DMI College of Engineering

Course Code/Course Name: AL3391/ ARTIFICIAL INTELLIGENCE

UNIT I INTELLIGENT AGENTS

Introduction to AI – Agents and Environments – Concept of rationality – Nature of environments Structure of agents. Problem solving agents – search algorithms – uninformed search strategies.

PART-A (2 Marks)

1. Define Artificial intelligence.

   "It is a branch of computer science by which we can create intelligent machines whichcan behave like a human, think like humans, and able to make decisions."

2. Define Rationality.

   - Rationality is nothing but status of being reasonable, sensible, and having goodsense of judgment.
   - Rationality is concerned with expected actions and results depending upon whatthe agent has perceived.
   - Performing actions with the aim of obtaining useful information is an importantpart of rationality.

3. List out the types of uninformed search Algorithm.

   - Breadth-first search
   - Uniform cost search
   - Depth-first search
   - Iterative deepening depth-first search
   - Bidirectional Search

4. Define Agent.

   In artificial intelligence, an agent is a computer program or system that is designed to perceive its environment, make decisions and take actions to achieve a specific goal or set of goals. The agent operates autonomously, meaning it is not directly controlled by a human operator.

5. Define utility-based agents

   A utility-based agent is an agent that acts based not only on what the goal is, but the best way to reach that goal.

6. Define payoff?

Payoff function is used for modeling human behavior. Payoff function for a player is a mapping from the cross-product of players strategy spaces to the players set of payoffs.

7. Write advantages and disadvantages of AI.

Following are some main advantages of Artificial Intelligence:

- **High Accuracy with less errors:** AI machines or systems are prone to less errors and high accuracy as it takes decisions as per pre-experience or information.
- **High-Speed:** AI systems can be of very high-speed and fast-decision making, because of that AI systems can beat a chess champion in the Chess game.
- **High reliability:** AI machines are highly reliable and can perform the same action multiple times with high accuracy.
- **Useful for risky areas:** AI machines can be helpful in situations such as defusing a bomb, exploring the ocean floor, where to employ a human can be risky.
- **Digital Assistant:** AI can be very useful to provide digital assistant to the users such as AI technology is currently used by various E-commerce websites to show the products as per customer requirement.
- **Useful as a public utility:** AI can be very useful for public utilities such as a self-driving car which can make our journey safer and hassle-free, facial recognition for security purpose, Natural language processing to communicate with the human in human-language, etc.

Following are the disadvantages of AI:

- **High Cost:** The hardware and software requirement of AI is very costly as it requires lots of maintenance to meet current world requirements.
- **Can't think out of the box:** Even we are making smarter machines with AI, but still they cannot work out of the box, as the robot will only do that work for which they are trained, or programmed.
- **No feelings and emotions:** AI machines can be an outstanding performer, but still it does not have the feeling so it cannot make any kind of emotional attachment with human, and may sometime be harmful for users if the proper care is not taken.

- **Increase dependency on machines:** With the increment of technology, people are getting more dependent on devices and hence they are losing their mental capabilities.

8. List out agent terminologies.
    - **Performance Measure of Agent** − It is the criteria, which determines howsuccessful an agent is.
    - **Behavior of Agent** − It is the action that agent performs after any given sequenceof percepts.
    - **Percept** − It is agent's perceptual inputs at a given instance.
    - **Percept Sequence** − It is the history of all that an agent has perceived till date.
    - **Agent Function** − It is a map from the precept sequence to an action.

9. Define Rational agent.

    A rational agent is an artificial intelligence (AI) component. It applies AI to different real-world problems. As such, it chooses an action from a set of distinct options. It has models that allow it to deal with unexpected variables and always selects the best possible outcome from all the available options.

    The term "rational agent," however, is not only applied to a system. It can also refer to a person, a company, or an application, practically anything or anyone that makes rational decisions.

10. What is meant by informed search algorithm.

    The algorithms of an informed search contain information regarding the goal state. It helps an AI make more efficient and accurate searches. A function obtains this data/info to estimate the closeness of a state to its goal in the system. For example, Graph Search and Greedy Search.

11. Define DFS.

    Depth-first search (DFS) is an algorithm for traversing or searching tree or graph data structures. The algorithm starts at the root node (selecting some arbitrary node as the root node in the case of a graph) and explores as far as possible along each branch before backtracking.

12. Define BFS.

    BFS, or Breadth-First Search, is a node method for obtaining the graph's shortest path. It makes use of a queue data structure with FIFO (first in, first out) ordering.

