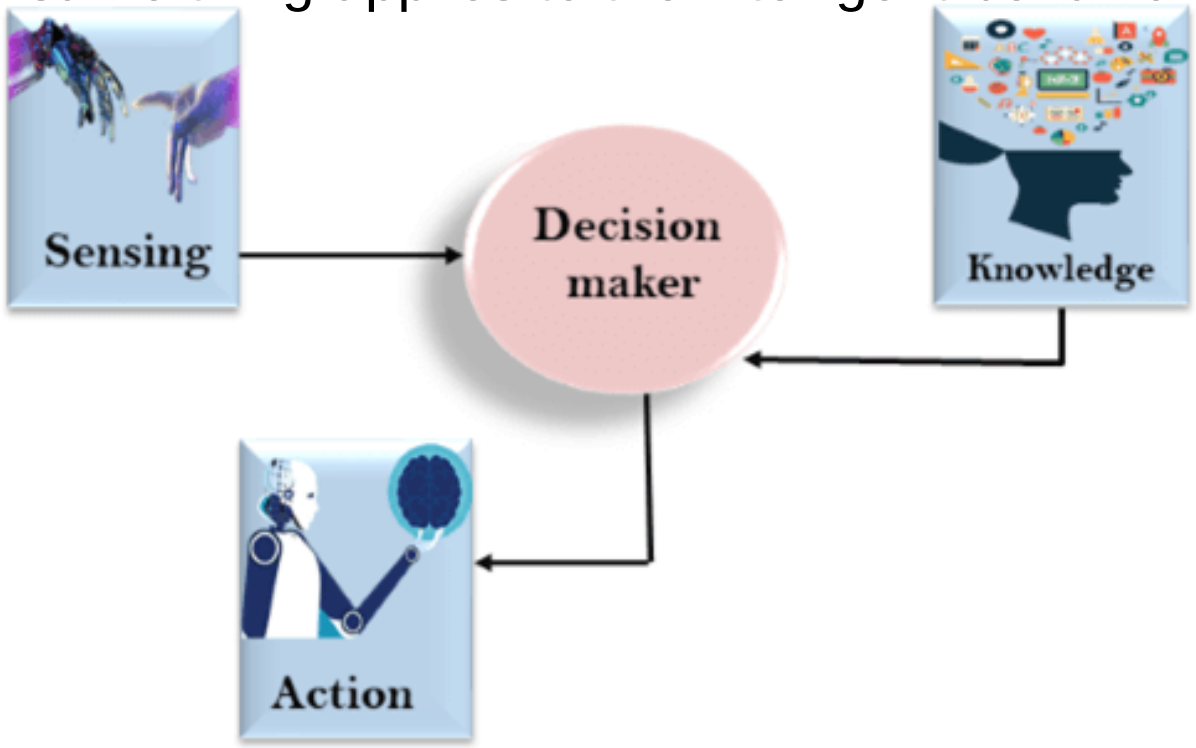
3. **Meta-Knowledge**
   - Knowledge about the other types of knowledge is called Meta-knowledge.
4. **Heuristic knowledge:**
   - Heuristic knowledge is representing knowledge of some experts in a field or subject.
   - Heuristic knowledge is rules of thumb based on previous experiences, awareness of approaches, and which are good to work but not guaranteed.
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.

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.

Let's suppose if you met some person who is speaking in a language which you don't know, then how you will be able to act on that. The same thing applies to the intelligent behavior of the agents.

