Knowledge representation

LECTURE 2

What is knowledge?

facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject.

Knowledge = information + rules

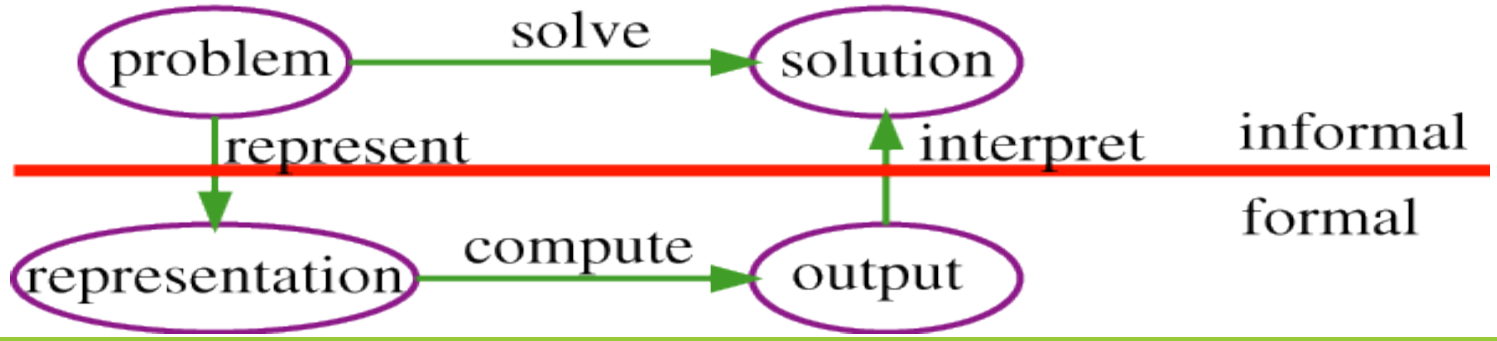
EXAMPLE

Doctors, managers.

What is Knowledge representation?

Knowledge representation is a relationship between two domains.

Knowledge representation(KR) is the field of **artificial intelligence** (**AI**) that representing information about the world in a form of computer system, that can solve complex tasks, such as diagnosing a medical condition.



There are 5 types of knowledge according to the nature and function of the knowledge

There are 5 types of knowledge.

1) Procedural k.

2) Declarative k.

3) Meta k.

4) Heuristic k.

5) Structural k.

1)Procedural Knowledge

Gives information/ knowledge about how to achieve something.

Describes how to do things provides set of directions of how to perform certain tasks.

Procedural knowledge, also known as imperative/الزامي **knowledge**, is the **knowledge** exercised in the performance of some task.

Example

How to drive a car?

2)Declarative knowledge

Declarative knowledge, also referred to as verbal or factual knowledge, describes things, events, or processes; their attributes; and their relation to each other.

It is contrary to procedural or implicit knowledge, which refers to the knowledge of how to perform or operate.

"*Can this knowledge be true or false*?"

Example

It is sunny today

I ate oatmeal for breakfast this morning'

3)Meta Knowledge

It’s a knowledge about knowledge and how to gain them.

Example

The knowledge that blood pressure is more important for diagnosing a medical condition then eyes color.

4)Heuristic Knowledge

Representing knowledge of some expert in a field or subject.

Rules of thumb, Heuristic Knowledge are sometimes called shallow knowledge.

Heuristic knowledge are empirical/ تجريبيه as opposed to deterministic.

Example:

If you're traveling to a popular destination, book flights and hotels several months in advance to save money

5)Structural Knowledge

Describes what relationship exists between concepts/ objects.

Describe structure and their relationship.

Example

How to various part of car fit together to make a car, or knowledge structures in term of concepts, sub concepts and objects.

Classification according to source, nature, and method of representation or use.

