Forward Chaining Steps

1) From(2): Enemy (Country E, America) and Owns (Country E, Missile 1).

2) From(3): Weapon (Missile 1)

3) From(4): Sells (Solan, Missile 1, Country E)

4) From(5): American (Solan)

5) From(6): Hostile (Country E)

6) Apply (1): American (Solan) ∧ Weapon (Missile 1) ∧ Sells (Solan, Missile1, Country E) ∧ Hostile (Country E) → Criminal (Solan)

Therefore, Solan is a criminal

Hence, proved

ASSIGNMENT - 2

Q1) Explain backward chaining algorithm with an example.

Ans Backward chaining is a goal-driven reasoning method in Artificial Intelligence. It starts with a desired goal or conclusion and works backward through a set of rules and facts to find the evidence or conditions that support that goal. This process is also known as backward reasoning or backward deduction.

Algorithm Steps

1) Start with the goal - Identify the ultimate goal or conclusion that needs to be proven.

2) Find the rules that conclude the goal

Search the knowledge base for rules where the consequent (the "then" part) matches the current goal.

3) Establish sub goals

For each matching rule, the antecedents (the "if" part) becomes new sub goal.

4) Check for facts

If a sub-goal is a known fact in the knowledge base, it is considered proven.

5) Recursively Apply

If a sub-goal is not a fact, treat it as a new goal and repeat steps 2-4 until all sub-goals are either proven facts or no more supporting rules can be found.

Ex Example - Medical Diagnosis

Knowledge base

1) Rule 1 = IF (patient has fever) AND (patient has rash) THEN (patient might have measles)

2) Rule 2 = IF (patient has cough) AND (patient has runny nose) THEN (patient might have common cold)

3) Fact 1 : Patient has fever

4) Fact 2 : Patient has rash

Backward Chaining Process

1) Goal : Patient might have measles
2) Find Rules : Rule 1 concludes Patient might have measles.
3) Sub goals : To prove Rule 1, we need to prove its antecedents
   Sub goal - 1 : Patient has fever
   Sub goal - 2 : Patient has rash

Check for Facts:

1) Sub goal 1 (Patient has fever) is found as fact 1 in the knowledge base. This sub-goal is proven.

2) Sub-goal 2: (Patient has rash) is found at as fact 2 in the knowledge base. This sub-goal is proven.

Conclusion: Since both sub-goals of Rule-1 are proven, the original goal (Patient might have measles) is confirmed.

Q2) Define Classical Planning. With the blocks word example, explain the same in detail.

Sol: Classical Planning is a fundamental concept in Artificial Intelligence (AI) that involves forming a sequence of actions to achieve a specific goal. It plays an important role such as robotics, automated problem-solving and game in AI where actions must be taken to transition from an initial state to a goal state while sticking to certain constraints.

It differs from other problem-solving techniques because it focuses on predetermined actions with a clear understanding of the current environment and the effects of action on that environment.

Key Concepts of Classical Planning

1) Initial state : The starting configuration of the world, such as the initial positions of the blocks.

2) Actions : The available operations that an agent can perform to change the state of the world.

(i) Pre-conditions : The conditions that must be true for an action to be executable.

(ii) Effects : The change to the state of the world that result from executing the action.

3) Goal state : The desired final configuration of the world that the agent wants to achieve.

4) Plan : A sequence of actions that when executed in order, transforms the initial state into the goal state.

Example - Block World Example

In the blocks world, a common scenario involves rearranging the blocks using a robotic arm to match a goal state stack.

6) Debug the knowledge base

Test system with known examples to ensure correct reasoning.

7) Maintain and Update

Modify rules as new gate types or logic designs appear.

Q) Define Universal and Existential Instantiation and give examples for both. Prove the following using forward chaining: "As per the law, it is a crime for an American to sell weapons to hostile nations. Country E an enemy of America, has some missiles, and all the missiles were sold to it by Solan, who is an American citizen. Prove that Solan is a criminal.

Sol: Universal Instantiation

Universal Instantiation (UI) is a rule of inference in predicate logic that lets you go from a universally quantified statement. i.e. one that says "for all $x$, $P(x)$" - to a statement about a particular object.

In symbolic form, $\forall x \; A(x) \Rightarrow A(t)$

Here, "t" is a specific term / individual in the domain.

Ex $\forall x$ Human $(x) \rightarrow$ Mortal $(x)$, infer Human (Socrates) $\longrightarrow$ Mortal (Socrates)

Q3) Considering the digital circuit example illustrate the seven steps in knowledge engineering process.

Ans Considering digital circuit example, the seven steps in knowledge engineering process are :-

1) <u>Identify the task</u>

Design a knowledge - based system to analyze digital circuits

Ex ( Identify the faults) .

2) <u>Assemble relevant knowledge</u>

Gather facts about circuit components - AND, OR, NOT, gates and rules for their output.

3) <u>Decide on Vocabulary</u>

Define predicate like , ~~GATE~~ Gate (AND) , Input (A, B) , Output (C) .

4) <u>Encode the knowledge</u>

Ex Output ( AND, 1) $\leftrightarrow$ ( Input = 1 $\wedge$ Input2 = 1)

5) <u>Implement Reasoning</u>

Use Interface inference rules to deduce circuit output or detect faults

Existential Instantiation

It is a rule of inference in predicate logic that allows you to replace an existentially quantified variable with a new, unique constant symbol.

Statement like "there exists an x such that P(x) is true" ($\exists x\, P(x)$), you can infer that for some new const, say 'c' the property P(c) must hold. The key restriction is that the new constant 'c' must be a term that has not appeared anywhere else in the proof.

Symbolically, $\exists x\, P(x) \Rightarrow P(c)$

Ex $\exists x$ Animal(x), infer Animal(Fido)

Given Scenario (English → Logic)

1) $\forall x \forall y \forall z$ [American(x) ∧ Weapon(y) ∧ Sells(x, y, z) ∧ Hostile(z) → Criminal(x)]

2) $\exists x$ [Enemy(x, America) ∧ Owns(x, Missiles(x))]

3) $\forall x$ [Missile(x) → Weapon(x)]

4) $\forall x \forall y$ [Owns(y, x) ∧ Missile(x) → Sells(Solan, x, y)]

5) American(Solan)

6) Enemy(Country E, America) → Hostile(Country E)