KNOWLEDGE REPRESENTATION AND REASONING.

Meta knowledge : It refers to information about the structure, rules and constraints of knowledge base. Meta knowledge includes the content, Semantics and relationships between different pieces of knowledge.

Example : Knowing the format and structure of database where medical records are stored would be meta knowledge, where as the actual medical records are primary knowledge.

Knowledge Base : It is crucial for reasoning and decision-making processes as it provides the foundational facts and rules needed for these tasks.

Ex : Patient Records, medical procedures, Drug Information, Symptoms and Diagnoses, Clinical Guidelines.

Events are natural occurances (or) significant occurances which change the state of the world (or) system.

What is Knowledge Representation ?

→ It is the study of how the beliefs, intentions and then utilize this knowledge to solve the complex real life problems like communicating with human beings in natural language.

It allows machine to learn from that knowledge and behave intelligently like a human being.

Different kinds of knowledge that need to be represented in AI

→ Objects, Events, Performance facts, Meta-knowledge, Knowledge-base, object → Book
Attributes → Title
Author
ISBN
Published
Genre.

Types of knowledge. Behaviour
Relationship.

1. Declarative knowledge : It includes concepts, facts, and objects and expressed in declarative sentence. → Fact
Location
Elevation → Mount Everest.

2. Structural knowledge : It is a basic problem solving knowledge that describes the relationship between concepts and objects. → OSI model, Network Topology

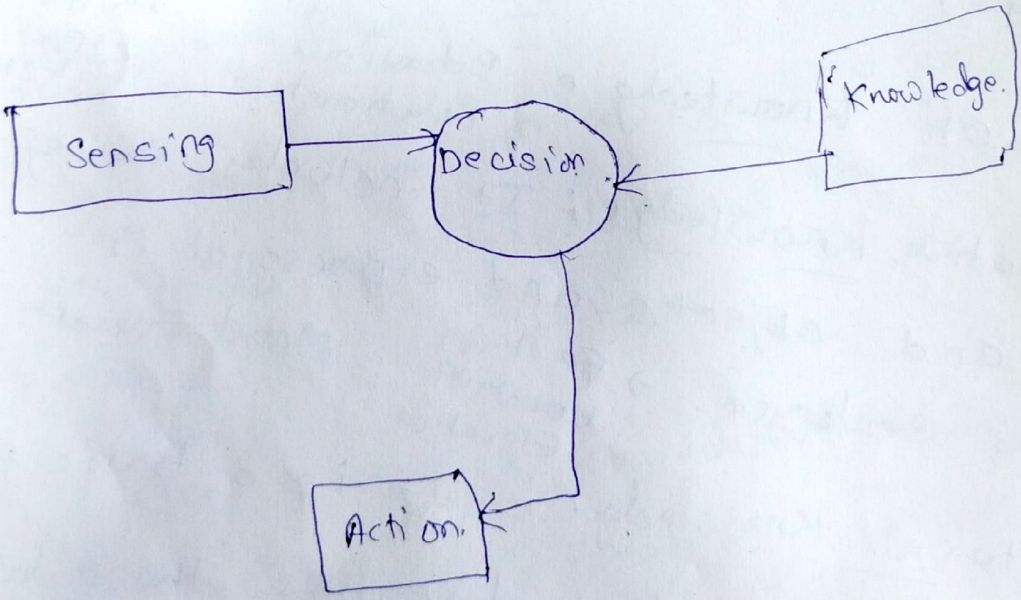
3. Procedural knowledge : This is responsible for knowing how to do something and includes rules, strategies, procedures etc. → Preparation of Receipe.

→ Meta knowledge : Meta knowledge about other types of knowledge. Employee handbook.

→ Heuristic knowledge : This represents some expert knowledge in the field (or) subject. Trouble shooting the O.S

Cycle of Knowledge Representation in AI

→ Perception → NLP, Rec. compuervision → Automonow vehicles
→ Learning → Supervised, unsupervised learning
→ KRR
→ Planning
→ Execution.



Techniques of knowledge Representation in AI.

