**Unit 1**

**Q.1) What are the knowledge representation issues? explain in brief?**

* **KNOWLEDGE REPRESENTATION ISSUES:** Several issues must be considered when representing various kinds of real-world knowledge

1. **IMPORTANT ATTRIBUTES:** Is any attribute of objects so basic that they occur in almost every problem domain?

* If there are, we need to make sure that they are handled appropriately. There are two attributes: **1. Instance:** Indicates class membership **2. Isa:** Indicates class inclusion.

1. **RELATIONSHIPS AMONG THE ATTRIBUTES:** Any important relationships exist among attributes of objects? There are four properties of attributes:
2. **Inverse:** We use the attributes instance, isa, and team, There are two ways to show the relationship.
3. Represent two relationships in a single representation that ignores a focus team(Pee-Wee-Reese, Brooklyn-Dodgers) Can equally be interpreted as a statement about Pee-Wee-Reese or about the Brooklyn Dodgers (How it is actually used depends on the other assertion that a system contains) This is used in the logical representation.
4. To use attributes that focus on a single entity but to use them in pairs, one the inverse of the other. In this approach, we would represent the team information with two attributes:

* **One associated with Pee-Wee-Reese:** team = Brooklyn Dodgers.
* **One associated with Brooklyn Dodgers** : (Instance)team-members = Pee-Wee-Reese. This second approach is followed in semantic net and frame-based systems

1. **Existence in an ‘isa’ hierarchy:** This is about generalization-specialization, like, classes of objects and specialized subsets of those classes. There are attributes and specialization of attributes.

* For example, the attribute "height" is a specialization of the general attribute “physical size" which is, in turn, a specialization of “physical attribute". These generalization-specialization relationships for attributes are important because they support inheritance.

1. **Techniques for reasoning about the values:** This is about reasoning values of attributes not given explicitly. Several kinds of information are used in reasoning, like,

* **height:** must be in a unit of length
* **age:** of person can not be greater than the age of a person's parents.

1. **Single valued attributes:** This is about a specific attribute that is guaranteed to take a unique value.**Example:** A baseball player can at times have only a single height and be a member of only one team.
2. **CHOOSING THE GRANULARITY OF REPRESENTATION:** At what level should knowledge be represented?, is there a good set of primitives in which all knowledge can be broken down?, is it helpful to use such primitives?,Primitives are fundamental concepts such as holding, seeing, and playing…..

* **Example : Fact:** Vetal spotted Vikram

**Representation:** Spotted(agent(Vetal),object(Vikram))

* Question 1: Who spotted Vikram? Question 2: Did Vetal see Vikram? (We can not answer)
* In order to discover the answer, we have added other facts such as **Spotted(x,y) Saw (x,y)**
* **Alternate solution could be:** Represent the fact that spotting is really a special type of seeing. **saw(agent(Vetal),object(Vikram),timespan(briefly))**
* In this representation we have broken the idea of spotting apart into more primitive concepts of seeing and timespan

1. How should a set of objects be represented? It is very important to represent a set of objects because of two reasons:
2. There are some properties that are true for the sets but not true for the individual member of a set.

* Example: Consider the assertion:
* There are more sheep than people in Australia.

1. It is important to represent sets of objects is that if the property is true for all (or even most) elements of the set, then it is more efficient to associate it once with the set rather than associate it explicitly with every element of the set.
2. **FINDING THE RIGHT STRUCTURE AS NEEDED:** Given a larger amount of knowledge stored in a knowledge-based, how can relevant parts be accessed when they are needed?

* **Runtime problem solving :** **1.** Content of working memory and content of knowledge base should match. **2.** How to perform this matching and how to search for particular knowledge.
* This is about accessing the right structure for describing a particular situation.
* Problem of matching rules against state descriptions during the problem-solving process.
* There is no good, general-purpose method for solving all these problems. Some knowledge representation techniques solve some of these issues.

