1)

AI: 1, 3, 4

AI

UNIT-IV

Knowledge Representation:

- Ontological Engineering
- Categories and objects, Events
- Mental Events & Mental Objects
- Reasoning Systems for Categories
- Reasoning with Default information

Classical Planning:

- Definition of classical planning
- Algorithms for planning with State-Space Search
- Planning Graphs
- Other Classical planning Approaches
- Analysis of planning approaches

* Knowledge Representation (KR)

→ It is a method
- to represent info about the world in a form that a computer can use.

→ It is the way AI systems store knowledge about the world.

→ It helps machines to understand like humans.

→ It is how AI stores & uses knowledge.

→ Helps machines understand the world

→ Like how we remember facts, AI uses KR to remember things.

→ KR helps AI store & use knowledge logically.

→ It helps AI in decision-making

→ It helps AI in learning.

→ It enables reasoning like humans.

KR Techniques

1. Propositional logic: Simple true/false statements.
2. Predicate logic: uses variables, functions, quantifiers.

Real-life examples

→ Voice assistants

→ Autonomous cars

→ It helps AI to think & make decisions.

→ It bridges the gap b/w human understanding & machine processing.

Types of Knowledge

1. Facts – ex: Water is wet
2. Concepts – Dog is an animal
3. Procedures – How to cook rice
4. Meta-Knowledge – Knowledge about Knowledge

⇒ Helps AI answering, planning, understanding learning

* Ontological Engineering

- Ontology → List of concepts & how they are related
  - → Like a dictionary for AI
  - Ex: Hospital Ontology – Doctor, Patient, Medicine
  - → Ontology = ① formal description of concepts & relationships in a domain
    ② formal way of describing knowledge
  - → used in robotics.
  - → It is like dictionary for machines

⇒ Ontological Engineering is the process of designing, creating & maintaining ontologies

→ It helps AI systems to understand the world better by sharing knowledge.

→ It is the process of creating & using ontologies in AI.

→ It is a subfield of AI.

→ It helps AI systems:
- Represent knowledge clearly
- Share knowledge b/w systems
- Make decisions using relationships & logic

→ It is crucial in NLP, Health care, AI, Robotics

Benefits

→ encourages data sharing → Makes knowledge reusable & updatable
→ Supports reasoning, logic, decision-making
→ Increases reusability
→ Bridges human & machine understanding
→ Helps AI understand & reason

→ Traditional systems only store data.
→ AI systems store, understand meaning & relationships & make decisions.
→ Ontological Engineering provides this understanding.

Steps in OE

1. Select domain - eg: Medicine
2. Identify key concepts - Doctor, Patient, Disease
3. Create hierarchies - Doctor is a Person
4. Define properties & relationships - Doctor treats Patient.
5. Add rules - Every Patient must have one disease
6. Use tools

Challenges

→ requires deep domain knowledge
→ hard to update large ontologies
→ Needs tools

Category * Categories and Objects

→ A category is a collection of similar things/ objects that share common properties.

→ Also called Concepts & Classes.

→ It is used to group knowledge.

→ So it is easy to understand & process to AI

Ex: Category: Fruit

Members: Apple, Mango, Banana

Features of categories

1. Name - What the category is called
   ex: Animal
2. Properties - Common attributes
   ex: Animals can move
3. Subcategories - Categories inside categories
   ex: Dog is a type of animal
4. Relations - How categories are connected
   ex: Dog is a animal

⇒ Categories group similar objects

Object

→ An object is a specific instance of a category.

→ It has unique values
- but still shares the common features of the category

Ex: Object: Red Apple
Belong to category: Fruit

Features of Objects

→ Represent real-world entities.

→ Each object belongs to at least one category.

→ It has unique values

Why Categories & Objects important

→ Helps AI store knowledge

→ Allows inheritance (objects get properties from their categories)

→ Supports reasoning & inference.

→ Makes learning easier for Machines

→ Makes decision-making easier for Machines.

⇒ Frame is data structure.
- to represent Categories & Objects.

⇒ A frame has: attributes
values
inheritance

Ex: Category Frame: Animal
- HasLegs = Yes
- canMove = Yes

Object Frame: Dog
- isA = Animal
- Sound = Bark

Applications

→ NLP
→ Chatbots
→ Robotics
→ Vision AI

Benefits

- Reusability
- Efficiency
- Reasoning
- Learning

Real-World example

- Self driving car

* Event

→ An event is something that occurs

→ An event is something that happen at a certain time.

→ In AI, it is used to describe actions or changes in environment.

→ Events are time-dependent.

→ Events help AI systems to track changes & respond.

Event Representation

Event(Name, Time, Location, Participants)

Ex: Event(Fire, 12:30PM, Lab1, Sensor23)

Components of an Event

1. what - what happened (eg: fire alarm)
2. when - time
3. where - location
4. who - Agents or sensors
5. Effect - Result or reaction

⇒ Events help in reasoning

⇒ used in planning, prediction & scheduling.