PART-B (13 Marks)

1. Explain with example about Bidirectional search Algorithm.
2. Explain detail about structure and nature of environments.
3. Explain structure of Intelligent agents in detail.
4. Explain detail about BFS search algorithm
5. Explain detail about DFS search algorithm.
6. Explain detail about properties of agent Environments.

PART-C (15 Marks)

1. Explain details about any two uninformed search algorithm with an example.

2. Write about Rational agents with Real time example in AI.

3. Analyze performace of Blind search and its types in detail.

UNIT II PROBLEM SOLVING

Heuristic search strategies – Heuristic functions. Local search and optimization problems – local search in continuous space – search with non-deterministic actions – search in partially observable environments – online search agents and unknown environments.

PART-A (2 Marks)

1. What is heuristic functions?
    - ✓ Heuristics function: Heuristic is a function which is used in Informed Search, andit finds the most promising path.
    - ✓ It takes the current state of the agent as its input and produces the estimation ofhow close agent is from the goal.
    - ✓ The heuristic method, however, might not always give the best solution, but itguaranteed to find a good solution in reasonable time.
    - ✓ Heuristic function estimates how close a state is to the goal.
    - ✓ It is represented by h(n), and it calculates the cost of an optimal path between thepair of states. The value of the heuristic function is always positive.
    - ✓ Admissibility of the heuristic function is given as:h(n) <= h*(n)
    - ✓ Here h(n) is heuristic cost, and h*(n) is the estimated cost. Hence

heuristic costshould be less than or equal to the estimated cost.

2. Define greedy search.

- ✓ Greedy best-first search algorithm always selects the path which appears best atthat moment.
- ✓ It is the combination of depth-first search and breadth-first search algorithms.
- ✓ It uses the heuristic function and search.
- ✓ Best-first search allows us to take the advantages of both algorithms.
- ✓ With the help of best-first search, at each step, we can choose the most promising node. In the best first search algorithm, we expand the node which is closest to the goal node and the closest cost is estimated by heuristic function, i.e.

$$f(n)= g(n).$$

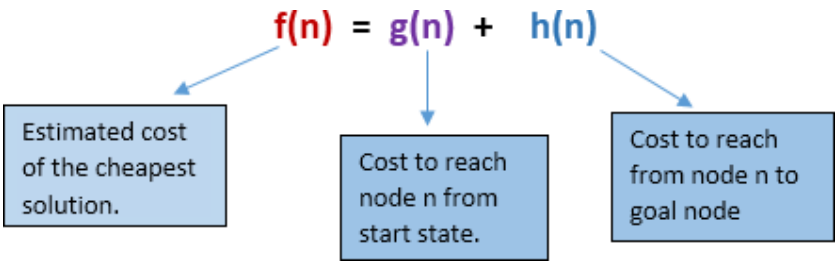
Where, h(n)= estimated cost from node n to the goal.

The greedy best first algorithm is implemented by the priority queue.

3. What is A*search.

- ✓ A* search is the most commonly known form of best-first search.
- ✓ It uses heuristic function h(n), and cost to reach the node n from the start state g(n).
- ✓ It has combined features of UCS and greedy best-first search, by which it solve the problem efficiently.
- ✓ A* search algorithm finds the shortest path through the search space using the heuristic function.
- ✓ This search algorithm expands less search tree and provides optimal result faster. A* algorithm is similar to UCS except that it uses g(n)+h(n) instead of g(n).

In A* search algorithm, we use search heuristic as well as the cost to reach the node. Hence we



4. Write a advantages and disadvantages of A* search.

Advantages:

- A* search algorithm is the best algorithm than other search algorithms.
- A* search algorithm is optimal and complete.
- This algorithm can solve very complex problems.

Disadvantages:

- It does not always produce the shortest path as it mostly based on heuristics andapproximation.
- A* search algorithm has some complexity issues.
- The main drawback of A* is memory requirement as it keeps all generatednodes in the memory, so it is not practical for various large-scale problems.

5. Write a advantages and disadvantages of greedy search.

The main advantage of the greedy method is that it is relatively easy to implement and understand. However, there are some disadvantages to using this method. First, the greedy method is not guaranteed to find the best solution. Second, it can be quite slow.

