Knowledge Representation (KR) in Artificial Intelligence

Knowledge Representation is the method used in AI to **store real-world information in a form that a computer can understand, reason about, and use to make decisions**.

In simple words:
👉 *KR is how an AI system "knows" things.*

Why Knowledge Representation is important

- Converts human knowledge into machine-readable form
- Enables **reasoning and problem solving**
- Helps AI answer questions, make decisions, and plan actions
- Separates **knowledge** from **control/program logic**

Types of Knowledge Representation

1. Logical Representation

Knowledge is represented using **formal logic** (rules, facts, predicates).

Examples

- Propositional Logic
- Predicate (First Order) Logic

Example

All humans are mortal
Socrates is a human
Therefore, Socrates is mortal

Advantages

- Precise and unambiguous
- Supports mathematical reasoning

Limitations

- Hard to represent uncertainty
- Complex for large real-world problems

2. Semantic Network

Knowledge is represented as a **graph**:

- Nodes → objects/concepts
- Edges → relationships

Example

Dog → is-a → Animal
Dog → has-part → Tail

Advantages

- Easy to visualize
- Good for representing relationships

Limitations

- Weak formal semantics
- Difficult to perform complex reasoning

3. Frame-Based Representation

Knowledge is organized into **frames (structured objects)** with:

- Slots (attributes)
- Values (data)

Example

Frame: Student
Name: Rahul
Branch: CSE
Semester: 4

Advantages

- Similar to object-oriented programming
- Supports inheritance

Limitations

- Less flexible for dynamic knowledge

4. Production Rules (Rule-Based Representation)

Knowledge is represented using **IF–THEN rules**.

Example

IF fever AND cough
THEN disease = Flu

Advantages

- Easy to understand and modify
- Widely used in expert systems

Limitations

- Rule explosion problem
- Difficult to manage large rule sets

5. Ontologies

Knowledge is represented using **concept hierarchies, properties, and constraints**.

Used in

- Semantic Web
- Medical AI
- Knowledge Graphs (Google, Wikidata)

Advantages

- Standardized and reusable
- Supports interoperability

Limitations

- Time-consuming to build

Inference in Artificial Intelligence

Inference is the process by which an AI system **derives new knowledge or conclusions from existing knowledge**.

In simple words:
👉 *Inference is how an AI system "thinks" using stored knowledge.*

Types of Inference in AI

1. Deductive Inference

General → Specific
If premises are true, conclusion is **always true**.

Example

All birds can fly
Sparrow is a bird
Sparrow can fly

Used in

- Expert systems
- Logic-based AI

2. Inductive Inference

Specific → General
Conclusion is **probable**, not guaranteed.

Example

Sun rose in the east every day
Sun will rise in the east tomorrow

Used in

- Machine Learning
- Pattern recognition

3. Abductive Inference

Observation → Best explanation

Example

Road is wet
It probably rained

Used in

- Medical diagnosis
- Fault detection

4. Forward Chaining

Data-driven inference
Starts with known facts and **applies rules to reach conclusions**.

Example

Fact: Fever
Rule: IF Fever → DoctorVisit
Conclusion: DoctorVisit

Used in

- Expert systems
- Real-time decision systems

5. Backward Chaining

Goal-driven inference
Starts with a **goal** and works backward to check if facts support it.

Example

Goal: Disease = Flu
Check: Does Fever AND Cough exist?

Used in

- Prolog
- Diagnostic systems

One-line Difference (Good for Exams)

- **Knowledge Representation** → *How knowledge is stored in AI*
- **Inference** → *How new knowledge is derived from stored knowledge*