2015

a. What is artificial intelligence?

Artificial intelligence (AI) is technology that enables computers and machines to simulate human learning, comprehension, problem solving, decision making, creativity and autonomy.

b. Define omniscience.

Omniscience is the quality or state of being omniscient. If an artificial system is said to be omniscient, it knows everything. In other words, any AI program that knows the exactly what will happen for all its possible actions is omniscient.

Artificial Intelligence is the science of making machines do things that would require intelligence if done by man.

Artificial intelligence is the study of how to make computers do things which, at the moment, human do better.

c. How is performance of search algorithm measured?

- Time Complexity: This measures how the execution time of the algorithm scales with the size of the input. It helps to understand the efficiency of the algorithm in terms of computational resources required. Common time complexities include O(n), O(log n), O(n^2), etc.
- Space Complexity: This measures the amount of memory or storage required by the algorithm as the input size grows. It's important to evaluate how much additional memory the algorithm needs, beyond the input data itself.
- Accuracy: For algorithms that make decisions or predictions, accuracy measures how often the algorithm's output matches the correct result. This is crucial in scenarios where the search algorithm is part of a larger AI system, such as classification or regression tasks.
- Completeness: This measures whether the algorithm is guaranteed to find a solution if one exists. A search algorithm is complete if it will find a solution (if there is one) within a finite amount of time.
- Optimality: This assesses whether the algorithm finds the best possible solution according to a given metric. For instance, in pathfinding algorithms, optimality means finding the shortest path.
- Scalability: This evaluates how well the algorithm performs as the size of the input or the problem domain increases. A scalable algorithm can handle larger problems without a significant increase in computational resources.
- Efficiency: This is a broader measure that encompasses both time and space complexity. Efficient algorithms solve problems using the least amount of computational resources possible.
- Heuristics Quality: In algorithms that use heuristics (like A* search), the quality of the heuristic function affects the performance. A good heuristic can drastically reduce the search space and improve performance.

- Robustness: This measures how well the algorithm performs under different conditions, such as noisy data or variations in the problem domain.

d. What is cryptarithmetic?

Cryptarithmetic, also known as cryptarithm, is a type of mathematical puzzle in which digits are replaced by letters or symbols, and the goal is to figure out which digits correspond to which letters. The puzzle usually involves solving an arithmetic problem, where each letter represents a unique digit (0-9), and no two letters can represent the same digit.

e. What is the limitation of propositional logic over predicate logic?

Propositional Logic deals with simple propositions and logical connectives, focusing on the structure of statements rather than their internal structure.

Predicate Logic incorporates predicates and quantifiers, allowing it to express more detailed relationships and properties about objects in a domain.

f. State Modus Ponens inference rule with suitable example.

Modus Ponens (MP) is a fundamental rule of inference in propositional logic, which allows us to derive a conclusion from two premises:

Premise 1: If P, then Q (P → Q) Premise 2: P Conclusion: Q

In other words, if we have a conditional statement (P → Q) and we know that P is true, then we can logically conclude that Q must also be true.

Example:

- Premise 1: If it rains, then the streets will be wet (W) (R → W)
- Premise 2: It is raining (observed or known to be true)
- Conclusion: The streets will be wet (W) (logically inferred)

g. Define conjunctive normal form with suitable example.

A statement is in conjunctive normal form if it is a conjunction (sequence of ANDs) consisting of one or more conjuncts, each of which is a disjunction (OR) of one or more literals (i.e., statement letters and negations of statement letters). Examples of conjunctive normal forms include

- A
- (A v B) ∧ (¬A v C)
- A ∧ (B v C)

Definition

A formula is in Conjunctive Normal Form if it is represented as:

$$(L_{11} \vee L_{12} \vee \cdots \vee L_{1m}) \wedge (L_{21} \vee L_{22} \vee \cdots \vee L_{2n}) \wedge \cdots \wedge (L_{k1} \vee L_{k2} \vee \cdots \vee L_{km})$$

where:

- Each $(L_{i1} \vee L_{i2} \vee \cdots \vee L_{im})$ is a disjunction (OR) of literals.
- A **literal** is either a variable x or its negation $\neg x$.
- The overall formula is a conjunction (AND) of these disjunctions.

h. Define mutation in genetic algorithm.

Mutation is a fundamental operator in genetic algorithms that introduces random changes to chromosomes, helping to maintain genetic diversity, explore new solutions, and escape local optima. It plays a crucial role in the overall effectiveness of a genetic algorithm by balancing exploration and exploitation of the search space.

i. Define rule based expert system.

A rule-based expert system is a type of artificial intelligence (AI) system that uses a collection of predetermined rules to reason and make decisions. These rules are based on human expertise and are applied to specific domains or problems. The system relies on a set of IF-THEN statements, where:

- IF a specific condition or set of conditions (antecedents) is met
- THEN a particular action or conclusion (consequent) is derived

These rules are executed through a match-resolve-act cycle, where:

- The system matches the current situation or input against the rule base
- Resolves the applicable rules based on the match
- Takes the specified action or derives the conclusion

j. What is meant by machine translation in NLP?

Machine Translation is a subfield of Natural Language Processing (NLP) that involves the use of computational techniques to translate text or speech from one language to another. This process aims to capture the contextual, idiomatic, and pragmatic nuances of both languages, enabling accurate and meaningful communication between humans and machines.

Key Characteristics

- Automated: Machine Translation is performed by computers without human intervention, making it a rapid and scalable process.
- Translation: It converts text or speech from a source language to a target language, preserving the original meaning and context.
- Computational: MT relies on algorithms and statistical models to analyze and generate translations, rather than relying solely on rule-based systems.

Evolution of Machine Translation

- Rule-Based MT: Early approaches used pre-defined rules to translate text, often resulting in inconsistent and predictable quality.
- Statistical MT: Later developments employed statistical models to analyze large datasets and generate translations, improving accuracy but still limited by data quality and complexity.
- Neural Machine Translation: Recent advancements in neural networks have led to significant improvements in MT quality, enabling the capture of subtle linguistic nuances and idioms.

2017

a. When a machine is termed intelligent in Turing Test?

A machine is considered intelligent in the Turing Test if it can engage in a conversation with a human judge in such a way that the judge cannot reliably distinguish between the machine and a human based on their responses.

b. Define agent function.

In artificial intelligence, an agent function is a mathematical function that defines the behavior of an intelligent agent. It maps a given set of percepts (inputs or sensory data from the environment) to actions (outputs or responses) that the agent should perform. Essentially, it describes how the agent should act based on the information it perceives from its environment.

c. Why pragmatic analysis is necessary in NLP?

Pragmatic analysis is essential for creating NLP systems that understand and generate language in a way that aligns with human communication and context.

d. In what type of situation fuzzy logic can be used?

Fuzzy logic provides a way to work with and reason about uncertain or imprecise information, making it valuable in real-world applications where exact precision is not always possible or necessary.

e. "Every husband loves his wife", convert the above statement in FOPL.

1. Define Predicates:
   - $\text{Husband}(x)$: x is a husband.
   - $\text{Wife}(y)$: y is a wife.
   - $\text{Loves}(x, y)$: x loves y.
2. Formalize the Statement:
   - We need to express that for every individual x, if x is a husband, then there exists a y such that y is the wife of x and x loves y.
3. Convert to FOPL:
   - Let $\text{WifeOf}(x, y)$ denote "y is the wife of x."
   - Then the statement becomes:

$$\forall x(\text{Husband}(x) \rightarrow \exists y(\text{WifeOf}(x, y) \land \text{Loves}(x, y)))$$

This means "For every x, if x is a husband, then there exists a y such that y is the wife of x and x loves y."

f. What is unsupervised learning?

Unsupervised learning is a type of machine learning where the model is trained on data without explicit labels or predefined outcomes. The goal is to identify patterns, structures, or relationships within the data on its own. Unlike supervised learning, which relies on labeled data to train the model, unsupervised learning works with input data that does not have corresponding output labels.

g. Write any two conflict resolution strategies in production system.

- Specificity - If all of the conditions of two or more rules are satisfied, choose the rule according to how specific its conditions are. It is possible to favor either the more general or the more specific case. The most specific may be identified roughly as the one having the greatest number of preconditions. This usefully catches exceptions and other special cases before firing the more general (default) rules.
- Recency - When two or more rules could be chosen, favor the one that matches the most recently added facts, as these are most likely to describe the current situation.
- Not previously used - If a rule's conditions are satisfied, but previously the same rule has been satisfied by the same facts, ignore the rule. This helps to prevent the system from entering infinite loops.
- Order - Pick the first applicable rule in order of presentation. This is the strategy that Prolog interpreters use by default, but any strategy may be implemented by building suitable rules in a Prolog system.
- Arbitrary choice - Pick a rule at random. This has the merit of being simple to compute.

h. What is Skolemization?

A procedure in first-order logic that converts a formula into its Skolem normal form by removing existential quantifiers and replacing them with Skolem functions.
Here are the key steps involved in Skolemization:

- Replace free variables with constants.
- Replace any variable bound by an existential quantifier (in the scope of an even number of logical negations) with a Skolem function.
- Replace any variable bound by a universal quantifier (in the scope of an odd number of negations) with a Skolem function.

i. What do you mean by Admissible heuristics?

An admissible heuristic is one that provides an estimate of the cost to reach the goal that is always less than or equal to the true cost, ensuring that search algorithms using it can find optimal solutions.

j. What is alpha-beta pruning?

Alpha-Beta Pruning is an optimization technique used to improve the performance of the Minimax algorithm, a fundamental algorithm in game theory and decision-making. It reduces the computational complexity of the Minimax algorithm by pruning branches in the game tree that do not affect the optimal decision.
Here's a concise explanation:

- Alpha (α) represents the best value that the maximizing player can guarantee at a given level or above.
- Beta (β) represents the best value that the minimizing player can guarantee at a given level or below.
- During the search, the algorithm maintains these values and uses them to prune branches.

- If the maximizing player's best possible value (α) is greater than the minimizing player's best possible value (β), the algorithm can safely stop exploring that branch, as it cannot lead to a better decision.
- This pruning reduces the number of nodes to evaluate, significantly decreasing the computational complexity.

2018

a. What is learning agent?

A learning agent is an artificial intelligence (AI) agent that improves its performance over time by learning from its interactions with the environment. Unlike static agents that operate with a fixed set of rules or strategies, a learning agent adapts and evolves its behavior based on experience and feedback.

b. 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 states it has to examine are exponential in depth of the tree. Since we cannot eliminate the exponent, but we can cut it to half. Hence there is a technique by which without checking each node of the game tree we can compute the correct minimax decision, and this technique is called pruning. This involves two threshold parameter Alpha and beta for future expansion, so it is called alpha-beta pruning. It is also called as Alpha-Beta Algorithm.

c. Define inference engine.

An inference engine is a core component of an artificial intelligence (AI) system or expert system that applies logical rules to a knowledge base to deduce new information or make decisions. It is responsible for drawing conclusions from the given data and rules, enabling the system to reason and solve problems.

d. List the components of problem definition.

The components of a problem definition in the context of problem-solving, particularly in fields like artificial intelligence, operations research, or project management, typically include:

- Problem Statement: A clear and concise description of the problem, outlining what needs to be solved or achieved. It specifies the issue and why it is important.
- Objectives: The goals or desired outcomes that need to be achieved. This includes what the solution should accomplish and the criteria for success.
- Constraints: The limitations or restrictions within which the problem must be solved. This can include time constraints, resource limitations, technical constraints, or regulatory requirements.
- Inputs: The data, resources, or initial conditions available to the problem. This includes any relevant information or resources that will be used to solve the problem.
- Outputs: The expected results or solutions that should be produced. This defines what the final outcome should look like.

- Assumptions: The assumptions made during problem definition, which might impact how the problem is approached and solved. These are conditions that are accepted as true for the purpose of problem-solving.

- Stakeholders: The individuals or groups affected by the problem or involved in the problem-solving process. This includes anyone who has a vested interest in the outcome.

- Scope: The boundaries of the problem, including what is included and excluded from the problem definition. This helps to focus on the relevant aspects and avoid scope creep.

- Evaluation Criteria: The metrics or standards used to assess whether the problem has been successfully solved. This includes how the solution will be measured and evaluated.

e. What is meant by logical consequence?

Logical consequence refers to the relationship between statements in formal logic where one statement (the conclusion) logically follows from one or more other statements (the premises).

f. In which situation fuzzy logic can be used?

g. What is meant by expert system shell?

An Expert system shell is the skeleton of an expert system with the knowledge removed. To build a new expert system application, all the user has to do is add knowledge in the form of rules and provide relevant data.

An expert system shell in AI refers to the framework or software platform that provides the infrastructure for building and running expert systems. It serves as a foundation for developing customized expert systems by providing tools and functionalities to represent knowledge, make inferences, and deliver intelligent advice.

Some main or generic components of the expert system are:

- Knowledge Base
- Knowledge Acquisition System
- Reasoning or Inference Engine
- User Interface
- Explanation Facilities
- Maintenance and Adaptation Tools

h. With suitable example write on crossover operator in genetic algorithm.

The crossover operator in genetic algorithms is a technique used to combine parts of two parent solutions to create one or more offspring solutions. The goal is to produce new solutions that inherit characteristics from both parents, ideally leading to improved performance in subsequent generations.

Consider a genetic algorithm where each individual is represented as a binary string (chromosome).

Suppose we have the following parent chromosomes:
Parent 1: 11001010
Parent 2: 00110101
Let's apply single-point crossover with a crossover point at position 4.
Before Crossover:
Parent 1: 1100|1010
Parent 2: 0011|0101
After Crossover:
Offspring 1: 1100|0101 (first part from Parent 1, second part from Parent 2)
Offspring 2: 0011|1010 (first part from Parent 2, second part from Parent 1)
Resulting Offspring:
Offspring 1: 11000101
Offspring 2: 00111010

i. What is pragmatic analysis?

j. What is DENDRAL?

DENDRAL is an early and influential expert system developed for chemical analysis, specifically for the problem of identifying molecular structures from mass spectrometry data. It was created in the 1960s and 1970s by Edward Feigenbaum, Bruce Buchanan, and other researchers at Stanford University.

DENDRAL is considered the first expert system in artificial intelligence (AI), developed in the 1960s. It was a computer software program that automated the decision-making process and problem-solving behavior of organic chemists. The project consisted of two main programs: Heuristic DENDRAL and Meta-DENDRAL, along with several sub-programs.

2019

a. Define Omniscience.

b. Define sequential environment.

In Artificial Intelligence (AI), a sequential environment is a type of environment where the agent's current actions affect not only the immediate situation but also future states of the environment. In such environments, decisions must consider not just the immediate consequences but also how actions will influence future scenarios, creating a need for planning and long-term strategy.

The sequential environment is an environment where the next state is dependent on the current action. So agent current action can change all of the future states of the environment.

c. Write Modus Ponens Rule.

d. In NLP, why semantic analysis is used?

Semantic analysis allows computers to interpret the correct context of words or phrases with multiple meanings, which is vital for the accuracy of text-based NLP applications.

e. What does a Production Rule Consist of?

A production rule is a fundamental concept in rule-based systems, expert systems, and formal grammars. It consists of two main parts:

- Condition (or Antecedent): This part specifies the condition or set of conditions that must be true for the rule to be applicable. The condition is often expressed in the form of a logical expression or pattern that needs to be matched against the current state of the system or environment.
- Action (or Consequent): This part specifies the action that is triggered or the outcome that is produced when the condition is satisfied. The action can modify the state of the system, make inferences, or provide a solution to a problem.
  production rule typically follows the format:
- IF (condition) THEN (action)

f. Define fuzzy set and crisp set.

A fuzzy set is a mathematical concept that extends the classical notion of a set. Unlike classical sets, where elements either belong or do not belong to the set, fuzzy sets allow elements to have degrees of membership. This degree of membership is represented by a value between 0 and 1, where 0 indicates no membership and 1 indicates full membership.
A crisp set, also known as a classical set, is a fundamental concept in set theory. It is a set where each element is either a member of the set (true) or not a member of the set (false). In other words, crisp sets have a binary membership, where an element either fully belongs or fully does not belong to the set.

g. Compare expert system and human expert.

The significant distinction between expert systems in artificial intelligence and human experts is that expert systems process knowledge represented in the form of rules and use representational reasoning in a limited area, whereas human experts use knowledge in the form of heuristics of rules of thumb to solve problems in a limited domain.

Expert systems are always accessible, unlike human experts, who are only available during certain hours of the day. Expert systems handle any problem in a concise amount of time, but human experts can take their time.

h. Define disjunctive normal form.

In boolean logic, Disjunctive Normal Form (DNF) is a canonical normal form of a logical formula consisting of a disjunction of conjunctions. It can also be described as an OR of ANDs, a sum of products, or, in philosophical logic, a cluster concept.

i. Write any one importance of artificial intelligence.

- Automation of Repetitive Tasks:
- Enhancing Decision-Making:
- Personalization:
- Solving Complex Problems:
- Improving Healthcare:
- Economic Growth and Innovation:
- Enhancing Cybersecurity:
- Increasing Accessibility:
- Improved Customer Service:
- Reducing Human Error:
- Enhancing Education:

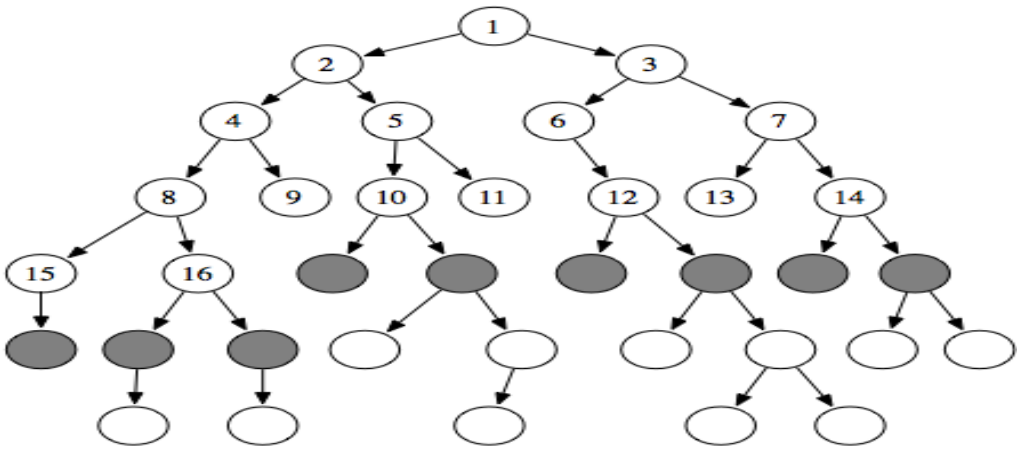
j. What do you mean by fringe nodes?

Fringe nodes refer to a set of nodes or states in a search space, typically represented as a graph or tree, that are at the boundary or edge of the explored area.

In the context of AI search algorithms, the state (or search) space is usually represented as a graph, where nodes are states and the edges are the connections (or actions) between the corresponding states. If you're performing a tree (or graph) search, then the set of all nodes at the end of all visited paths is called the fringe, frontier or border

A fringe node is a node on the boundary of the current search frontier, waiting to be expanded during the search process in algorithms like BFS, DFS, or A*.

In the picture below, the grey nodes (the lastly visited nodes of each path) form the fringe.



2020 (Make Up)

a. What are the requirements to pass the Turing Test?

- **Natural language processing** to enable it to communicate successfully in English (or some
  other human language);
- **Knowledge representation** to store information provided before or during the interrogation;
- **Automated reasoning** to use the stored information to answer questions and to draw new conclusions
- **Machine learning** to adapt to new circumstances and to detect and extrapolate patterns

b. What is agent function?

c. Convert given statement into predicate logic "Every teacher is liked by some student".

Predicates:

- $\text{Teacher}(x)$: x is a teacher.
- $\text{Student}(y)$: y is a student.
- $\text{Likes}(y, x)$: Student y likes teacher x.

Conversion into Predicate Logic:

The statement says that for every teacher x, there exists at least one student y such that the student likes the teacher.

$$\forall x(\text{Teacher}(x) \rightarrow \exists y(\text{Student}(y) \land \text{Likes}(y, x)))$$

Explanation:

- $\forall x$: For every x (teacher).
- $\text{Teacher}(x) \rightarrow$: If x is a teacher, then...
- $\exists y$: There exists at least one y (student).
- $\text{Student}(y) \land \text{Likes}(y, x)$: y is a student and y likes teacher x.

This formalization captures the intended meaning of the statement.

d. Define triggering in production system.

In a production system, triggering refers to the process by which a specific rule or production is activated based on the current state of the system.

Triggering in production systems refers to the process of initiating a measurement or controlled output of measurement data in response to a specific event or condition. This concept is crucial in production and process automation environments, where efficient and flexible production is essential.

e. Compare fuzzy logic with binary logic.

Fuzzy logic differs from traditional binary logic systems by allowing for intermediate degrees of truth instead of just true or false. In fuzzy logic, statements can have degrees of truth between 0 and 1, which allows for a more nuanced representation of uncertainty and imprecision [2]. Traditional binary logic, on the other hand, only allows for two truth values - true or false [3]. Fuzzy logic is based on the concept of fuzzy sets, which assign membership degrees to elements based on their degree of belonging to the set [2]. This allows for a more flexible and human-like way of reasoning, as it can capture the vagueness and ambiguity present in many real-world situations [1]. In contrast, traditional binary logic is based on crisp sets, where elements either fully belong or do not belong to a set [4]. Overall, fuzzy logic provides a more expressive and interpretable framework for dealing with uncertainty and imprecision compared to traditional binary logic systems [5].What do you mean by machine learning?

f. Differentiate between universal and existential quantifiers.

Universal Quantifier(∀)

- Denotes "for all" or "every" element in a domain (D)
- Asserts that a predicate (P) is true for all values of the variable (x) in the domain (D)
- Symbolized as ∀x P(x), read as "for all x, P(x) is true"
- Example: "All numbers raised to the fourth power are non-negative" ($\forall x, x^4 \geq 0$)

Existential Quantifier (∃)

- Denotes "there exists" or "at least one" element in a domain (D)
- Asserts that a predicate (P) is true for at least one value of the variable (x) in the domain (D)
- Symbolized as ∃x P(x), read as "there exists an x such that P(x) is true"
- Example: "There exists a number raised to the third power that is negative" ($\exists x, x^3 < 0$)

g. **Define plateau problem**.

The plateau problem occurs when a search algorithm encounters a flat region in the solution space where no immediate improvement is evident, making it difficult to progress. This can slow down or hinder the search, especially in local search algorithms like hill climbing.

h. Why natural language processing is a difficult task?

NLP is difficult because human language is complex, context-dependent, ambiguous, and constantly evolving. These challenges require sophisticated algorithms, large datasets, and deep contextual understanding to achieve accurate language comprehension and processing in AI systems.

i. Define knowledge engineering in expert system.

Knowledge engineering is a field of artificial intelligence (AI) that tries to emulate the judgment and behavior of a human expert in a given field.

2022

a. Why do we need to make the machine learn?

b. What is rational agent?

A rational agent is a digital entity or program that makes decisions based on logical reasoning and optimizes its behavior to achieve a specific goal. It assesses its environment by considering what it is like, evaluates each available action, and determines how it will affect the environment and help it attain its goal

c. Give an example of CNF expression.

d. What are the four ways to evaluate the performance of searching?

e. Why do we need to analyze semantics over syntactic?

Analyzing semantics (the meaning of words and sentences) is crucial in Natural Language Processing (NLP) because understanding the meaning of a sentence goes beyond just analyzing its syntax (the structure or arrangement of words). While syntactic analysis helps to understand how words are organized, it is the semantic analysis that allows us to grasp the actual meaning and intent behind a sentence.

- Better handling of ambiguity: Syntactic analysis alone may not disambiguate words with multiple meanings, whereas semantic analysis can consider context and relationships to infer the intended meaning.
- Improved understanding of figurative language: Idioms, metaphors, and other figurative language devices rely heavily on semantic relationships, which syntactic analysis may not capture accurately.
- Enhanced entity recognition: Semantic analysis enables the identification of entities and their roles, which is crucial for tasks like information retrieval and question answering.

f. What is the function of inference engine in expert system?

The inference engine is a crucial component of an expert system, responsible for interpreting and evaluating the facts in the knowledge base to provide an answer or solution. Its primary function is to infer information based on a set of rules and data.

- Reasoning
- Pattern Matching
- Rule Application
- Decision Making

Types

- Forward Chaining
- Backward Chaining

g. Why we need probabilistic reasoning in AI?

Probabilistic reasoning is a technique used in AI to address uncertainty by modeling and reasoning with probabilistic Information. It allows AI systems to make decisions and predictions based on the probabilities of different outcomes, taking into account uncertain or incomplete Information. Probabilistic reasoning provides a principled approach to

handling uncertainty, allowing machines to reason about uncertain situations in a rigorous and quantitative manner.

Probabilistic reasoning is necessary in AI to handle uncertainty, make decisions with incomplete information, and model the complexities of the real world. It allows AI systems to be more flexible, robust, and human-like in their reasoning, which is critical for success in applications like autonomous vehicles, healthcare, speech recognition, and natural language understanding. Without probabilistic reasoning, AI systems would struggle to perform effectively in dynamic, unpredictable environments.

h. List out any two activation functions.

- Binary Step Function
- Linear Activation Function
- Sigmoid / Logistic Activation Function

i. Why do we need to address fuzzy logic in AI?

Fuzzy logic is essential in AI to mimic human reasoning and cognition, particularly in situations where input data is unclear or ambiguous.

j. What do you mean by reinforcement learning?

Reinforcement learning (RL) is a subfield of machine learning that focuses on training agents to make decisions in complex, uncertain environments. The core idea is that an agent learns by interacting with its environment and receiving feedback in the form of rewards or penalties for its actions.

2023

a. How does utility-based agent differ with goal-based agent?

Utility-based agents differ from goal-based agents in that they do not have a specific goal to achieve. Instead, they focus on maximizing a utility function. Goal-based agents, on the other hand, have a predefined goal and work towards achieving it. This fundamental difference affects how each type of agent makes decisions and prioritizes actions.

b. How does deterministic environment differ from stochastic environment?

- Deterministic are the environments where the next state is observable at a given time. So there is no uncertainty in the environment.
  Real-life Example: The traffic signal is a deterministic environment where the next signal is known for a pedestrian (Agent)
- The Stochastic environment is the opposite of a deterministic environment. The next state is totally unpredictable for the agent. So randomness exists in the environment.
  Real-life Example: The radio station is a stochastic environment where the listener is not aware about the next song or playing a soccer is stochastic environment.

c. What is constraint satisfaction problem?

Constraint satisfaction problems (CSPs) are mathematical questions defined as a set of objects whose state must satisfy a number of constraints or limitations. CSPs represent the entities in a problem as a homogeneous collection of finite constraints over variables, which is solved by constraint satisfaction methods.

d. Give an example of Skolemization.

Skolemization is a process used to eliminate existential quantifiers (∃) from logical formulas. Here's an example:

Original formula: $\forall x\ (x = 0 \vee \exists y\ (x = y + 1))$

In this formula, the existential quantifier ($\exists y$) expresses the existence of a value y such that the predicate ($x = y + 1$) is true.

Skolemization replaces the existential quantifier with a Skolem function or constant. Let's introduce a new function symbol, say f, to represent the Skolem function. Then, we replace the existential quantifier with f(x):

Skolemized formula: $\forall x\ (x = 0 \vee x = f(x) + 1)$

In this Skolemized formula, the Skolem function f(x) takes x as input and returns a value y such that $x = y + 1$. The formula now has only universal quantifiers (∀) and no more existential quantifiers (∃).

Note that the Skolem function f(x) is a new symbol introduced to satisfy the original formula. It's often denoted by the formula it realizes, in this case, $c\ \exists x\ \phi(x)$ (where c is a constant).

Skolemization is used to simplify logical formulas, making them more tractable for automated theorem proving and other applications in artificial intelligence and logic programming.

e. List the problem of depth limited search.

The problems associated with depth-limited search are:

- Optimally setting the depth limit (l): It's challenging to determine the optimal value of l, as it requires estimating the maximum depth of the search tree. If l is too small, the search may not be complete; if l is too large, the time and space complexity may become excessive.
- Balancing completeness and complexity: The depth limit must be set to ensure both completeness (i.e., finding the optimal solution) and reasonable time and space complexity. If l is too low, the search may not be complete; if l is too high, the complexity may become impractical.
- Handling uncertainty in estimating depth: For many problems, it's difficult to estimate the maximum depth of the search tree until the problem is solved. This uncertainty makes it hard to set an optimal depth limit.

f. What is the limitation of sigmoid activation function?

g. Write any two conflict resolution strategy in production system.

h. Numerically illustrate fuzzy union operation.

i. Write the heuristic function for A* search.

j. What are the types of crossover in genetic algorithm?