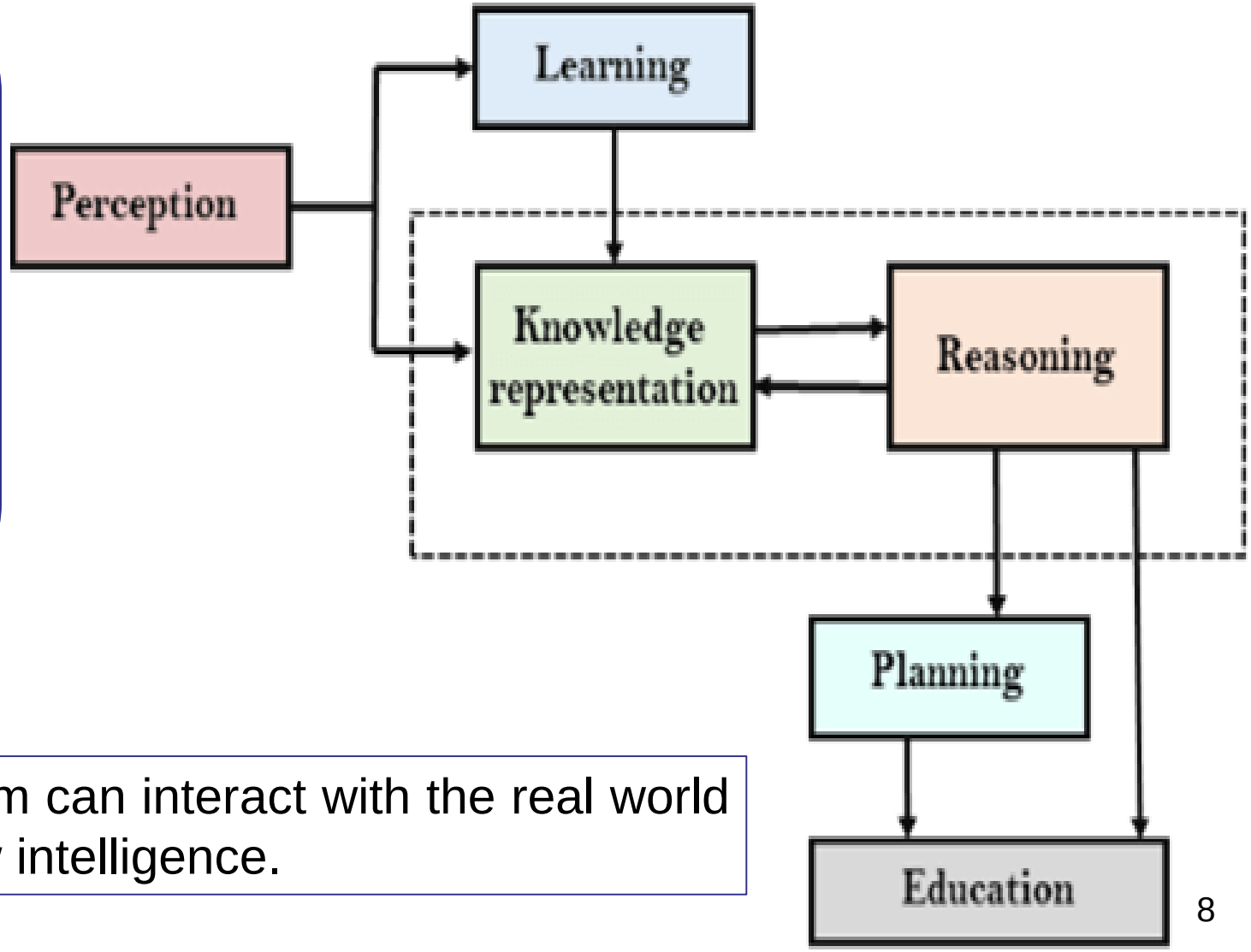
As we can see in given diagram, there is one decision maker which acts by sensing the environment and using knowledge. But if the knowledge part will be absent then, it cannot display intelligent behavior.



AI Knowledge Cycle

An Artificial intelligence system has the following components for displaying intelligent behavior:

- Perception
- Learning
- Knowledge Representation and Reasoning
- Execution



The diagram shows how an AI system can interact with the real world and what components help it to show intelligence.