1. Logical Representation : It decides how we can construct legal sentence logic. It determines which symbol we can use in knowledge representation. → It is saining

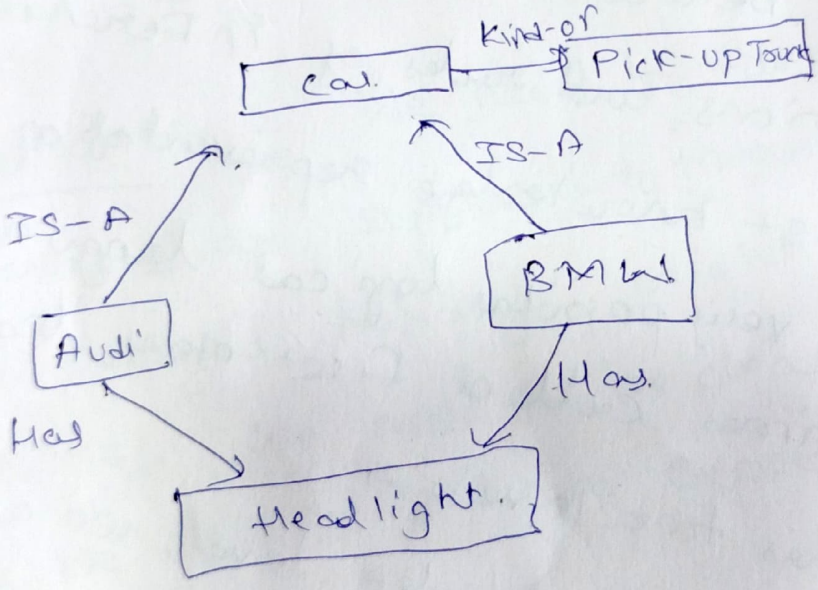
Semantic Network Representation :

→ In semantic networks, you can represent your knowledge in the form of graphical networks. This network consists of nodes representing objects and arcs which describe the relationship between those object.

→ This representation consist of two types of relations:

→ IS-A relation (Inheritance)

→ Kind-of-relation



→ Frame Representation : It is a record like structure that consists of collection of attributes and values to describe an entity in the world. Ex → Car.

Production Rules : The production rule system consists of three main parts

→ the set of production rules.

→ Working memory.

→ The recognize-act-cycle.

→ If student scores greater than 35% then pass.

AI Knowledge Cycle.

→ Role of Logic in KRR

. Entailment between the relations - languages, truth conditions, and rules of inference.

→ The First knowledge representation language a very popular logical language. It some times called First order logic.

→ It has two levels →

→ At the knowledge level, we ask questions concerning the representing language and its semantics.

→ At the symbol level, on the other hand, we ask questions concerning the computational aspects.

Assignment (or) Exercise.

1. Consider a task requiring knowledge, like baking a cake. Examine a receipe and state what needs to know

1. Syntax : Specifies group of words (or) symbols, which should be properly formed. The string of words for example : "the cat my mother loves" is a well formed phrase. but "the my love mother cat" is not for knowledge representation.

2. Semantics : We need to form well formed expressions are supposed to mean, "the hard nosed decimal holiday", might not mean anything. We need to be clear about what idea about the world is being expressed.

3. Pragmatics : We need to specify how the meaningful expressions in the language are to be used. for example : "There is some one behind you". could be a warning to be careful in someone content.

Syntax : In First Order logic there are two sort of symbols 1) logical ones and non logical ones. The logical symbols have a fixed meaning (or) use in the language. There are three sorts of logical symbols.

1. puntuation : "(", ")", and ","
2. connectives : $\sim$ $\wedge$ $\vee$ $\exists$ $\forall$ $\Leftrightarrow$ $=$

$\sim$ = logical negation $\quad$ $\vee$ = logical disjunction

$\wedge$ - and $\quad$ $\exists$ = there exists

$\vee$ - OR $\quad$ $\forall$ - for all.

3. Variables : like u, y, z & sometimes with superscripts and subscripts.

The non logical symbols are application dependent .. There are two sort of non logical symbols.

1. functional symbols : An infinite supply of symbols, which we will write in

uncapitalized uncapitalized mixed case.

Eg :- best friend.

2. Predicate symbols :- An infinite supply of symbols, which we will write. In Capitalized mixed case. Ex; P, Q, R.

Semantics :- Explains the expression of a language. It includes non logical symbols.

Ex :- puddle of water.

→ There are objects in the world.

⇒ The assumption made in FOL is that this is all you need to say regarding the meaning of non logical symbols, hence the meaning of all semantics.

⇒ Example :- ~~Decom~~ Democratic country where the dictionary is free from elections, representative government, majority rule and so on.