Knowledge Type	Description
Domain knowledge	Domain knowledge is valid knowledge for a specified domain. Specialists and experts develop their own domain knowledge and use it for problem solving.
Meta knowledge	Meta knowledge can be defined as knowledge about knowledge.
Commonsense knowledge	Common sense knowledge is a general purpose knowledge expected to be present in every normal human being. Common-sense ideas tend to relate to events within human experience.
Heuristic knowledge	Heuristic is a specific rule-of-thumb or argument derived from experience.
Explicit knowledge	Explicit knowledge can be easily expressed in words/numbers and shared in the form of data, scientific formulae, product specifications, manuals, and universal principles. It is more formal and systematic.
Tacit knowledge	Tacit knowledge is the knowledge stored in subconscious mind of experts and not easy to document. It is highly personal and hard to formalize, and hence difficult to represent formally in system. Subjective insights, intuitions, emotions, mental models, values and actions are examples of tacit knowledge.

Table 1: Types of Knowledge

For Reading

Type of Knowledge	Representation	Examples
Declarative Knowledge	Logical Representation	Mathematical rules, business logic
Conceptual/Hierarchical	Semantic Networks	Taxonomies, ontologies
Structured Knowledge	Frames	Object attributes, scenarios
Procedural Knowledge	Production Rules	Expert systems, decision rules
Domain-Specific Knowledge	Ontologies	Medical ontologies, NLP systems
Probabilistic Knowledge	Bayesian Networks	Risk assessment, diagnosis
Implicit Knowledge	Neural Networks	Image/speech recognition
Tabular Knowledge	Relational Databases	Business records, inventories
Experiential Knowledge	Case-Based Representation	Legal cases, medical diagnoses

Knowledge Representation and Reasoning

- ✓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.

What kind of knowledge to Represent:

The different kinds of knowledge that need to be represented in AI include:

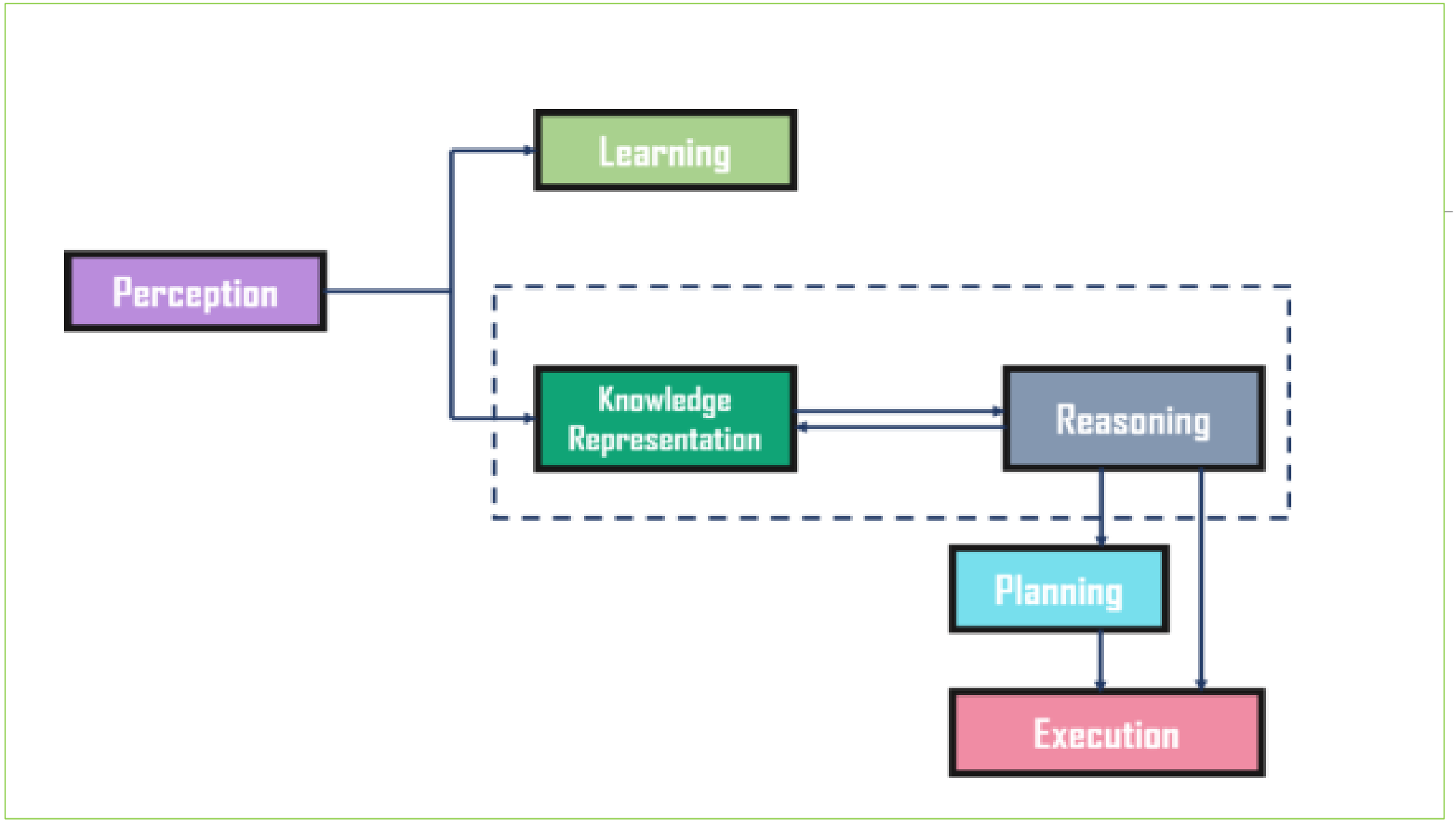
- ✓**Objects -** All the facts about objects in our world domain. E.g., Guitars contains strings, trumpets are brass instruments.
- ✓**Events -** Events are the actions which occur in our world.
- ✓**Performance -** It describe behavior which involves knowledge about how to do things
- ✓**Facts -** Facts are the truths about the real world and what we represent
- ✓**Meta-Knowledge** It is knowledge about what we know.