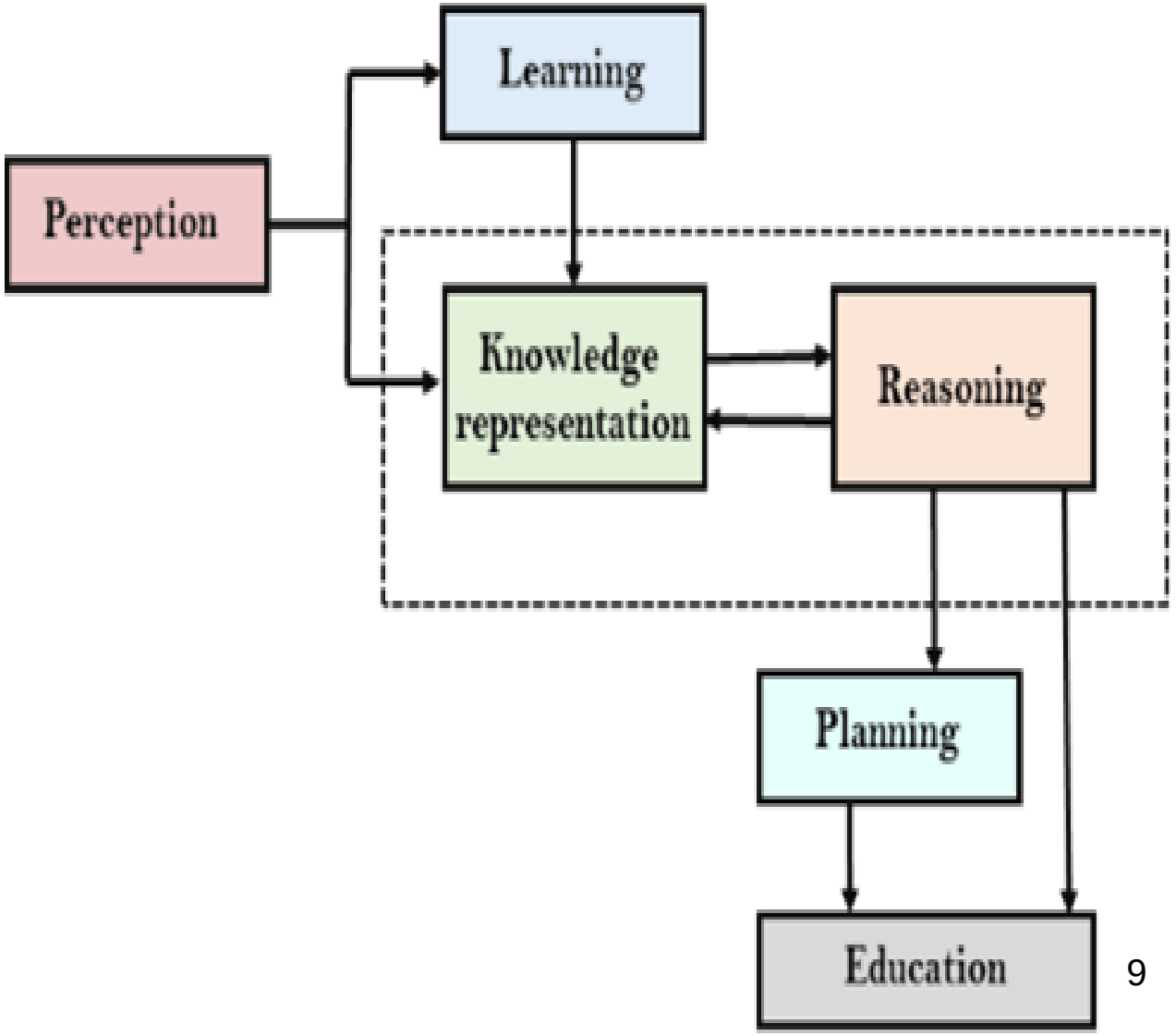
AI Knowledge Cycle

AI system has **Perception** component by which it retrieves information from its environment. It can be visual, audio or another form of sensory input.

The **learning** component is responsible for learning from data captured by Perception comportment.

In the complete cycle, the main components are **knowledge representation and Reasoning**. These two components are involved in showing the intelligence in machine-like humans. These two components are independent of each other but also coupled together.

The **planning** and **execution** depend on analysis of Knowledge representation and reasoning.



Approaches to Knowledge Representation

There are mainly four approaches to knowledge representation, which are given below:

1. 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.