Interpretations: Meanings are captured by specific interpretations:-

An interpretation $\tilde{S}$ in FOL is a pair (D, I), where D is non-empty set of objects, called the domain of interpretation and I is called mapping, called interpretation mapping from nonlogical symbols to functions & relations over D.

Example: Consider the following sentences

:= All dogs are mammals.

To interpret this in FOL we need

Domain (D): let say our domain consists of all animals.

Interpretation mapping (I):

Dog: This predicate symbol is assigned to set of all dogs within the domain D.

→ Mammal: The predicate symbol is assigned to set of all mammals within D.

Evaluating Truth:

Under this interpretation, the statement "All dogs are mammals" is true if the set of dogs is a subset of the set of mammals.

$$I(D) \subseteq D \times \ldots D$$
(n times)

Denotation: Denotation refers to the literal (or) dictionary meaning of a word.

Example: Living Room light.

Interpretation (I): maps "living Room light" to specific light fixture in living room.

Domain (D): In this case, it might include all lights in the house represented as objects the system can manipulate (Eg: turn on / OFF)

Turn off the living room light

↓ Parses ↓ looks up light fixture

Derotation.

Derotation is the link between the symbols in our KR & the actual objects or concepts in real world.

1. If x is a variable then $\|x\|_{I,u} = u[x]$

2. if $t_1 \ldots t_n$ are terms and f is a function symbol of parity n then

$$\|f(t_1 \ldots t_n)\|_{I,u} = F(d_1 \ldots d_n)$$

where $I = I[f] = d_i = \|t_i\|_{I,u}$

→ Satisfaction and Models.

Satisfaction refers to whether a given model satisfies a particular logical formula (or) set of formulas. it check if the statements in the knowledge base hold true under a specific interpretation.

Model : It is an interpretation of the symbols in a logical language that assigns meaning to them. It provides a way to evaluate the truth of logical statements based on given interpretation.

Example :

1. Knowledge Base (KB)

P. It is raining

Q : The ground is wet

R : It is cloudy.

2. Logical statements :

$P \rightarrow Q$: If it is raining, then the ground is wet.

$R \rightarrow P$: If it is cloudy, then it is raining.

3. Model : Let's assume the following interpretation.

P = True (It is raining)

Q = True (The ground is wet)

R = True (It is cloudy)

4. Satisfaction : We check if the knowledge base is satisfied by this model.

→ $P \rightarrow Q$: since P is True and Q is True, the implication $P \rightarrow Q$ is satisfied.

→ $R \rightarrow P$: Since R is True and P is True, the implication $R \rightarrow P$ is satisfied.

2.4 The Pragmatics : The content in which knowledge is used and the goals (or) intentions of the agents interacting with it. At pragmatic level of representation,

knowledge is interpreted and applied in specific situations, taking into account contextual factors, user preferences and task requirements.

Pragmatics bridge the gap between symbolic representation and their real world applications.

Ex: "What's the weather like?" → user location & current time.

Meta-level Representation: At this level, knowledge is represented in higher-order form, allowing computational system to reason about the properties, relationships, and structure of knowledge itself. Meta level representation enables self awareness, introspection and reflection within computational systems.

Varieties of Logic:

1) Syntax: Representation of symbols like.

⊃ ∃ and algebraic notations.

Where it follows same propositional logic.

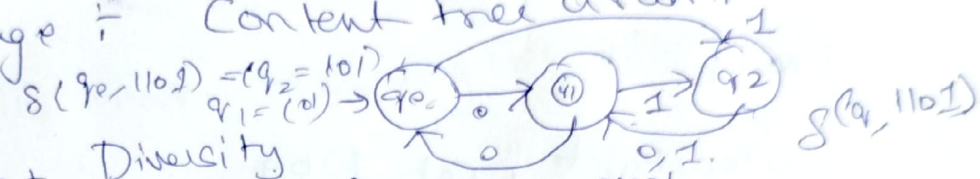
2.) Subsets: Combination of operators

3. Proof theory :- Logical equivalent expressions, logical rules etc.

4. Model theory :- Notations, operators and proofs. → Every non zero element has a square root. Two straight lines are perpendicular to each other, one of them touches parabola at $y^2 = 4a(x+a)$ & other at $y^2 = 4b(x+b)$. Find the point of intersection.

5. Ontology

6. Meta language :- Content Free Grammar.



Unity Amidst Diversity

→ string accepted.

∀ common difference.

Knowledge representation language must have four essential features.