- ✓**Knowledge-base - -** The central component of the knowledge-based agents is the knowledge base. The Knowledge base is a group of the Sentences (Here, sentences are used as a technical term and not identical with the English language).

Cycle of Knowledge Representation in AI

Artificial Intelligent Systems usually consist of various components to display their intelligent behavior. Some of these components include:

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


Learning
Perception
Knowledge Representation
Reasoning
Planning
Execution

Perception component

- ✓The Perception component retrieves data or information from the environment.
- ✓with the help of this component, you can retrieve data from the environment
- ✓Find out the source of noises and check if the AI was damaged by anything.
- ✓ Also, it defines how to respond when any sense has been detected.
  - ✓A self-driving car uses cameras, radar, and LiDAR to detect pedestrians, traffic signs, and other vehicles.

Learning Component

✓There is the Learning Component that learns from the captured data by the perception component.
✓The goal is to build computers that can be taught instead of programming them.
✓Learning focuses on the process of self-improvement.
✓In order to learn new things, the system requires knowledge acquisition, inference, acquisition of heuristics, faster searches, etc.

- ✓A recommendation system like Netflix learns user preferences by analyzing past viewing habits to suggest movies or TV shows.

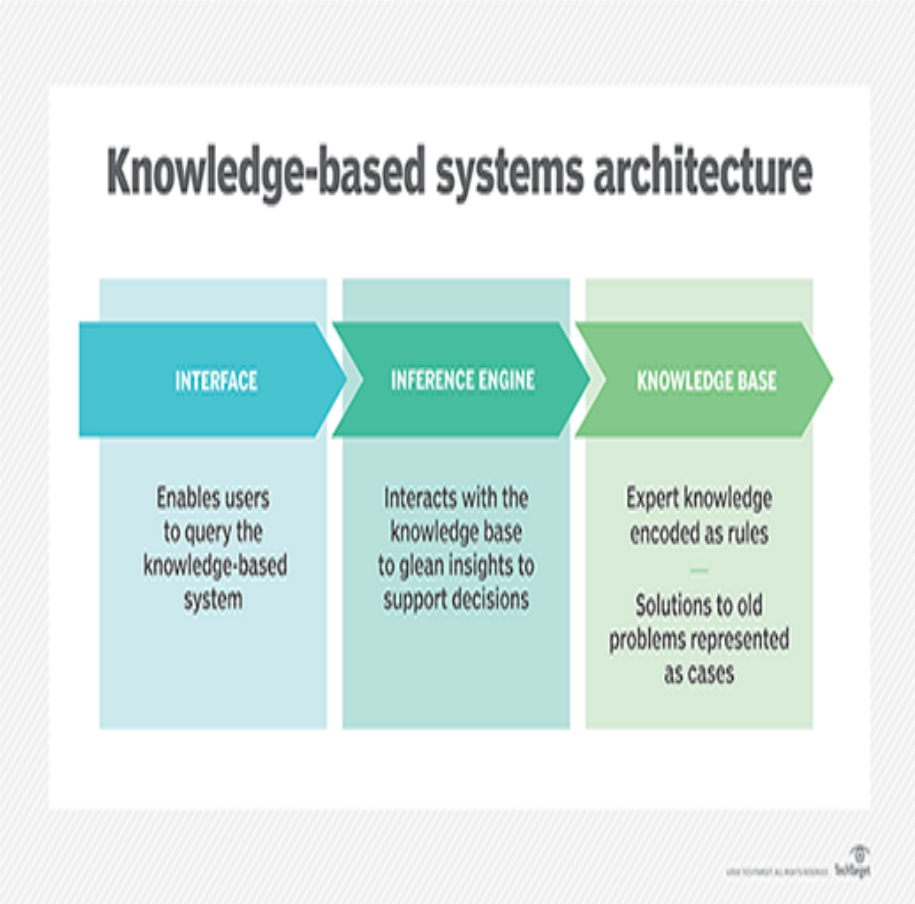
Main Component

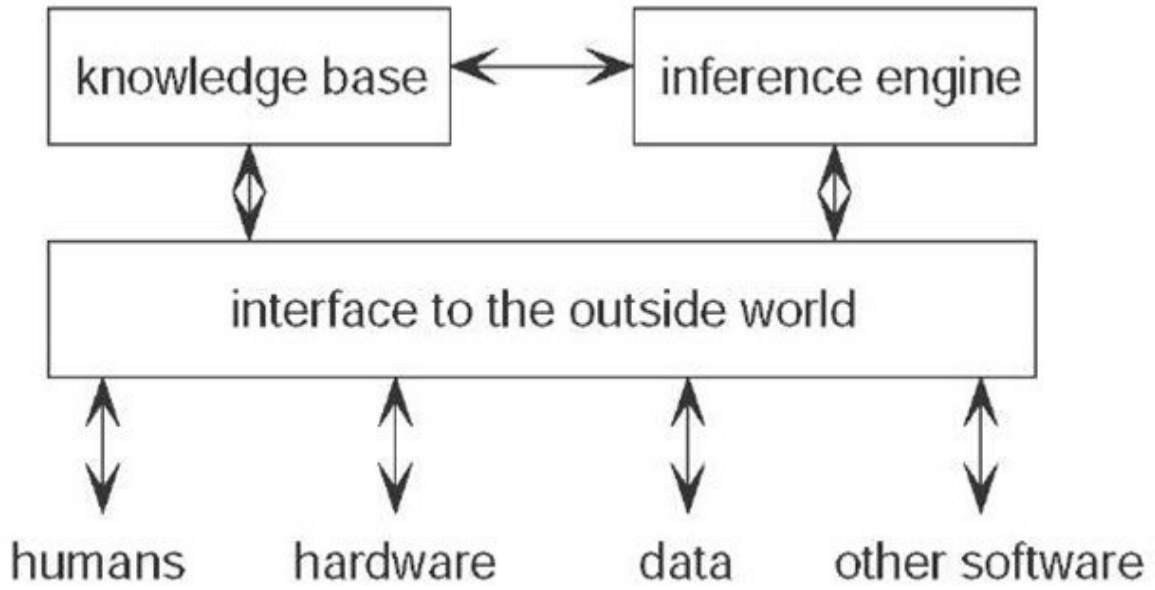
- ✓The main component in the cycle is **Knowledge Representation and Reasoning** which shows the human-like intelligence in the machines.
- ✓Knowledge representation is all about understanding intelligence.
- ✓Instead of trying to understand or build brains from the scratch, its goal is to understand and build intelligent behavior from the top-down and focus on **what** needs to be known in order to behave intelligently.
- ✓Also, it defines how automated reasoning procedures can make this knowledge available as needed.
  - ✓In a medical diagnosis system, knowledge about diseases, symptoms, and treatments is stored. Reasoning is used to match patient symptoms to possible diagnoses and suggest treatments.