6. Define pure heuristic search

- ✓ Pure heuristic search is the simplest form of heuristic search algorithms.
- ✓ It expands nodes based on their heuristic value h(n). It maintains two lists, OPEN and CLOSED list. In the CLOSED list, it places those nodes which have already expanded and in the OPEN list, it places nodes which have yet not been expanded.
- ✓ On each iteration, each node n with the lowest heuristic value is expanded and generates all its successors and n is placed to the closed list.
- ✓ The algorithm continues unit a goal state is found.
- ✓ In the informed search we will discuss two main algorithms which are given below:
  - Best First Search Algorithm(Greedy search)
  - A* Search Algorithm

7. Write a properties of heuristic search algorithm.

Use of heuristic function in a heuristic search algorithm leads to following propertiesof a heuristic search algorithm:

- **Admissible Condition:** An algorithm is said to be admissible, if it returns anoptimal solution.
- **Completeness:** An algorithm is said to be complete, if it terminates with asolution (if the solution exists).
- **Dominance Property:** If there are two admissible heuristic algorithms **A1** and **A2** having **h1** and **h2** heuristic functions, then **A1** is said to dominate **A2** if **h1** is better than **h2** for all the values of node **n.**
- **Optimality Property:** If an algorithm is **complete, admissible**, and **dominating** other algorithms, it will be the best one and will definitely give an optimal solution.

8. Define hill climbing algorithm.

- Hill climbing algorithm is a local search algorithm which continuously moves inthe direction of increasing elevation/value to find the peak of the mountain or best solution to the problem.
- It terminates when it reaches a peak value where no neighbor has a higher value.
- Hill climbing algorithm is a technique which is used for optimizing the mathematical problems. One of the widely discussed examples of Hill climbing algorithm is Traveling-salesman Problem in which we need to minimize the distance traveled by the salesman.
- It is also called greedy local search as it only looks to its good immediate neighbor state and not beyond that.
- A node of hill climbing algorithm has two components which are state and value.
- Hill Climbing is mostly used when a good heuristic is available.
- In this algorithm, we don't need to maintain and handle the search tree or graph asit only keeps a single current state.

9. List out the features of hill climbing.

Following are some main features of Hill Climbing Algorithm:

- **Generate and Test variant:** Hill Climbing is the variant of Generate and Test method. The Generate and Test method produce feedback which helps to decide which direction to move in the search space.

- **Greedy approach:** Hill-climbing algorithm search moves in the direction which optimizes the cost.
- **No backtracking:** It does not backtrack the search space, as it does not remember the previous states.

10. List out types of hill climbing algorithm.
    - Simple hill Climbing:
    - Steepest-Ascent hill-climbing:
    - Stochastic hill Climbing:

11. Define online search Agent.
    - ✓ After each action, an online agent receives a percept telling it what state it has reached; from this information, it can augment its map of the environment.
    - ✓ The current map is used to decide where to go next.
    - ✓ This interleaving of planning and action means that online search algorithms are quite different from the offline search algorithms we have seen previously.
    - ✓ For example, offline algorithms such as A can expand a node in one part of the space and then immediately expand a node in another part of the space, because node expansion involves simulated rather than real actions.
    - ✓ An online algorithm, on the other hand, can discover successors only for a node that it physically occupies.
    - ✓ To avoid traveling all the way across the tree to expand the next node, it seems better to expand nodes in a *local* order.
    - ✓ Depth-first search has exactly this property because (except when backtracking) the next node expanded is a child of the previous node expanded.

12. What is Genetic algorithm?

    A genetic algorithm (GA) is a heuristic search algorithm used to solve search and optimization problems. This algorithm is a subset of evolutionary algorithms, which are used in computation. Genetic algorithms employ the concept of genetics and natural selection to provide solutions to problems.

PART-B (13 Marks)

1. Explain details about greedy search algorithm in detail.

2. Explain detail about A*search algorithm with an example.

3. Explain detail about Heuristic functions in detail.

4. Explain detail about Hill Climbing Algorithm with an example.

5. Explain detail about Steepest-Ascent hill climbing and stochastic hill climbing algorithm.

6. Explain detail about Online search Agent with an example.

PART-C (15 Marks)

1. How the searching algorithm works in Non Deterministic Actions. A how the AND-OR trees are involved in Non Deterministic Actions.

2. Analyze Online search problem in detail with an example

3. Write brief about following local search algorithms:
   (i)Simulated annealing
   (ii) Local beam search

UNIT III GAME PLAYING AND CSP

Game theory – optimal decisions in games – Alpha-beta search – Monte-carlo tree search – Stochastic games – partially observable games. Constraint satisfaction problems – constraint propagation backtracking search for CSP – local search for CSP – structure of CSP.