⇒ Ex: If door opens → turn on light after 5 sec

⇒ before event, changes after event.

Real-world Example

- Smart Security System
  Event: Motion detected at night
  Reaction: Turn on light + send alert.

Applications

→ Smart Devices
→ Self-driving cars
→ Healthcare
→ Industrial
→ Expert Systems

⇒ Events are time-based occurences
⇒ It helps AI systems: observe,
reason
respond to changes

* Mental Events and Mental objects

Mental Events → thought actions

→ Mental events are thought processes that happen in the mind.

→ It include thinking, believing, deciding, remembering, imagining etc.

→ In AI, It help in simulating human-like thinking & behaviour.

Ex: Mental event : thinking about solving a math problem

in Robots : Deciding to move left in a maze.

Mental Objects → thought content

→ Mental objects are things the mind works with ideas, beliefs, goals, intentions

→ They are the content of mental events.

→ Helps AI represent knowledge, goals, plans, memories.

Ex: Belief : the room is hot

Goal : Turn on fan

Mental Events	Mental Objects
①. Mental action or Mental Processes	①. Mental things or Mental representations
②. Decading, planning	②. Beliefs, goals, ideas
③. Process of reasoning	③. Data used in reasoning
④. It is time-based	④. Not time-based

⇒ Helps AI to:

- Make decisions
- Simulate human thought
- Set & manage goals
- understand.

Mental events used in

- expert System
- Robotics
- Intelligent agents.

Applications

- Robotics
- Autonomous cars
- Chatbots

* Reasoning Systems for Categories

Reasoning System

→ A reasoning system is a part of AI.

→ It helps to give conclusions based on stored knowledge.

→ It uses logic, rules to think.

Category

→ A category is a group of similar objects.

Ex: Category: Vehicle

Objects: Car, bike

Reasoning Systems for Categories

→ these systems help reason about category memberships, properties & relationship.

→ they Allow AI to answer:

- is X a member of Y?
- What properties does Y inherit?
- Can Y do Z?

→ It classify objects.

Real-life Use Cases

- → Health care
- → NLP
- → Chatbots
- → Robotics

Benefits

- → Makes AI intelligent & adaptable
- → Supports learning
- → Helps in prediction
- → Helps in classification
- → Knowledge reuse
- → Knowledge sharing

⇒ RSC help AI understand, classify knowledge.

* Reasoning with Default Information

→ Default reasoning means assuming something is true by default
- unless there is evidence

→ It is used when complete information is not available.

Ex: Assumption: Birds can fly
- But Penguins can't fly.

→ It is a method of reasoning,

→ where we assume something as true unless proven

→ It helps AI to make decisions
- when complete info is not available.

→ In real-world situations, AI doesn't have full knowledge.

→ Default Reasoning allows AI to:
- Deal with incomplete
- Deal with uncertain
- Act faster & Smarter

Eng

Known fact: Parrot is a bird

GK: Birds can fly

* So, AI assumes: Parrot can fly

New fact: Penguin is a bird

So, AI assumes: Penguin can fly

Default Rule Format

- If X is a bird, then by default X can fly
- Unless X is a bird like Penguin or ostrich (exceptions)

[X is a Bird]

↓

[Birds can fly → Assume X can fly]

↓

[If X is Penguin → Exception → X cannot fly]

* Default = assume true by common sense
* Exception = Special case that breaks the rule

How it works

1. Check given information
2. Apply default rule
3. Assume something is true
4. If exception comes, ~~remove~~ remove or change that assumption,

Adv

→ Saves time
→ Saves effort
→ Helps AI to think like humans
→ works when data is incomplete

* Classical Planning

Def: Classical Planning is a method in AI
- where an agent creates a sequence of actions to move from a known starting state to a desired goal state.
- in a fully observable environment.

(or)

⇒ It is planning where everything is known & the result of every action is predictable

Ex: cleaning robot

→ A robot knows the full map of a house. -Plans the exact steps to clean each room without any surprises

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→ Classical Planning is a type of planning in AI where:
- the world is fully known
- the world is static (doesn't change by itself)
- Results are predictable

→ the goal is to find a sequence of actions that moves from a start state to the goal state.

Components

- Initial State
- Goal State
- Plan
- Actions

Simple Real-life Example

1. Making tea

① Initial State: Water, milk, tea powder.

② Goal State: Hot cup of tea

③ Actions: Boil water → add milk → Add tea powder → Pour → Serve

④ Plan: A correct sequence of steps to reach the goal.

2. AI Robot Cleaner

- Initial: Room is dirty
- Goal: Room is clean
- Actions: Move, Vaccum / Clean
- Plan: Move to dirt → Vaccum → Repeat → Goal reached

Steps in Classical Planning

1. Define initial state
2. Define goal state
3. List all possible action
4. Use a search algorithm to find best Path.
5. Return the Path.

Advantages

→ Works well in simple & predictable environments.

→ Easy to understand.

→ Easy to implement.

→ Good for robotics, games, automated tasks