**Q.2) Explain the concept of KBA?**

* KBA are those agents which can combine knowledge with current percepts to Infer hidden aspects of the current state. KBA is an agent which has knowledge with intelligence.
* **Knowledge-based agents have the capability of** : maintaining an internal state of knowledge, reason over that knowledge, update their knowledge after observations and take action..
* **A KBA must be able to do : 1.** Represents the state, actions, **2.** Incorporate new percepts, **3.** An agent can update the internal representation of the world, **4.** An agent can deduce the internal representation of the world, **5.** An agent can deduce appropriate actions.
* **The knowledge-based agent is composed of two parts:**

1. **Knowledge base:** Knowledge-base is a central component of a knowledge-based agent, it is also known as KB, It is a collection of sentences.

* These sentences are expressed in a language which is called a knowledge representation language
* The Knowledge-base of KBA stores facts about the world.
* Knowledge-base is required for updating knowledge for an agent to learn with experiences and take action as per the knowledge.

1. **Inference System:** Inference means deriving new sentences from old ones. 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.
* 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: **1.** Forward chaining, **2.** Backward chaining.
* **OPERATIONS PERFORMED BY KBA:**
* **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.
* **LEVELS OF KBA:**
* **Knowledge Level:** Knowledge level is the first level of a knowledge-based agent, and in this level, we need to specify what the agent knows, and what the agent’s goals are. With these specifications, we can fix its behavior.
* **Logical Level:** At this level, sentences are encoded into different logics. At the logical level, an encoding of knowledge into logical sentences occurs.
* **Implementation Level:** This is the physical representation of logic and knowledge. At the implementation level, agent perform actions as per logic and knowledge level.

**Q.3) What do you mean by knowledge representation and what to represent?**

* **knowledge representation:** Humans are best at understanding, reasoning, and interpreting knowledge. How machines do all these things comes under knowledge representation and reasoning.
* It is a way that describes how we can represent knowledge in artificial intelligence.
* Knowledge representation, represents the information from the real world for a computer to understand and then utilize this knowledge to solve complex real-life problems like communicating with human beings in natural language.
* 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.
* It is a study of how knowledge about the world can be represented and what kinds of reasoning can be done with that knowledge
* **what to represent:**
* **Object:** All the facts about objects in our world domain. E.g., Guitars contain strings, and trumpets are brass instruments.
* **Events:** Events are the actions that occur in our world.
* **Performance:** It describes behavior that involves knowledge about how to do things.
* **Meta-knowledge:** It is knowledge about what we know.
* **Facts:** Facts are the truths about the real world and what we represent.
* **Knowledge-Base:** It is the main component of any human, i.e., having a knowledge base. This refers to a group of information regarding any discipline, field, etc.

**Q.4) Representation and mappings?**

* **Knowledge Representation:** Knowledge Representation in AI describes the representation of knowledge. Basically, it is a study of how the beliefs, intentions, and judgments of an intelligent agent can be expressed suitably for automated reasoning.
* One of the primary purposes of Knowledge Representation includes modeling intelligent behavior for an agent.
* Knowledge Representation and Reasoning (KR, KRR) represents information from the real world for a computer to understand and then utilize this knowledge to solve complex real-life problems like communicating with human beings in natural language.
* Knowledge representation in AI is not just about storing data in a database, it allows a machine to learn from that knowledge and behave intelligently like a human being.
* **The different kinds of knowledge that need to be represented in AI include**: Objects, Events, Performance, Facts, Meta-Knowledge, Knowledge-base.
* **What is a knowledge Mappings?** A knowledge Mappings is a visual aid that shows where knowledge can be found within a group or organization and how to find those with the most expertise.
* The map shows who or what resources have the knowledge and where to find the needed information by linking sources together with nodes of additional information for an entire overview of an idea, process, or proficiency.
* **Types of knowledge mappings:** Knowledge mapping is different from simply gathering information. When we look at knowledge as the practical application of information, we can see how knowledge mapping will help us communicate how to apply that information. Knowledge maps can be categorized in one of three ways:
* Procedural knowledge mapping
* Conceptual knowledge mapping
* Competency knowledge mapping
* **Benefits of knowledge Mapping :**Knowledge mapping visually represent complex ideas, solving communication barriers that hurt productivity. These aids effectively communicate processes, share ideas, and map out strategies to organize the thoughts and ideas of a group into a central, actionable direction. Here are some benefits of knowledge mapping.
* **Knowledge mapping work well for things like:**
* Communicating onboarding information
* As a knowledge resource
* Sharing ideas across a team
* Strategic planning
* Complex problem solving
* Documenting brainstorming sessions