PART-A (2 Marks)

1. Define game theory.

Game : Any set of circumstances that has a result dependent on the actions of two or moredecision-makers (players)

- **Players** : A strategic decision-maker within the context of the game
- **Strategy**: A complete plan of action a player will take given the set of circumstances thatmight arise within the game
- **Payoff** : The payout a player receives from arriving at a particular outcome (The payoutcan be in any quantifiable form, from dollars to utility.)

- ✓ We first consider games with two players, whom we call MAX and MIN for reasons thatwill soon become obvious.
- ✓ MAX moves first, and then they take turns moving until the game is over.

- ✓ At the end of the game, points are awarded to the winning player and penalties are givento the loser.

2. List out the types of games in AI.
    - **Perfect information:** A game with the perfect information is that in which agents can look into the complete board. Agents have all the information about the game, and they can see each other moves also. Examples are Chess, Checkers, Go, etc.

    - **Imperfect information:** If in a game agents do not have all information about the game and not aware with what's going on, such type of games are called the game with imperfect information, such as tic-tac-toe, Battleship, blind, Bridge, etc.
    - **Deterministic games:** Deterministic games are those games which follow a strict pattern and set of rules for the games, and there is no randomness associated with them. Examples are chess, Checkers, Go, tic-tac-toe, etc.

    - **Non-deterministic games:** Non-deterministic are those games which have various unpredictable events and has a factor of chance or luck. This factor of chance or luck is introduced by either dice or cards. These are random, and each action response is not fixed. Such games are also called as stochastic games. Example: Backgammon, Monopoly, Poker, etc.

3. Write a applications of game theory.

    The game theory is widely applied to study human as well as animal behaviors. It is utilized in economics to understand the economic behaviors, such as behaviors of consumers, markets and firms. Game theory has been commonly used in social sciences as well. It is applied in the study of sociological, political and psychological behaviors. The use of analysis based on game theory is seen in biology too. In addition to behavioral prediction, game theory utilized in the development of theories of normative or ethical behavior.

    - ✓ The following are just a few examples of game theory applications:

- Stock trades and the investors' reactions and decisions against stock marketdevelopments and the behaviors and decisions of other investors
- OPEC member countries' decision to change the amount of oil extraction and sale andtheir compliance or non-compliance with quota arrangements
- Corporate behavior regarding product pricing in monopoly or multilateral competition markets
- Animal interaction with one another in social life (hunting or sharing achievements orsupporting each other)

4. List out the elements of game theory.
   - ✓ A game can be defined as a type of search in AI which can be formalized of thefollowing elements:
     - **Initial state:** It specifies how the game is set up at the start.
     - **Player(s):** It specifies which player has moved in the state space.
     - **Action(s):** It returns the set of legal moves in state space.
     - **Result(s, a):** It is the transition model, which specifies the result of moves in the statespace.
     - **Terminal-Test(s):** Terminal test is true if the game is over, else it is false at any case. The state where the game ends is called terminal states.
     - **Utility(s, p):** A utility function gives the final numeric value for a game that ends interminal states s for player p. It is also called payoff function. For Chess, the outcomes are a win, loss, or draw and its payoff values are +1, 0, ½. And for tic-tac- toe, utility values are +1, -1, and 0.

5. What is maximizer and minimizer.
   The two participants in Minimax are referred to as the maximizer and minimizer. The maximizer strives to achieve the maximum score, whereas the minimizer seeks to achieve the lowest score. A value accompanies each board state.
6. What is Tic -Tac -To.
   - Mini-max algorithm is a recursive or backtracking algorithm which is used indecision-making and game theory.
   - It provides an optimal move for the player assuming that opponent is also playingoptimally.
   - Mini-Max algorithm uses recursion to search through the game-tree.
   - Min-Max algorithm is mostly used for game playing in AI.

- Such as Chess, Checkers, tic-tac-toe, go, and various tow-players game.
- This Algorithm computes the minimax decision for the current state.

7. What is Alpha-Beta pruning.
   - ✓ Alpha-beta pruning is a modified version of the minimax algorithm.
   - ✓ It is an optimization technique for the minimax algorithm.
   - ✓ As we have seen in the minimax search algorithm that the number of game statesit has to examine are exponential in depth of the tree.
   - ✓ There is a technique by which without checking each node of the game tree wecan compute the correct minimax decision, and this technique is called **pruning**.
   - ✓ This involves two threshold parameter Alpha and beta for future expansion, so itis called **alpha-beta pruning**.
   - ✓ It is also called as **Alpha-Beta Algorithm**.
   - ✓ Alpha-beta pruning can be applied at any depth of a tree, and sometimes it notonly prune the tree leaves but also entire sub-tree.