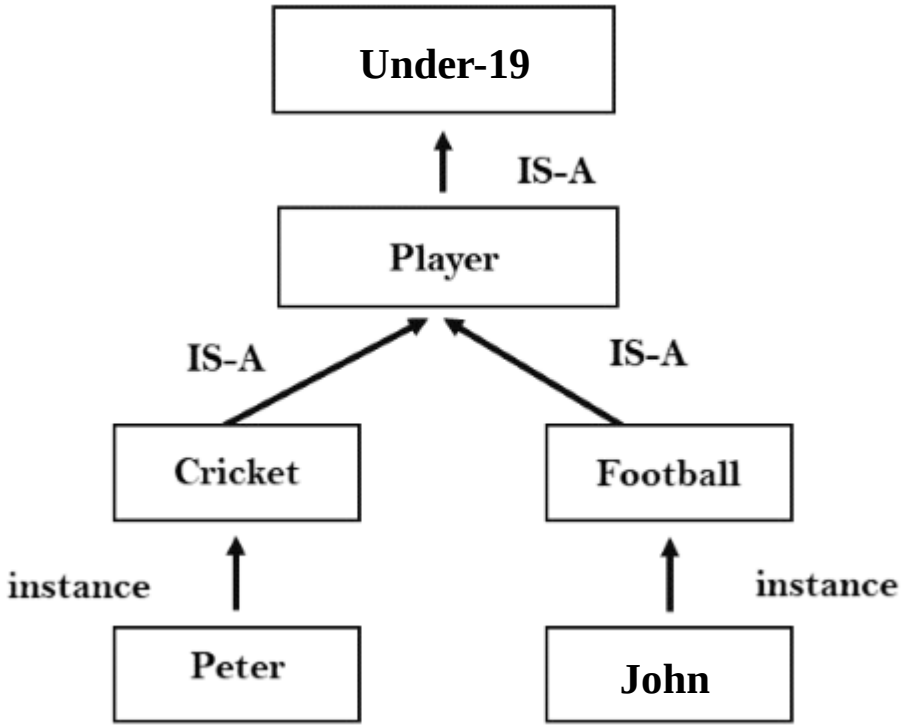
Player	Weight	Age
Player1	65	23
Player2	58	18
Player3	75	24

Approaches to Knowledge Representation

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.

Example



Approaches to Knowledge Representation

3. 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:
Statement-1: Ross is a football player.
Statement-2: All football player are athletes.
Then it can be represented as:

football player(Ross)
∀x = football player (x) ----------> athletes (x)s

Approaches to Knowledge Representation

4. 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.
- In this knowledge, we can use various coding languages such as LISP language and Prolog language.
- 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.

Requirements for KR System

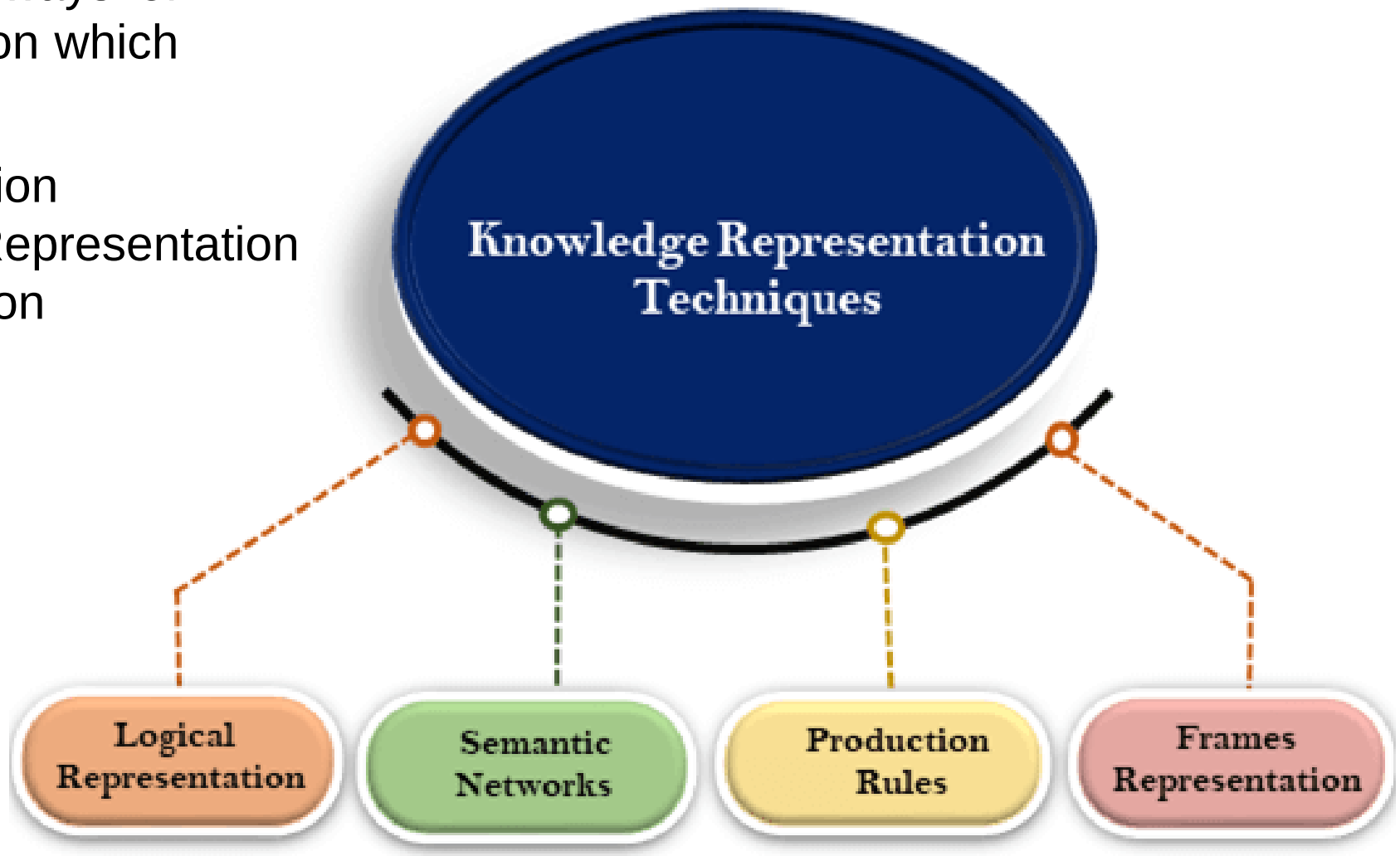
A good knowledge representation system must possess the following properties.