**Q.5) Describe in brief the AI knowledge cycle?**

* Cycle of Knowledge means how flow of knowledge goes in a learning process starting from a perception of any facts or events to the end as execution.
* Knowledge is not limited in the world. So, it should have a well organized way to be learned. That is the cycle of knowledge. Cycle of knowledge is the way to organizing the gathering process of knowledge. Every component in the cycle of knowledge should be arrived in order.

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| Cycle of Knowledge |

* **Components in Cycle of Knowledge:** A cycle of knowledge in artificial intelligence must have the following components for displaying intelligent behavior:
* Perception
* Learning
* Representation
* Reasoning
* Planning
* Execution
* **Functionality of AI Components in Cycle of Knowledge:** The following functionalities are done by the respective AI component in the cycle of knowledge.
* Perception gathers information from it’s environment. This component can be in audio, visual or any other form.
* Learning is responsible for data stored by the perception component.
* Representation is related to representing the knowledge in proper way so that machine’s can understand what the knowledge says. It is the most important component in the cycle of knowledge.
* Reasoning is involved to show the intelligence of machine as like real human. Reasoning is another important component. Although knowledge representation and reasoning are different components they are mostly coupled.
* Planning is the way how the execution process will be done.
* Execution is the final component in the cycle which completes the cycle.

**Q.6) What are the different approaches to knowledge representation?**

* **APPROACHES TO KNOWLEDGE REPRESENTATION:**

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| **Developer** | **Language** | **Experience** |
| Dennis Ritchie | C | 15 Years |
| Guido van Rossum | Python | 12 Years |

1. **SIMPLE RELATIONAL APPROACH:** It is the simplest way to represent the facts.

* This is a relational method of storing facts.
* This method helps in storing facts where each fact regarding an object is provided in columns.
* Low opportunity for inferences.
* This approach is used in DBMS (database management systems.).

1. **INHERITABLE KNOWLEDGE APPROACH:** In this approach, all data must be stored in the hierarchy of classes.

* In this approach we apply inheritance property. This approach shows the relation between instance and class, and it is called instance relation.
* In this approach, objects and values are represented in boxed nodes. We use arrows which points from objects to their values.

1. **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 :** Albert is a man, All men are mortal.

Then inferential knowledge can be represented as ; man (Albert) **∀𝑋 = 𝑚𝑎𝑛 𝑋 − > 𝑚𝑜𝑟𝑡𝑎𝑙 (𝑋)**

1. **PROCEDURAL KNOWLEDGE:** It uses small programs and codes which describe how to do specific things, and how to proceed. Most important rule used is the if-then rule.

* We can easily represent heuristic or domain-specific knowledge using this approach. Various coding languages are used such as LISP language and Prolog language.

**Q.7) State and explain types of knowledge ?**

* **TYPES OF KNOWLEDGE:**

1. **Declarative Knowledge:** What is known about the problem.

* Also called descriptive knowledge.
* **Tells us facts:** What things are.
* **Includes:** Concepts, facts, objects

1. **Procedural Knowledge:** Describes how to solve problems. Also known as Imperative knowledge. Provides direction on how to do something. Can be directly applied to a task

* **Includes:** Rules, Strategies, procedures

1. **Meta Knowledge:** Describe knowledge about another knowledge.