8. Define Monte Carlo Tree Search algorithm.
   - ✓ The Games like Tic-Tac-Toe, Rubik's Cube, Sudoku, Chess, Go and many others have common property that lead to exponential increase in the number of possible actions thatcan be played.
   - ✓ These possible steps increase exponentially as the game goes forward.
   - ✓ Ideally if you can predict every possible move and its result that may occur in the future.
   - ✓ You can increase your chance of winning.
   - ✓ But since the moves increase exponentially — the computation power that is required to calculate the moves also goes through the roof.
   - ✓ Monte Carlo Tree Search is a method usually used in games to predict the path (moves)that should be taken by the policy to reach the final winning solution

9. Write a advantages and disadvantages of Monte Carlo search algorithm.

Advantages of Monte Carlo Tree Search:

1. MCTS is a simple algorithm to implement.
2. Monte Carlo Tree Search is a heuristic algorithm. MCTS can operate

effectively without any knowledge in the particular domain, apart from the rules and end conditions, and can find its own moves and learn from them by playing random playouts.

3. The MCTS can be saved in any intermediate state and that state can be used in futureuse cases whenever required.
4. MCTS supports asymmetric expansion of the search tree based on the circumstances in which it is operating.

Disadvantages of Monte Carlo Tree Search:

1. As the tree growth becomes rapid after a few iterations, it requires a huge amount ofmemory.
2. There is a bit of a reliability issue with Monte Carlo Tree Search. In certain scenarios,there might be a single branch or path, that might lead to loss against the opposition

   when implemented for those turn-based games. This is mainly due to the vast amount ofcombinations and each of the nodes might not be visited enough number of times to understand its result or outcome in the long run.

3. MCTS algorithm needs a huge number of iterations to be able to effectively decide the most efficient path. So, there is a bit of a speed issue there.

10. Define stochastic games.

- ✓ In real life, many unpredictable external events can put us into unforeseensituations.
- ✓ Many games mirror this unpredictability by including a random element, such asthe throwing of dice.
- ✓ We call these **stochastic games**.
- ✓ Backgammon is a typical game that combines luck and skill.

✓ Dice are rolled at the beginning of a player's turn to determine the legal moves.

11. Define card games.

Card games provide many examples of *stochastic* partial observability, where the missing information is generated randomly. For example, in many games, cards are dealt randomly at the beginning of the game, with each player receiving a hand that is not

visible to the other players. Such games include bridge, whist, hearts, and some forms of poker.

At first sight, it might seem that these card games are just like dice games: the cards are dealt randomly and determine the moves available to each player, but all the "dice" are rolled at the beginning! Even though this analogy turns out to be incorrect, it suggests an effective algorithm: consider all possible deals of the invisible cards; solve each one as if it were a fully observable game; and then choose the move that has the best outcome averaged over all the deals. Suppose that each deal s occurs with probability P(s); then the move we want is

12. Define constraint satisfaction problem.

Constraint satisfaction is a technique where a problem is solved when its values satisfy certain constraints or rules of the problem. Such type of technique leads to a deeper understanding of the problem structure as well as its complexity.

13. List out types domains in CSP.

There are following two types of domains which are used by the variables :

- **Discrete Domain:** It is an infinite domain which can have one state for multiple variables. **For example,** a start state can be allocated infinite times for each variable.
- **Finite Domain:** It is a finite domain which can have continuous states describing one domain for one specific variable. It is also called a continuous domain.

14. Define backtracking search.

A backtracking search algorithm performs a depth-first traversal of a search tree, where the branches out of a node represent alternative choices that may have to be examined in order to find a solution, and the constraints are used to prune subtrees containing no solutions.

PART-B (13 Marks)

1. Explain detail about Tic-Tac- Toe game tree with an example.

2. Explain detail about game theory and its applications.
3. Explain detail about MINIMAX algorithm.
4. Explain detail about alpha-beta search algorithm.
5. Explain detail about Monte Carlo tree search algorithm.
6. Explain detail about constraint satisfaction problem(CSP).
7. Explain detail about constraint propagation.

PART-C (15 Marks)

1. Analyze the MINIMAX algorithm in game theory.
2. Explain detail about Monte Carlo Tree search algorithm .
3. Write a backtracking algorithm for CSPS.
4. Analyze the partially observable games in AI.

UNIT IV LOGICAL REASONING

Knowledge-based agents – propositional logic – propositional theorem proving – propositional model checking – agents based on propositional logic. First-order logic – syntax and semantics Knowledge representation and engineering – inferences in first-order logic – Forward chaining Backward chaining – resolution.