1. **Representational Accuracy:**
   KR system should have the ability to represent all kinds of required knowledge.
2. **Inferential Adequacy:**
   KR system should have ability to manipulate the representational structures to produce new knowledge corresponding to existing structure.
3. **Inferential Efficiency:**
   The ability to direct the inferential knowledge mechanism into the most productive directions by storing appropriate guides.
4. **Acquisitional Efficiency:**
   The ability to acquire the new knowledge easily using automatic methods.

Techniques of Knowledge Representation

There are mainly four ways of knowledge representation which are given as follows:

1. Logical Representation
2. Semantic Network Representation
3. Frame Representation
4. Production Rules



1. Logical Representation

Logical representation is a language with some concrete rules which deals with propositions and has no ambiguity in representation. Logical representation means drawing a conclusion based on various conditions. This representation lays down some important communication rules. It consists of precisely defined syntax and semantics which supports the sound inference. Each sentence can be translated into logics using **syntax and semantics**.

Syntax:

- Syntaxes are the rules which decide how we can construct legal sentences in the logic.
- It determines which symbol we can use in knowledge representation.
- How to write those symbols.

Semantics:

- Semantics are the rules by which we can interpret the sentence in the logic.
- Semantic also involves assigning a meaning to each sentence.

1. Logical Representation

Logical representation can be categorized into mainly two logics:

a. Propositional Logics
b. Predicate logics

Advantages of logical representation:

- Logical representation enables us to do logical reasoning.
- Logical representation is the basis for the programming languages.

Disadvantages of logical Representation:

- Logical representations have some restrictions and are challenging to work with.
- Logical representation technique may not be very natural, and inference may not be so efficient.

Do not be confused with **logical representation and logical reasoning** as logical representation is a representation language and reasoning is a process of thinking logically.

2. Semantic Network Representation

Semantic networks are alternative of predicate logic for knowledge representation. In Semantic networks, we can represent our knowledge in the form of graphical networks. This network consists of nodes representing objects and arcs which describe the relationship between those objects. Semantic networks can categorize the object in different forms and can also link those objects. Semantic networks are easy to understand and can be easily extended.