* Used to pick other knowledge that is best suited for solving problems

1. **Heuristics Knowledge:** It is representing knowledge of some experts in a field or subject. Describes the thumb rules that guide the reasoning process. Previous experiences, approaches.
2. **Structural Knowledge:** This type of knowledge helps establish relationships between concepts or objects and their description, acting as the basic form of knowledge to solve real-world problems.

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| The Wumpus World in Artificial intelligence |

**Q.8) Wumpus world in brief ?**

* **Performance measure:**
* +1000 Gold, -1000 Death,

-1 for each action,

and -10 for using an arrow.

* **Environment:** A 4\*4 grid of rooms.

The agent initially in room square [1, 1], facing toward the right, Location of Wumpus and gold are chosen randomly except the first square [1,1], Each square of the cave can be a pit with probability 0.2 except the first square.

* **Actuators:** Left turn, Right turn, Move forward, Grab, Release, Shoot.
* **Sensors:** (Stench, Breeze, Glitter, Bump, Scream)

Squares adjacent to wumpus are smelly

Squares adjacent to pit are breezy Glitter iff gold is in the same square

Bump when agent walks into a wall

When wumpus is killed, it screams

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* **Steps: 1.** Initial situation after percept [none, none, none, none, none]

**2.** After one move percept [none, Breeze, none, none, none]

**3.** After the third move percept [Stench, none, none, none, none]

**4.** After the fifth move percept [Stench, Breeze, Glitter, none, none]

* **Wumpus Model:**

**KB= Wumpus world Model + Observation**

**Q.9) Give a brief description of proposition logic ?**

* **PROPOSITIONAL LOGIC:** Propositional Logic is a Declarative statement. (True/False)
* **Example:** **1.** It is Sunday, **2.** The sun rises from the West, **3.** 6+4 =12, **4.** Open the door.
* **FACTS ABOUT PROPOSITIONAL LOGIC:** Propositional logic is also called Boolean Logic. In propositional logic, we use symbolic variables to represent the logic.
* Propositions can be either true or false, but they cannot be both.
* Propositional logic consists of an object, relations, and logical connectives.
* These connectives are also called logical operators.
* The propositions and connectives are the basic elements of propositional logic.
* Connectives can be said to be logical operator which connects two sentences.
* A proposition formula that is always true is called tautology, and it is also called a valid sentence. A proposition formula that is always false is called Contradiction.
* **Types of Propositions:**

1. **Atomic Proposition :** Atomic propositions are simple propositions. It consists of a single proposition symbol. These are the sentences that must be either true or false.

**Example:** **a)** Earth is square, **b)** 2 + 3 = 5

1. **Compound Proposition :** Compound propositions are constructed by combining simpler or atomic propositions, using parenthesis and logical connectives.

**Example:** **a)** It is raining today, and the street is weight, **b)** Mr.Amte is a doctor and his clinic is at Hemalkasa.

**Q.10) State the logical connectives with their precedence ?**

* **LOGICAL CONNECTIVES:**

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| --- | --- | --- | --- | --- |
| **Sr.no** | **Word** | **Symbol** | **Technical Term** | **Example** |
| **1** | **Not** | **¬** | **Negation** | **¬ X** |
| **2** | **And** | **⋀** | **Conjunction** | **X ∨ Y** |
| **3** | **Or** | **∨** | **Disjunction** | **X ∨ Y** |
| **4** | **Implies** | **→** | **Implication** | **(X→Y) if X then Y** |
| **5** | **If and only if** | **⇓→** | **Biconditional** | **(X ⇓→Y)** |