PART-A (2 Marks)

1. Define reasoning.
   - ✓ The reasoning is the mental process of deriving logical conclusion and making predictions from available knowledge, facts, and beliefs.

Or we can say, "**Reasoning is a way to infer facts from existing data**."

- ✓ It is a general process of thinking rationally, to find valid conclusions.
- ✓ In artificial intelligence, the reasoning is essential so that the machine can also think rationally as a human brain, and can perform like a human.
- ✓ When a system is required to do something, that it has not been explicitly told how to do,, it must figure out what it needs to know from what it already knows.

Fact 1 : Robins are Birds

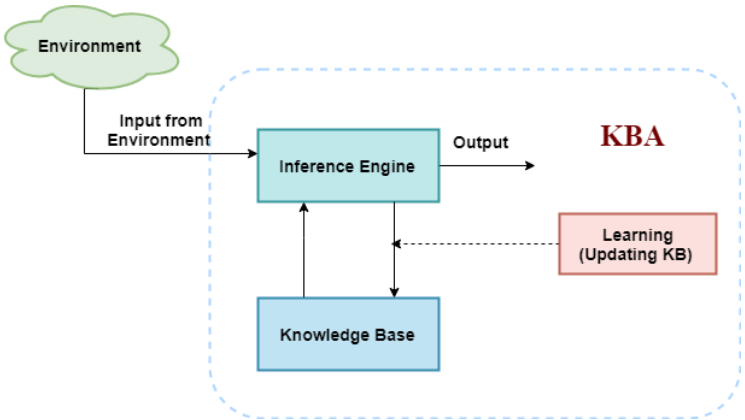
Fact 2 : All birds have wings

Question : Do Robins have wings?

- ✓ Hence Reasoning system, must find out, what it needs to know from what italready knows.
- ✓ Logic is a language of reasoning. It is a collection of rules called logic arguments,we use when doing logic reasoning.
- ✓ Logical Reasoning is a process of drawing conclusions from premises using rule ofinference.

2. Draw an architecture of knowledge based agents.

The architecture of knowledge-based agent:



- ✓ The above diagram is representing a generalized architecture for a knowledge-based agent.
- ✓ The knowledge-based agent (KBA) take input from the environment by perceivingthe environment.
- ✓ The input is taken by the inference engine of the agent and

which alsocommunicate with KB to decide as per the knowledge store in KB.

- ✓ The learning element of KBA regularly updates the KB by learning newknowledge.

3. Define knowledge based agents.
   - An intelligent agent needs **knowledge** about the real world for taking decisions and **reasoning** to act efficiently.
   - Knowledge-based agents are those agents who have the capability of **maintaining an internal state of knowledge, reason over that knowledge, update their knowledge after observations and take actions. These agents can represent the world with some formal representation and act intelligently**.
   - Knowledge-based agents are composed of two main parts:
     - Knowledge-base and
     - **Inference system**.

4. What are the operations performed by KBA.

   Following are three operations which are performed by KBA in order to show theintelligent behavior:

   1. **TELL:** This operation tells the knowledge base what it perceives from theenvironment.
   2. **ASK:** This operation asks the knowledge base what action it should perform.
   3. **Perform:** It performs the selected action.

5. What is propositional logic. Give an example?
   - ✓ Propositional logic (PL) is the simplest form of logic where all the statements aremade 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.

6. Define Davis-Putnam algorithm.

The Davis–Putnam algorithm was developed by Martin Davis and Hilary Putnam for checking the validity of a first-order logic formula using a resolution-based decision procedure for propositional logic.

7. Define hybrid agent.

A Hybrid Agent is a new kind of real estate professional that utilizes artificial intelligence to automate, digitize and increase daily production and income.

8. Define first order logic.

- ✓ First-order logic is symbolized reasoning in which each sentence, or statement, isbroken down into a subject and a predicate.
- ✓ First-order logic can be useful in the creation of computer programs. It is also ofinterest to researchers in artificial intelligence.

9. Define syntax and sematics.

The syntax and semantics of first-order (FO) logic allow us to explicitly represent objects and relationships among object, which provides us with much more representational power than the propositional case

10. Define inferences.

- ✓ Inference in First-Order Logic is used to deduce new facts or sentences fromexisting sentences.
- ✓ Before understanding the FOL inference rule, let's understand some basicterminologies used in FOL.

11. Define forward chaining

Forward chaining is a method of reasoning in artificial intelligence in which inference rules are applied to existing data to extract additional data until an endpoint (goal) is achieved.