This representation consist of mainly two types of relations:

- IS-A relation (Inheritance)
- Kind-of-relation

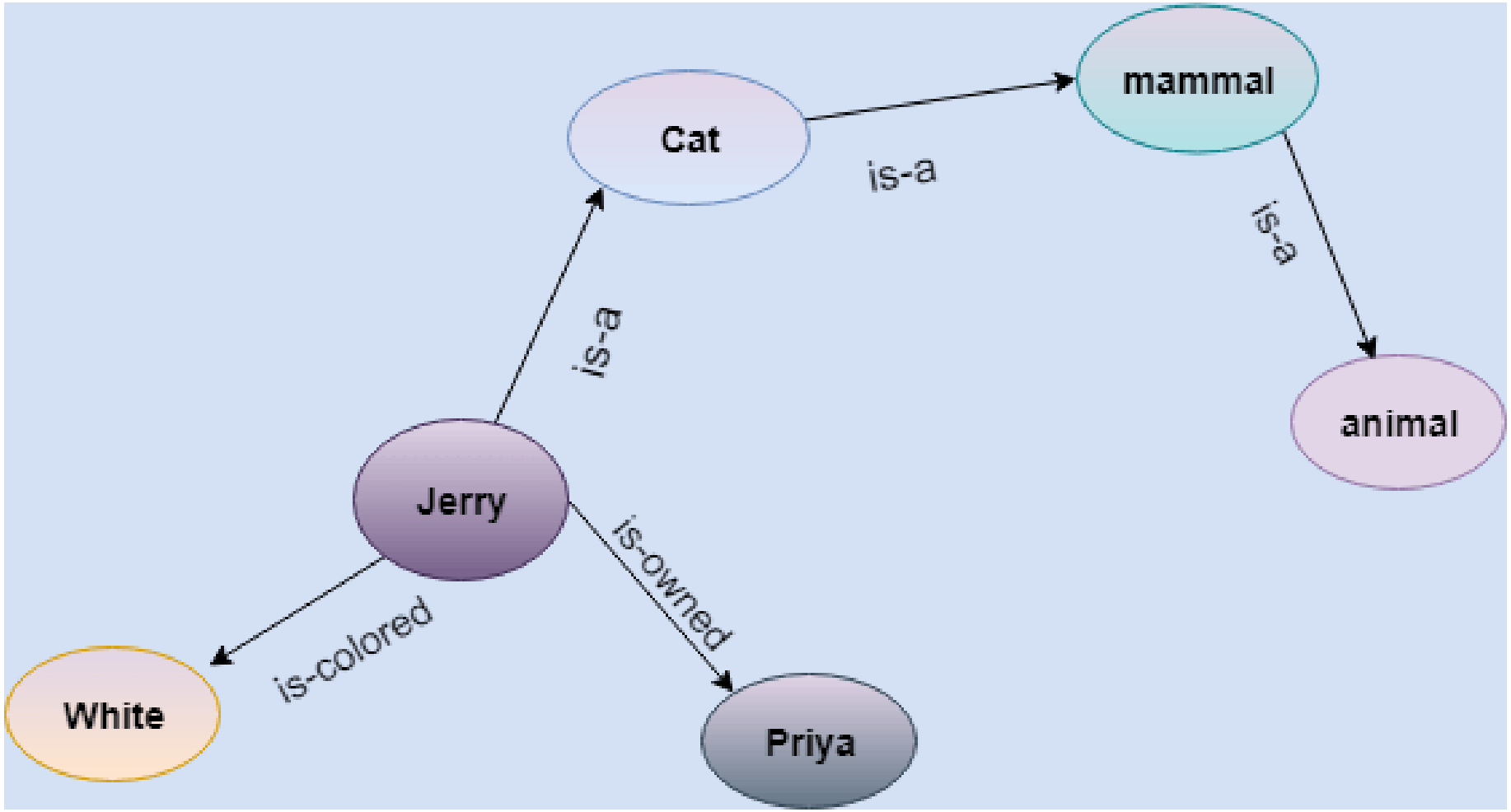
Example: Following are some statements which we need to represent in the form of nodes and arcs.

Statements:.

1.Jerry is a cat.
2.Jerry is a mammal
3.Jerry is owned by Priya.

4. Jerry is brown colored.
5. All Mammals are animal.

2. Semantic Network Representation



In the above diagram, we have represented the different type of knowledge in the form of nodes and arcs. Each object is connected with another object by some relation.