* **X:** It is hot, **Y:** It is Humid, **Z:** It is Raining

**1.** If it is humid then it is hot **𝑌 → 𝑋**

**2.** It is hot and humid then it is not raining **𝑋 ∧ 𝑌 ¬ 𝑍**

* **TRUTH TABLE:**
* **For negation:**

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| --- | --- |
| P | ¬P |
| True | False |
| False | True |

* **For Conjunction: For Disjunction:**

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* **For Implication: For Biconditional:**

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* **PRECEDENCE OF CONNECTIVES:**

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* **LOGICAL EQUIVALENCE:**

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* **LIMITATIONS OF PROPOSITIONAL LOGIC:**

**1.** With propositional logic, we cannot represent relations like ALL, some, or none.

**Example:** ▪ All the girls are intelligent.

▪ Some apples are sweet.

**2.** Propositional logic has limited expressive power.

**Q.11) Illustrate the propositional theorem proving?**

* **PROPOSITIONAL THEOREM PROVING:** so far, we have shown how to determine entailment by model checking: enumerating models and showing that the sentence must hold in all models.
* **In this section we show how entailment can be done by theorem proving:** applying rules of inference directly to the sentences in our knowledge base to construct the proof of the desired sentence without consulting models.
* **1.** Inference and proofs
* **2.** Proof by resolution.
* **Commutativity:** P∧ Q= Q ∧ P or P ∨ Q = Q ∨ P
* **Associativity:** (P ∧ Q) ∧ R= P ∧ (Q ∧ R), (P ∨ Q) ∨ R= P ∨ (Q ∨ R)
* **Identity Element:** P ∧ True = P, P ∨ True= True
* **Distributive:** P∧ (Q ∨ R) = (P ∧ Q) ∨ (P ∧ R), P ∨ (Q ∧ R) = (P ∨ Q) ∧ (P ∨ R)
* **DE Morgan's Law:** ¬ (P ∧ Q) = (¬P) ∨ (¬Q), ¬ (P ∨ Q) = (¬ P) ∧ (¬Q)
* **Double Negation Elimination:** ¬ (¬P) = P
* **Absorption law:** P ∧ (P ∨ Q) = P, P ∨ (P ∧ Q) = P
* **Law of contradiction:** P ∧ ¬P = False
* **Law of excluded middle:** P ∨ ¬ P = True
* **A simple knowledge base(Wumpus World):**

**Goal:** there is no pit in [1, 2] : ¬P 1, 2

P x, y is true if there is a pit in [x, y].

W x, y is true if there is a Wumpus in [x, y] dead or alive

B x, y is true if the agent perceives a breeze in [x, y]

S x, y is true if the agent perceives a stench in [x, y]

* There is no pit [1, 1]: R1 : ¬P1, 1

A square is breezy if and only if there is a pit in the neighboring square. This has to be stated for each square; for now, we include just the relevant squares:

R2 : B 1,1 ⇓→(P 1,2 V P 2,1)

R3 : B 2,1 ⇓→ (P 1,1 V P 2,2 V P3,1)

* Now if we include the breeze percepts for the first two squares visited in the specific world the agent is in leading up to the situation as shown in figure **R4 :** ¬B 1,1 **R5** : B 2,1
* **INFERENCE AND PROOFS:** Generating the conclusion from evidence and facts is termed inference.

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**R2 :** B 1,1 ⇓→(P 1,2 V P 2,1)

**R6 :** (B 1,1 → (P 1,2 ∨ P 2,1) ) ∧ ((P1,2 ∨ P2,1) → B 1,1 )

Now we apply AND Elimination to R6 to obtain

**R7 :** ((P1,2 ∨ P2,1) → B 1,1 Logical equivalence gives

**R8 :** (¬B 1,1 → ¬(P1,2 V P2,1))

Now we can apply Modus Ponens with R8 and percept R4

**R9 :** ¬(P1,2 V P2,1)

**Apply De Morgan’s rule**

**R10:** ¬P1,2 ∧ ¬ P2,1 That is,

**neither [1,2] nor [2,1] contains a pit.**