In this type of chaining, the inference engine starts by evaluating existing facts, derivations, and conditions before deducing new information. An endpoint (goal) is achieved through the manipulation of knowledge that exists in the knowledge base. Forward chaining can be used in planning, monitoring, controlling, and interpretingapplications.

12. Define backward chaining.

- ✓ Backward chaining is a concept in artificial intelligence that involves backtrackingfrom the endpoint or goal to steps that led to the endpoint.

- ✓ This type of chaining starts from the goal and moves backward to comprehend thesteps that were taken to attain this goal.
- ✓ The backtracking process can also enable a person establish logical steps that canbe used to find other important solutions.
- ✓ Backward chaining can be used in debugging, diagnostics, and prescriptionapplications.

13. Define Resolution.
    - ✓ Resolution is a theorem proving technique that proceeds by building refutation proofs, i.e., proofs by contradictions.
    - ✓ It was invented by a Mathematician John Alan Robinson in the year 1965.
    - ✓ Resolution is used, if there are various statements are given, and we need to provea conclusion of those statements.
    - ✓ Unification is a key concept in proofs by resolutions. Resolution is a single inference rule which can efficiently operate on the **conjunctive normal form or clausal form**.

PART-B (13 MARKS)

1. Explain detail about knowledge based agents and its operations.
2. Explain detail about Propositional logic.
3. Write brief notes about propositional model checking.
4. Write an algorithm for Hybrid Wumpus -Agent algorithm.
5. Write an brief notes about First Order Logic .

PART-C (15 MARKS)

1. Explain detail about forward and backward chaining algorithm with an example.
2. Write an algorithm for Forward and Backward chaining with an ϵ
3. Explain detail about knowledge representation and engineering.

4. Analyze the Resolution with an example and also draw a resoluti

UNIT V PROBABILISTIC REASONING

Acting under uncertainty – Bayesian inference – Naïve Bayes models. Probabilistic reasoning Bayesian networks – Exact inference in BN – Approximate inference in BN – Causal networks.

PART-A (2 Marks)

1. Define uncertainty. Give an example?

- ✓ Till now, we have learned knowledge representation using first-order logic and propositional logic with certainty, which means we were sure about the predicates.
- ✓ With this knowledge representation, we might write A→B, which means if A istrue then B is true, but consider a situation where we are not sure about whether A is true or not then we cannot express this statement, this situation is called uncertainty.
- ✓ So to represent uncertain knowledge, where we are not sure about the predicates, we need uncertain reasoning or probabilistic reasoning.

2. Define Belief state.

Problem-solving agents and Logical agents designed to handle uncertainty bykeeping track of a **belief state**—a representation of the set of all possible world states that it might be in—and generating a contingency plan that handles everypossible eventuality that its sensors may report during execution

3. Define Bayes rule.

- ✓ Bayes' rule allows us to compute the single term P(B|A) in terms of P(A|B), P(*B*),and P(A).
- ✓ This is very useful in cases where we have a good probability of these three termsand want to determine the fourth one.
- ✓ Suppose we want to perceive the effect of some unknown cause, and want tocompute that cause, then the Bayes' rule becomes:

$$P(\text{cause}\,|\,\text{effect}) = \frac{P(\text{effect}|\text{cause})\,P(\text{cause})}{P(\text{effect})}$$

Application of Bayes' theorem in Artificial intelligence

4. Define Bayesian network.

✓ Bayesian belief network is key computer technology for dealing with probabilistic events and to solve a problem which has uncertainty. We can define a Bayesian network as:

"A Bayesian network is a probabilistic graphical model which represents a set of variables and their conditional dependencies using a directed acyclic graph."

✓ It is also called a **Bayes network, belief network, decision network**, or **Bayesian model**.

Bayesian networks are probabilistic, because these networks are built from a **probability distribution**, and also use probability theory for prediction and anomalydetection.

5. List out the components of Bayesian network.

The Bayesian network has mainly two components:

- **Causal Component**
- **Actual numbers**

✓ Each node in the Bayesian network has condition probabil distribution $\mathbf{P(X_i\,|Parent(X_i))}$, which determines the effect of t parent on that node.

✓ Bayesian network is based on Joint probability distribution a conditional probability.

✓ So let's first understand the joint probability distribution:

Joint Probability – It is the measure of two events happening at t same time. It can be written as P(A∩B)

Conditional Probability– It is the measure of the probability of an eve occurring given that another event has occurred. In other terms, t conditional probability of an event X is the probability that the eve

will occur given that event Y has already occurred.