Planning and Execution components

- ✓The Planning and Execution components depend on the analysis of knowledge representation and reasoning.
- ✓Here, planning includes giving an initial state, finding their preconditions and effects, and a sequence of actions to achieve a state in which a particular goal holds.
- ✓ Now once the planning is completed, the final stage is the execution of the entire process.
  - ✓A robot tasked with cleaning a room plans the most efficient route to vacuum all areas while avoiding obstacles.
  - ✓A delivery drone executes the plan by flying to the delivery location, dropping off the package, and returning to the base.

KBS Architecture





Knowledge module is KB
Control Module is Inference Engine

Basically 4 types of knowledge representation in AI

1) Logical representation
2) Production rule
3) Semantic networks
4) Frame representation

1) LOGICAL REPRESENTATION

Logic is based on truth.

There are 2 types of LR

1) propositional logic(PL)

2) first order predicate logic(FOL)

Propositional Logic

Propositional logic (PL) is the simplest form of logic where all the statements are made by propositions.

A proposition is a declarative statement which is either true or false.

It is a technique of knowledge representation in logical and mathematical form.

Example:

> a) It is Sunday.
>
> b) The Sun rises from West (False proposition)
>
> c) 3+3= 7(False proposition)
>
> d) 5 is a prime number.

Some basic facts about propositional logic:

- Propositional logic is also called Boolean logic as it works on 0 and 1.
- In propositional logic, we use symbolic variables to represent the logic, and we can use any symbol for a representing a proposition, such A, B, C, P, Q, R, etc.
- Propositions can be either true or false, but it cannot be both.
- Propositional logic consists of an object, relations or function, and **logical connectives**.
- These connectives are also called logical operators.
- The propositions and connectives are the basic elements of the propositional logic.
- Connectives can be said as a logical operator which connects two sentences.
- A proposition formula which is always true is called **tautology**, and it is also called a valid sentence.
- A proposition formula which is always false is called **Contradiction**.
- Statements which are questions, commands, or opinions are not propositions such as "**Where is Rohini**", "**How are you**", "**What is your name**", are not propositions.

Syntax of propositional logic:

The syntax of propositional logic defines the allowable sentences for the knowledge representation. There are two types of Propositions:

Atomic Propositions

Compound propositions

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

Example:

a) 2+2 is 4, it is an atomic proposition as it is a **true** fact.

b) "The Sun is cold" is also a proposition as it is a **false** fact.

Cont.

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

Example:

a) "It is raining today, and street is wet."

b) "Ankit is a doctor, and his clinic is in Mumbai."

First Order Logic

- Statements that cannot be made in propositional logic but can be made in FOL.
- When you paint a block with green paint, it becomes green. – In propositional logic, one would need a statement about every single block, one cannot make the general statement about all blocks.
- When you sterilize a jar, all the bacteria are dead. – In FOL, we can talk about all the bacteria without naming them explicitly.
- A person is allowed access to this Web site if they have been formally authorized, or they are known to someone who has access.

First Order Logic

- First-order logic is another way of knowledge representation in artificial intelligence. It is an extension to propositional logic.
- **First-order logic** is also known as **Predicate logic** or First-order predicate logic.
- Propositional logic assumes the world contain **facts**.

Predicate Logic Example

A sentence in **first-order logic** is written in the form Px or P(x), where P **is the predicate** and x **is the** subject(object), represented as a variable.

John is tall. **John is Subject and tall is predicate**

tall(John)

Arun and Vijay are friends.

friends(Arun , Vijay).