2. Semantic Network Representation

Drawbacks in Semantic Representation:

1. Semantic networks take more computational time at runtime as we need to traverse the complete network tree to answer some questions. It might be possible in the worst case scenario that after traversing the entire tree, we find that the solution does not exist in this network.
2. Semantic networks try to model human-like memory to store the information, but in practice, it is not possible to build such a vast semantic network.
3. These types of representations are inadequate as they do not have any equivalent quantifier, e.g., for all, for some, none, etc.
4. Semantic networks do not have any standard definition for the link names.
5. These networks are not intelligent and depend on the creator of the system.

Advantages of Semantic network:

1. Semantic networks are a natural representation of knowledge.
2. Semantic networks convey meaning in a transparent manner.
3. These networks are simple and easily understandable.

3. Frame Representation

A frame is a record like structure which consists of a collection of attributes and its values to describe an entity in the world. Frames are the AI data structure which divides knowledge into substructures by representing stereotypes situations. It consists of a collection of slots and slot values. These slots may be of any type and sizes. Slots have names and values which are called facets.

Facets: The various aspects of a slot is known as Facets. Facets are features of frames which enable us to put constraints on the frames.

Example: IF-NEEDED facts are called when data of any particular slot is needed. A frame may consist of any number of slots, and a slot may include any number of facets and facets may have any number of values. A frame is also known as slot-filter knowledge representation in artificial intelligence.

3. Frame Representation

Frames are derived from semantic networks and later evolved into our modern-day classes and objects. A single frame is not much useful. Frames system consist of a collection of frames which are connected. In the frame, knowledge about an object or event can be stored together in the knowledge base. The frame is a type of technology which is widely used in various applications including Natural language processing and machine visions.

Example: 1 Let's take an example of a frame for a book

Slots	Filters
Title	Artificial Intelligence
Genre	Computer Science
Author	Peter Norvig
Edition	Third Edition
Year	1996
Page	1152

3. Frame Representation

Example 2:

Let's suppose we are taking an entity, Peter. Peter is an engineer as a profession, and his age is 25, he lives in city London, and the country is England. So following is the frame representation for this:

Slots	Filter
Name	Peter
Profession	Doctor
Age	25
Marital status	Single
Weight	78

3. Frame Representation

Advantages of Frame Representation:

- The frame knowledge representation makes the programming easier by grouping the related data.
- The frame representation is comparably flexible and used by many applications in AI.
- It is very easy to add slots for new attribute and relations.
- It is easy to include default data and to search for missing values.
- Frame representation is easy to understand and visualize.

Disadvantages of Frame Representation:

- In frame system inference mechanism is not be easily processed.
- Inference mechanism cannot be smoothly proceeded by frame representation.
- Frame representation has a much generalized approach.

4. Production Rules

Production rules system consist of (condition, action) pairs which mean, "If condition then action". It has mainly three parts:

1. The set of production rules
2. Working Memory
3. The recognize-act-cycle

In production rules agent checks for the condition and if the condition exists then production rule fires and corresponding action is carried out.

The condition part of the rule determines which rule may be applied to a problem. And the action part carries out the associated problem-solving steps. **This complete process is called a recognize-act cycle.**

4. Production Rules

The working memory contains the description of the current state of problems-solving and rule can write knowledge to the working memory. This knowledge match and may fire other rules.

If there is a new situation (state) generates, then multiple production rules will be fired together, this is called conflict set. In this situation, the agent needs to select a rule from these sets, and it is called a conflict resolution.

Example:

- IF (at bus stop AND bus arrives) THEN action (get into the bus)
- IF (on the bus AND paid AND empty seat) THEN action (sit down).
- IF (on bus AND unpaid) THEN action (pay charges).
- IF (bus arrives at destination) THEN action (get down from the bus).

4. Production Rules

Advantages of Production Rule:

- The production rules are expressed in natural language.
- The production rules are highly modular, so we can easily remove, add or modify an individual rule.

Disadvantages of Production Rule:

- Production rule system does not exhibit any learning capabilities, as it does not store the result of the problem for the future uses.
- During the execution of the program, many rules may be active hence rule-based production systems are inefficient.

Next

Propositional logic in Artificial intelligence

Rules of Inference in Artificial intelligence

First-Order Logic in Artificial intelligence