P(X|Y): Probability of event X occurring given that event Y already occurred.If X and Y are dependent events, then $P(X|Y) = P(X \cap Y)/P(Y)$

If X and Y are independent events, then $P(X \cap Y) = 0$So, $P(X|Y) = P(X)$

6. Write a Applications of Bayesian network.

Healthcare Industry: The Bayesian network is used in the healthcare industry for the detection and prevention of diseases. Based on models built, we can find out the likely symptoms and predict whether a person will be diseased or not. For instance, if a person has cholesterol, then there are high chances that the person gets a heart problem. With this information, a person can take preventive measures.

Web Search: Bayesian Network modes can be used for search accuracy based on userintent. Based on the user's intent, these models show things that are relevant to the person. For instance, when we search for Python functions most of the time, then the web search model activates our intent and it makes sure to show relevant things to the user.

Mail Spam Filtering: Gmail is using Bayesian Models to filter the mails by readingor understanding the context of mail. For instance, we may have observed spamemails in the spam folder in Gmail. So, how are these emails classified as spams? Using the Bayesian model, which observes the mail and based on the previousexperience and the probability it classifies mail as spam or not.

Biomonitoring: Bayesian Models are used to quantify the concentration of chemicals in blood and human tissues. These use indicators to measure blood and urine. To find the level of ECCs, one can conduct biometric studies.

Information Retrieval: Models can be used for retrieving information from the database. During this process, we refine our problem multiple times. It is used to reduce information overload.

7. Define causal networks. Give an example?

Causal reasoning is a crucial element to how humans understand, explain, and make decisions about the world. Causal AI means automating causal reasoning with machine learning. Today's learning machines have superhuman predictionability but aren't particularly good at causal reasoning, even when we train them on obscenely large amounts of data. In this book, you will learn how to write algorithms that capture causal reasoning in the context of machine learning and automated data science.

8. Define Exact inference. Give an example?

- It is the term used when inference is performed exactly (subject to standardnumerical rounding errors).
- Exact inference is applicable to a large range of problems, but may not bepossible when combinations/paths get large.

9. What is approximate Inference. Give an example?

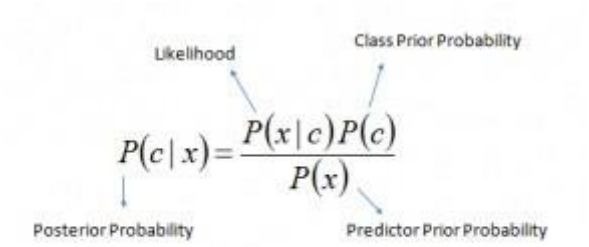
- Wider class of problems
- Non deterministic
- No guarantee of correct answer

10. Define Naïve Bayes model.

- ✓ It is a classification technique based on Bayes' Theorem with an assumption of independence among predictors. In simple terms, a Naive Bayes classifier assumes that the presence of a particular feature in a class is unrelated to the presence of any other feature.
- ✓ For example, a fruit may be considered to be an apple if it is red, round, and about 3 inches in diameter.
- ✓ Even if these features depend on each other or upon the existence of the other features, all of these properties independently contribute to the probability that this fruit is an apple and that is why it is known as 'Naive'.
- ✓ Naive Bayes model is easy to build and particularly useful for

very large data sets. Along with simplicity, Naive Bayes is known to outperform even highly sophisticated classification methods.

- ✓ Bayes theorem provides a way of calculating posterior probability P(c|x) from P(c), P(x) and P(x|c). Look at the equation below:



$$P(c \mid X) = P(x_1 \mid c) \times P(x_2 \mid c) \times \cdots \times P(x_n \mid c) \times P(c)$$

Above,

- $P(c|x)$ is the posterior probability of *class* (c, *target*) given *predictor* (x, *attributes*).
- $P(c)$ is the prior probability of *class*.
- $P(x|c)$ is the likelihood which is the probability of *predictor* given *class*.
- $P(x)$ is the prior probability of *predictor*.

PART-B (13 Marks)

1. Explain detail about Exact inference in BN with example.
2. Explain about Bayesian network with an example.
3. Explain about Naïve Bayes model with an example
4. Explain detail about Approximate inference in BN with example.
5. Explain about Bayesian inference with an example

PART C (15 MARKS)

1. Analyze approximate inference in Bayesian networks with real time example.

2. Analyze burglary Alaram networks using Bayesian network concept in detail.
3. Define causal networks. Analyze the causal networks with an example.