Basic Elements of First Order Logic

Elements	Examples
Constant	1, 2, Pune, Ajay…
Variables	x, y, a , b,…
Predicates	Brother, Father,…
Function	Sqrt, LeftLegOf,…
Connectives	^, V, ¬, (And, Or, Not)
Equality	== → ⟷
Quantifier	∀, ∃

Quantifiers

In First Order Logic , a sentence can be structured using the Universal quantifier or the Existential quantifier.

Universal Quantifier

- ∀<variable><sentence>
- True for all.
- We use implication“→” (conclusion)

Existential Quantifier

- ∃<variable><sentence>
- True for atlaest one.
- We use conjunction symbol “^” (connectors)

Some Examples of FOL

1. All kings are person.

$\forall x$: King(x) $\Longrightarrow$ person(x)

2. No-one likes noodles.

$\forall x$: person(x) $\Longrightarrow \neg$ likes(x, noodles)

3. Some dog is a pet.

$\exists x$: (dog(x) ^ pet(x))

4. Every student pass or fail.

$\forall x$: (student(x) $\Longrightarrow$ (pass(x) V fail (x)))

5. If x is a parent of y, then x is older than y.

$\forall x \forall y$ Parent(x,y) $\Longrightarrow$ older(x,y)

Properties of Quantifiers

∀x ∀y is the same as ∀y ∀x

∃x ∃y is the same as ∃y ∃x

∃x ∀y is **not** the same as ∀y ∃x

∃x ∀y loves(x,y)- “There is a person who loves everyone in the world”

∀y ∃x loves(x,y)-”Everyone in the world is loved by at least one person”

Quantifier duality: Each can be expressed using the other.

∀x likes(x, IceCream)	¬ ∃x ¬likes(x,Icecream)
∃x plays(x, Cricket)	¬ ∀x ¬plays(x, Cricket)

Self Test

- Every cat drinks milk.
- Virat loves Anushka
- Someone is Laughing
- Nobody loves George
- All men are mortal

Every cat drinks milk.
∀x: cat(x) -----→ drinks(milk)
Virat loves Anushka.
loves(virat , Anushka)
Someone is Laughing.
∃x: laughing(x)
Nobody loves George
¬ ∃x: loves(x, George)
All men are mortal.
∀x: men(x) --- →mortal(x)

2) PRODUCTION RULE

Production Rule is defined as a procedural representation of knowledge that links conditions to actions.

It allows domain experts to express their knowledge in the form of rules, making knowledge acquisition and maintenance easier.