Vocabulary :- It involves a set of symbols that we use to represent information and reason about it. These symbols can be characters, words, icons, diagrams, or even sounds. They are typically divided into four groups.

1. Domain-independent Logical symbols :- These are the symbols that are universal to logic and don't depend on the specific domain of application.

Example :- logical connectives such as ∧(and), ∨(or), ¬(not), → (implies)

→ Quantifiers such as ∀ (for all) and ∃ (there exists).

2. Domain Dependent Constants:

These symbols represent specific entities, properties, (or) relationships within the domain we are considering.

Example.

→ Constants: Cat, Dog

→ Properties: IsPet(x)

→ Relations: Likes(x, y).

3. Variables: These are symbols that can represent any element within the domain. Their range is determined by the quantifiers.

Example: x.

4. Puntoation: They are used to separate (or) group the other symbols to form well-structured statements.

Ex: Parantheses: (,)

Comma: ,

Syntax : A logic must also have grammar rules (or) formation rules that determine how the symbols are combined to form the grammatical (or) well formed sentences. The rules could be stated in a conventional linear grammar, a graph grammar (or) an abstract syntax that is independent of any concrete notation.

Semantics : To make meaningful statements, the logic must have a theory of reference that determines how the constants and variables are associated with the things in the universe of discourse.

Rules of Inference : To be more than a notation, a logic must include rules that determine how one pattern can be inferred from another. It helps in constructing logical proofs, deriving new knowledge, and reasoning about world effectively.

Semantics of propositional logic

p	q	p ∧ q	~(p → ~q)
0	0	0	0
0	1	0	0
1	0	0	0
1	1	1	1

Status of FOL : Classical FOL (first order logic) plays a foundational role in knowledge representation and reasoning.

1. Expressive Power : FOL has the ability to represent a wide range of information, from mathematical theories to digital computer operations. This makes it a universal language for defining complex systems and concepts. In knowledge representation, FOL can model relationships, properties, and entities within a domain.

2. Natural Language Translation :

FOL translations of natural language allow for the formalization of textual information.

→ This is crucial for transforming human-readable formats.

→ This capability ensures that FOL can define all aspects of mathematics and other formal sciences, making it powerful tool for knowledge representation.

1. Model Theory and Proof Theory :

Model theory allows for the interpretation of logical formulas in different structures, while proof theory focuses on the formal derivation of conclusions from premises.

2. Minimal Primitives :

→ FOL can be defined with a minimal set of primitives, such as quantifiers (Eg: "for all" and "there exists") and boolean operators (Eg "and", "or", and "not") which minimizes ambiguities.

Relating Various Logics : The power of FOL and the prestige of its adherents haven't deterred philosophers, logicians and computer scientist from developing other logics.

→ For various purposes, modal logics, higher-order logics, and other extended logics have some desirable properties.

1) Fewer axioms → In propositional logic, → simpler foundation base.

the axioms are typically very simple and few in number. For example, the system of axioms developed by Jan Lukasiewicz for classical propositional logic uses three axioms to build a complete system for logical reasoning.

Example 2 → (Group theory) In abstract algebra, the axioms for a group are minimal and consist of few basic properties like closure, associativity identity element and inverse element.

Axiom is a fundamental statement or) proposition that is assumed to be true without proof.

Ex :- Two sets are equal if and only if they have same elements.

LHS = RHS problems

$2x + 5 = 15$

$2x = 15 - 5$

$2x = 10$

$x = 10/2 = 5$

$2(5) + 5 = 15$

$15 = 15$

$10x + 7 = 13 - 5x$

$10x + 5x = 13 - 7$

$15x = 6$

$x = 6/15 = 2/5$

$10(2/5) + 7 = 13 - 5(2/5)$

$\frac{20}{5} + 7 = 13 - \frac{10}{5}$

$4 + 7 = 13 - 2$

$= 11$

⇒ More natural translations : Without modal logic, an English sentence like like "It may rain" would be an awkward paraphrase. Of all the states of affairs in the set of causal successors of the present.

It refers to the process of converting natural language expression into formal representations that can be used by artificial intelligence systems for reasoning and decision making.

→ Ex → Chatbots

More efficient computation: By incorporating features of ontology (OL) meta language operators such as symbols □ and ◇, a complex logic can sometimes simplify knowledge representation. With this technique, much of the computation is transferred from axioms to rule of inference.

→ machine executable code.