Logic

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.

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 (like natural language) does not only assume that the world contains facts like propositional logic but also assumes the following things in the world:

- **Objects**: A, B, people, numbers, colors, wars, theories, squares, pits, wumpus, etc.
- **Relations**: It can be unary relation such as: red, round, is adjacent, or n-any relation such as: the sister of, brother of, has color, comes between
- **Function**: Father of, best friend, third inning of, end of, etc.

Model checking:

- To test whether α (entail) β, enumerate all models and check truth of α and β.
- α entails β if no model exists in which α is true and β is false (i.e. $(\alpha \wedge \neg\beta)$ is unsatisfiable.

Resolution:

The general idea is the same, convert all sentences to CNF, Repeatedly apply resolution rule

Definite clause:

A clause which is a disjunction of literals with **exactly one positive literal** is known as a definite clause or strict horn clause.

Horn clause:

A clause which is a disjunction of literals with **at most one positive literal** is known as horn clause. Hence all the definite clauses are horn clauses.

TABLE 1 Rules of Inference.

Rule of Inference	*Tautology*	*Name*
p $p \rightarrow q$ $\therefore q$	$(p \wedge (p \rightarrow q)) \rightarrow q$	Modus ponens
$\neg q$ $p \rightarrow q$ $\therefore \neg p$	$(\neg q \wedge (p \rightarrow q)) \rightarrow \neg p$	Modus tollens
$p \rightarrow q$ $q \rightarrow r$ $\therefore p \rightarrow r$	$((p \rightarrow q) \wedge (q \rightarrow r)) \rightarrow (p \rightarrow r)$	Hypothetical syllogism
$p \vee q$ $\neg p$ $\therefore q$	$((p \vee q) \wedge \neg p) \rightarrow q$	Disjunctive syllogism
p $\therefore p \vee q$	$p \rightarrow (p \vee q)$	Addition
$p \wedge q$ $\therefore p$	$(p \wedge q) \rightarrow p$	Simplification
p q $\therefore p \wedge q$	$((p) \wedge (q)) \rightarrow (p \wedge q)$	Conjunction
$p \vee q$ $\neg p \vee r$ $\therefore q \vee r$	$((p \vee q) \wedge (\neg p \vee r)) \rightarrow (q \vee r)$	Resolution

Proposition:

Any proposal or statement

Premise:

A proposition that forms the basis of an argument or from which a conclusion can be drawn.

P1. All human beings are mortal.

P2. Jimmy is a human being.

C. Jimmy is mortal.

Conclusion:

A proposition that is justified by a number of premises.

Forward-chaining:

An algorithm that starts from known facts, triggers all rules whose premises are satisfied, and add their conclusion to the known facts. This process repeats until the problem is solved.

backward chaining:

An algorithm that is a form of reasoning, which starts with the goal and works backward, chaining through rules to find known facts that support the goal.

Unification:

a process of making two different logical atomic expressions identical by finding a substitution. Unification depends on the substitution process. It enables the application of inference rules

Uncertainty

Probabilistic Reasoning:

Probabilistic reasoning is a branch of artificial intelligence (AI) that deals with the representation and management of uncertainty. It allows AI systems to make inferences based on incomplete, noisy, or uncertain data.

Importance:

- Managing uncertainty
- Inference with incomplete data
- Use in Real-world applications
- Improved decision making

Bayesian Networks:

A Bayesian network is a graphical model that represents the probabilistic relationships among a set of variables. Each node represents a variable, and edges represent conditional dependencies. These networks are used to compute the probability of certain outcomes based on given evidence.

Probabilistic reasoning over time

Extends traditional probabilistic reasoning to model dynamic systems or processes that evolve over time. Allowing for the representation of variables at different time steps and edges represent dependencies between these variables across time.

Markov process decision

Markov Decision Process (MDP) is a mathematical framework used to model decision-making problems where outcomes are partly random and partly under the control of a decision maker.

Functions

```
Initialize Q(s,a)
Repeat for each episode
    Initialize state s
    Repeat for each step in episode
        Choose action a from state s using policy derived from Q
        Take action a, observe r and s'
        Update Q = current Q value + learning rate [target Q value – current Q value]
        s = s'
    Until s is terminal
```

```
Function minimax (node, depth, maxPlayer)
    If depth == 0 or node is terminal node then
        Return static evaluation of node
    If maxPlayer == True then
        maxEva = – Infinity
        For each child in node do
            eva = minimax(child, depth – 1, False)
            maxEva = max(maxEva, eva)
        return maxEva
    else
        minEva = + Infinity
        for each child in node do
            eva = minimax(child, depth – 1, True)
            minEva = min(minEva, eva)
        return minEva
```