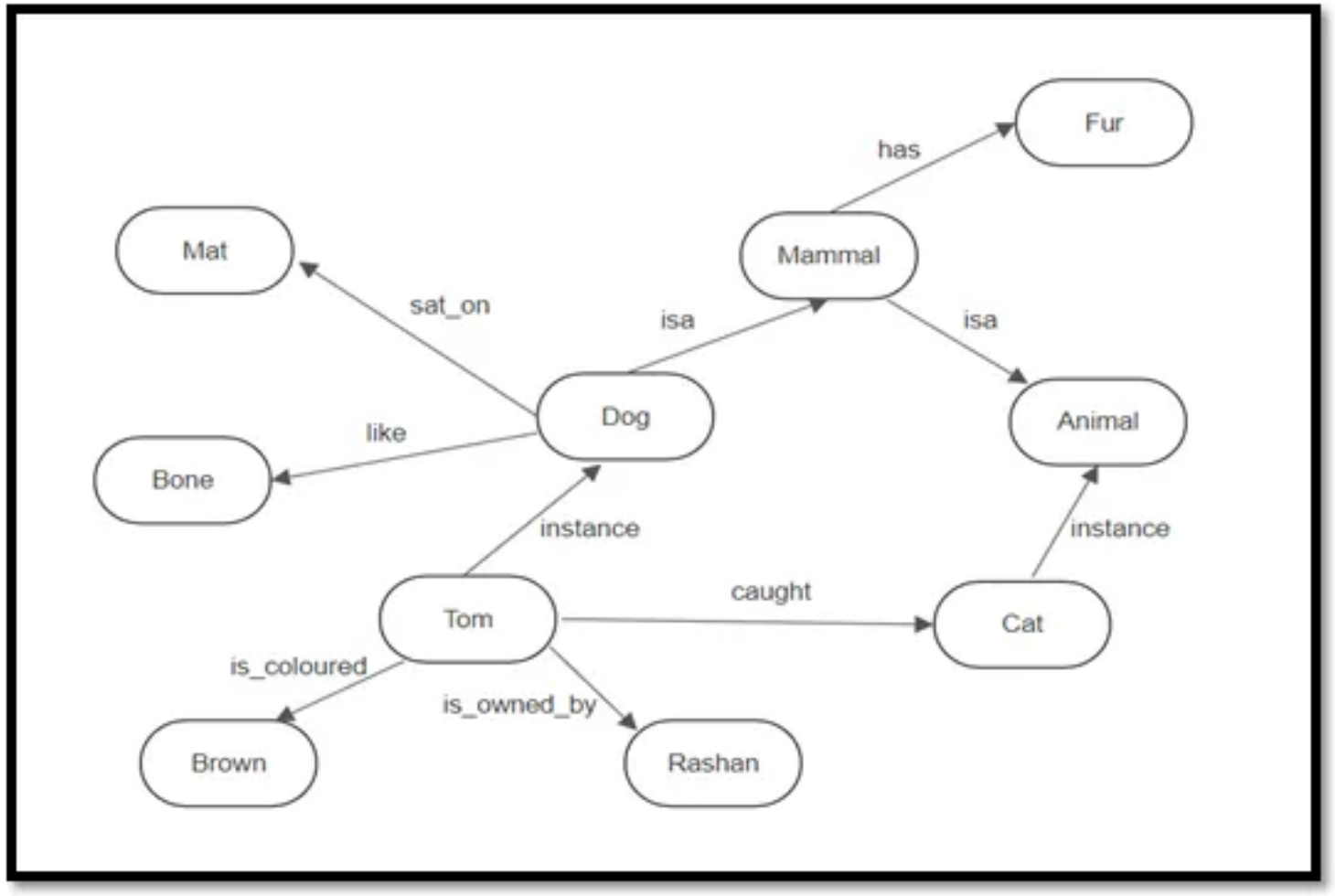
For example, “if a customer automobile order includes the exterior appearance option, then add chrome trim and decals to the bill of materials.”

3) SEMENTIC NETWORK

These represent knowledge in the form of graphical network.

Example

- Tom is an instance of dog.
- · Tom caught a cat
- · Tom is owned by rashan.
- · Tom is brown in colour.
- · Dogs like bones.
- · The dog sat on the mat.
- · A dog is a mammal.
- · A cat is an instance animal
- · All mammals are animals.
- · Mammals have fur.


Fur
has
Mat
Mammal
sat_on
isa
isa
Dog
Animal
like
Bone
instance
instance
caught
Tom
Cat
is_coloured
is_owned_by
Brown
Rashan

```
|                    Book Frame                    |
+--------------------------------------------------+
| Slots:                                           |
| Title: "To Kill a Mockingbird"                   |
| Author: "Harper Lee"                             |
| Publication Year: 1960                           |
| ISBN: "978-0-06-112008-4"                        |
| Genre: "Fiction"                                 |
+--------------------------------------------------+
| Facets:                                          |
| Publication Year:                                |
|   - Type: Integer                                |
|   - Range: 1450 to current year                  |
| ISBN:                                            |
|   - Format: 13-digit number                      |
+--------------------------------------------------+
| Default Values:                                  |
| Genre: "Unknown" (if not specified)              |
+--------------------------------------------------+
| Procedures:                                      |
| CheckAvailability: Method to check if the book   |
|   is currently available in the library.         |
| UpdateRecord: Method to update the book's        |
|   record when it is borrowed or returned.        |
+--------------------------------------------------+
```

4) FRAME REPRESENTATION

Frames are record like structures that consist of a collection of slots or attributes and the corresponding slot value.

Slots have names and values called facets.