Artificial Intelligence Knowledge Representation

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Representation

- AI agents deal with knowledge (data)
  - Facts (believe & observe knowledge)
  - Procedures (how to knowledge)
  - Meaning (relate & define knowledge)

Some General Representations

1. Logical Representations
    1. Propositional logic
    2. First order predicate logic
2. Production Rules
3. Semantic Networks
    - Conceptual graphs, frames

Mathematical Logic

- A **statement**, or a **proposition**, is a declarative sentence that is either true or false, but not both
- Uppercase letters denote propositions
  - Examples:
    - P: 2 is an even number (true)
    - Q: 7 is an even number (false)
    - R: A is a vowel (true)
  - The following are not propositions:
    - P: My cat is beautiful
    - Q: My house is big

Propositional Logic

- Compound statement
  - Connectives: and, or, not, implies, iff (equivalent)

    $\wedge \quad \vee \quad \neg \quad \longrightarrow \quad \longleftrightarrow$
  - Brackets, (true) and F (false)
  - Use **truth tables** to work out the truth of statements

Mathematical Logic

Conjunction

- Let *P* and *Q* be statements. The **conjunction** of *P* and *Q*, written *P* ^ *Q* , is the statement formed by joining statements *P* and *Q* using the word "and"
- The statement *P* ^ *Q* is true if both p and q are true; otherwise, *P* ^ *Q* is false
- