DISCRETE MATH PROJECT

AI USING PREDICATE LOGIC

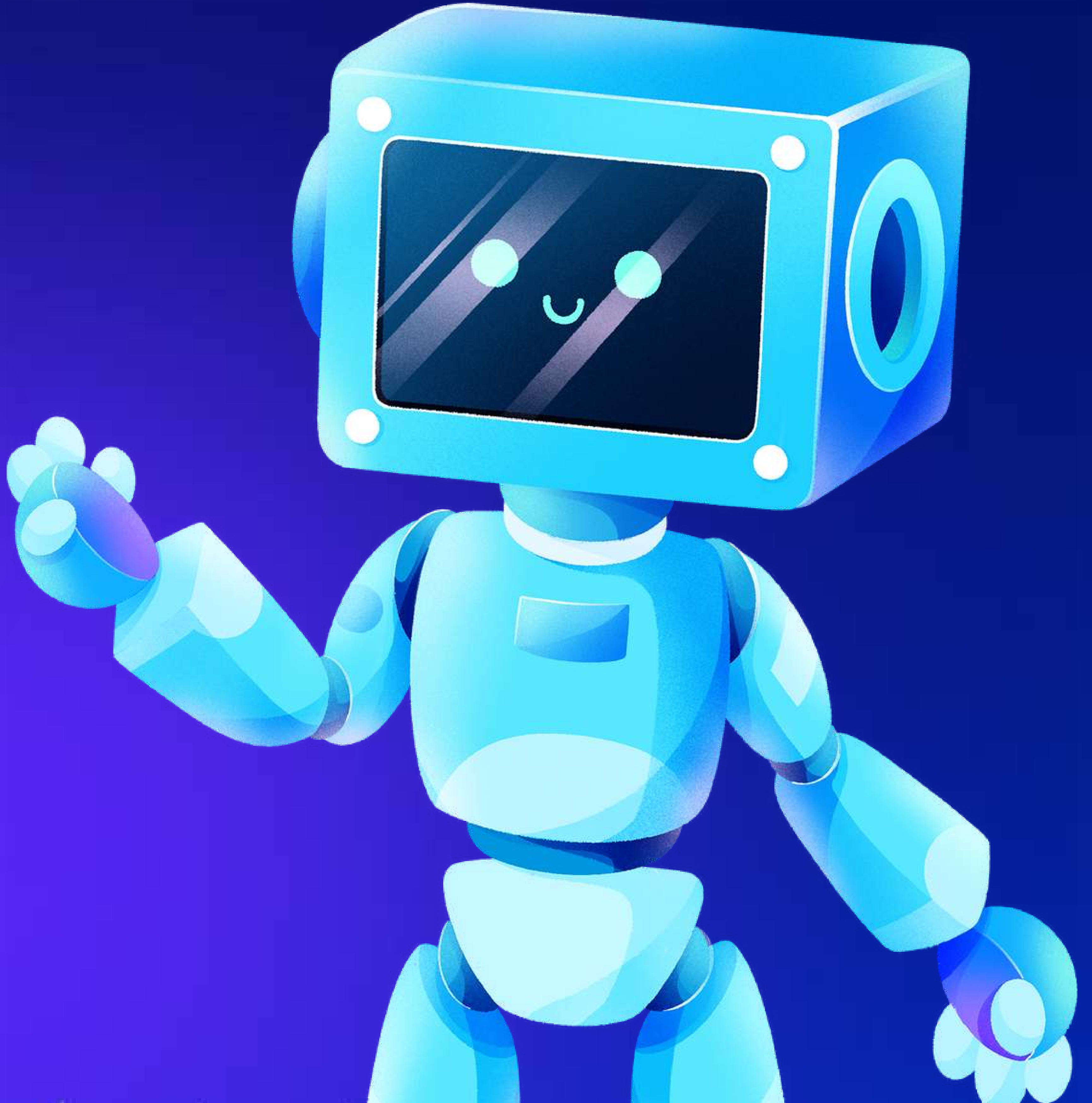

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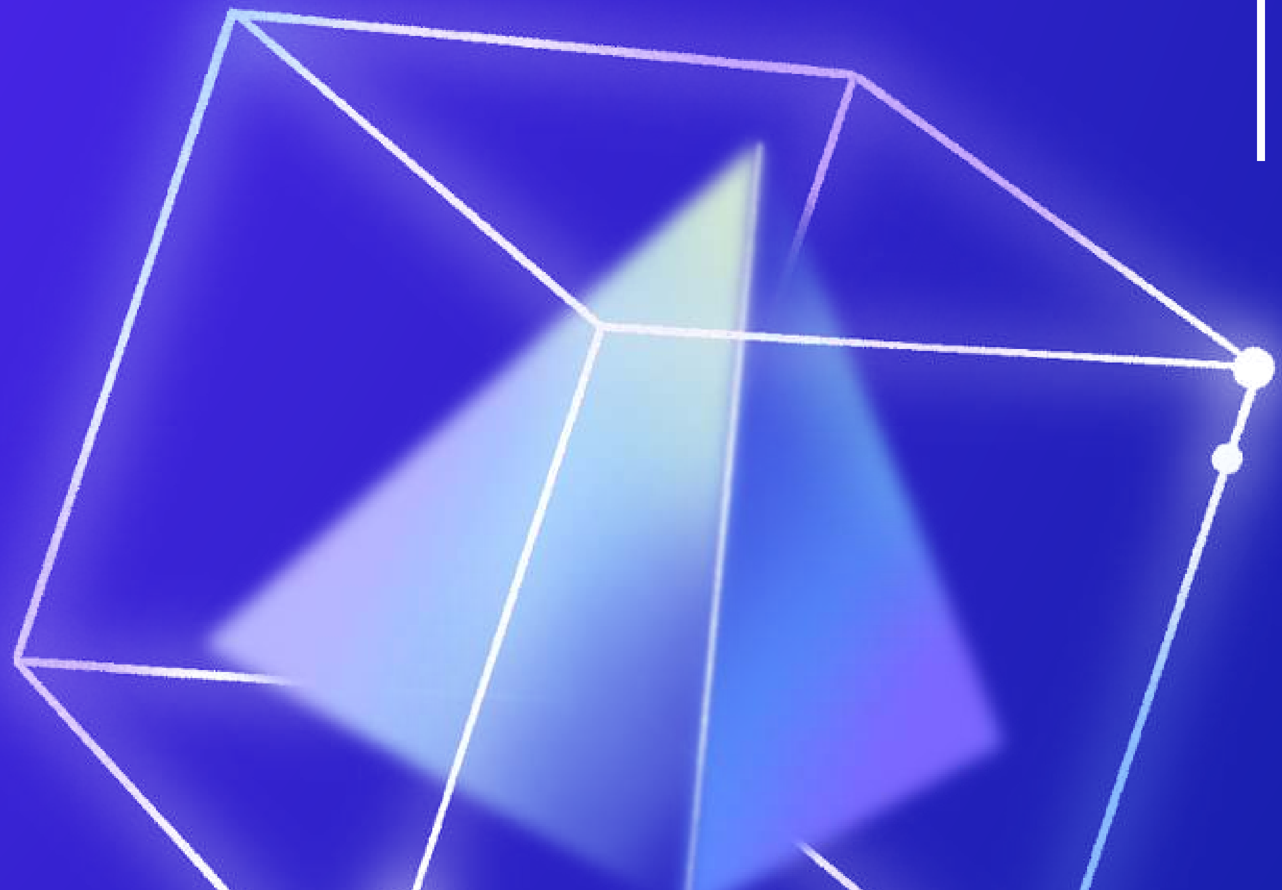
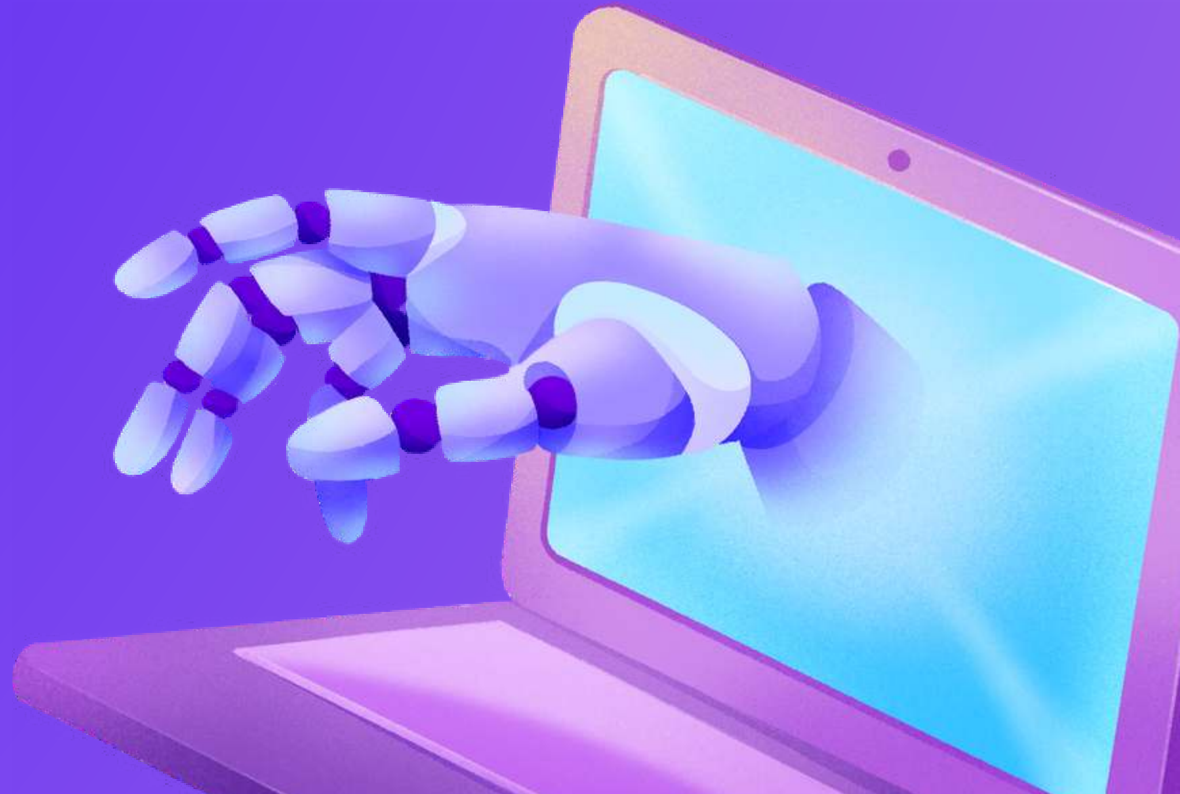
TABLE OF CONTENTS



PREDICATE LOGIC IN AI

- A predicate is a claim that is made about one or more things.
- In Artificial Intelligence, Predicate Logic is used to describe and reason about complex relationships between objects & their properties.
- It is helpful for formatting & logically representing knowledge about the world, which can then be used to draw inferences and deductions.
- Used to help figure out whether or not a member of a certain set possesses a given property.
- It allows handling expressions of generalization (quantificational expressions) and talking about variables (pronouns).
- It breaks down sentences into smaller: predicates and individuals.



CHARACTERISTICS

Predicate Logic in AI has several characteristics making it a powerful tool for AI applications. Some of these are:

- Logical inference is allowed.
- More accurate knowledge representation of facts of the real world.
- Program designing is its application area.
- Better theoretical foundation.
- A predicate with no variable is called a Ground Atom.

WHY ISN'T PROPOSITIONAL LOGIC USED?

- Since we can only represent information as either true or false in propositional logic:

1. PL is not sufficient to represent complicated or natural language statements.
2. PL cannot describe object relationships or reason about complex statements
3. Due to its limited expressive power, we use First Order Logic instead.

- FOL allows representation and reasoning of complicated relationships between things and their properties. It is more powerful & flexible.

FIRST ORDER LOGIC

- FOL is an extension of proposition logic & a mode of representation in AI
- It represents natural language statements in a concise way
- It is a powerful language used to develop information about an object and express the relationship between objects.
- It not only assumes that the world contains facts (like PL does), but it also assumes:
    a. Objects: A, B, people, numbers, colors, wars, theories, squares, pit, etc.
    b. Relations: It is unary relation such as red, round, sister of, brother of, etc.
    c. Function: father of, best friend, third inning of, end of, etc.

Basic elements of FOL

Name	Symbol
Constant	1, 6, A,W,New York, Elie, Dog…
Variables	a, b, c, x, y, z…
Predicates	<, >, brother, sister, father…
Equality	==
Function	Sqrt, LessThan, Sin(θ)…
Quantifier	∀, ∃
Connectives	∧, ∨, ¬, ⇒, ⇔

ATOMIC FORMULA

- In predicate logic in AI, an atomic formula is an assertion that cannot be broken down into simpler statements using logical connectives or quantifiers.
- It comprises a single predicate symbol and an unlimited number of factors.

  Cat(x) Dog(y)

- Predicate symbol followed by a parenthesis with a sequence of terms.

  Eg: John and Michael are colleagues → Colleagues (John, Michael)

- A ground atomic formula is a predicate with all constant arguments.

EXPLAINING FOL IN AI

- Problem: Given a family tree, determine if Alice is a cousin of Bob.

Family Tree **representation**: Some predicates and constants for this example:

1. Constants: Alice, Bob, Carol, David, Emily
2. Predicate "Parent(x, y)": This predicate indicates that x is the parent of y.
3. Predicate "Male(x)" and "Female(x)": These predicates indicate whether a person is male or female.

Family tree **information** through predicates:

1. Parent(Carol, Alice) (Carol is Alice's parent)
2. Parent(David, Alice) (David is Alice's parent)
3. Parent(David, Bob) (David is Bob's parent)
4. Parent(Emily, Carol) (Emily is Carol's parent)
5. Female(Alice)
6. Female(Carol)
7. Male(David)
8. Male(Bob)

EXPLAINING FOL IN AI

Solution using Predicate Logic:

1. **Define predicates:**

- Cousin(x, y): x is a cousin of y if they share a common grandparent but are not siblings.
- Express the relationship between Alice and Bob:
- Cousin(Alice, Bob) is true if there exists a common grandparent between Alice and Bob, and they are not siblings.

2. **Reasoning:**

- We can reason using predicate logic by breaking it down into simpler statements:
- $\exists z$ (Parent(z, Alice) $\wedge$ Parent(z, Bob)): There exists a common parent (z) of Alice and Bob.
- $\exists g$ (Parent(g, z) $\wedge$ Parent(g, Carol) $\wedge$ Parent(g, David)): There exists a common grandparent (g) of Alice and Bob, who is also a parent of Carol and David.
- $\neg$(Parent(Alice, Bob)): Alice and Bob are not siblings.
- Combine the statements:
- Cousin(Alice, Bob) is true if $\exists z$ (Parent(z, Alice) $\wedge$ Parent(z, Bob)) $\wedge$ $\exists g$ (Parent(g, z) $\wedge$ Parent(g, Carol) $\wedge$ Parent(g, David)) $\wedge$ $\neg$(Parent(Alice, Bob)).

3. **Evaluate the statement:**

- If this combined statement is true, Alice is a cousin of Bob.
- In this example, you can use predicate logic to determine whether Alice is a cousin of Bob by examining the relationships between individuals and the criteria for being cousins. If the combined statement is satisfied, then Alice is indeed a cousin of Bob.

1. $man(Marcus)$
2. $Pompeian(Marcus)$
3. $\forall x : Pompeian(x) \rightarrow Roman(x)$
4. $ruler(Caesar)$
5. $\forall x : Roman(x) \rightarrow loyalto(x, Caesar) \vee hate(x, Caesar)$

Pure Predicate Logic

1. $instance(Marcus, man)$
2. $instance(Marcus, Pompeian)$
3. $\forall x : instance(x, Pompeian) \rightarrow instance(x, Roman)$
4. $instance(Caesar, ruler)$
5. $\forall x : instance(x, Roman) \rightarrow loyalto(x, Caesar) \vee hate(x, Caesar)$

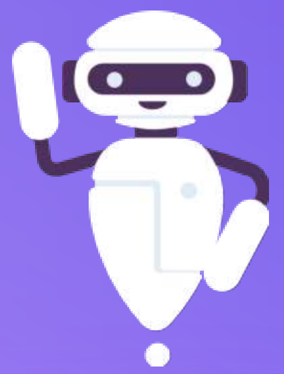
Instance Relationship

1. $instance(Marcus, man)$
2. $instance(Marcus, Pompeian)$
3. $isa(Pompeian, Roman)$
4. $instance(Caesar, ruler)$
5. $\forall x : instance(x, Roman) \rightarrow loyalto(x, Caesar) \vee hate(x, Caesar)$
6. $\forall x : \forall y : \forall z : instance(x, y) \wedge isa(y, z) \rightarrow instance(x, z)$

Isa Relationship

Three Ways of Representing Class Membership

INFERENCE RULES



UNIVERSAL GENERALIZATION

This rule can be used if we want to show that every element has a similar property

UNIVERSAL INSTANTIATION

Here, we get a general statement and we can infer from that statement for a particular object.

EXISTENTIAL INSTANTIATION

if we know that there exists an x such that P(x) is true, then we can conclude that there is at least one element in the domain that satisfies P(x).

EXISTENTIAL INTRODUCTION

if there is some element c which has a property P, then we can infer that there exists something in the universe which has the property P

TYPES OF REASONING

01 Deductive Reasoning

02 Inductive reasoning

03 Abductive reasoning

04 Common sense reasoning

05 Monotonic Reasoning

06 Non-Monotonic Reasoning

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THANK YOU!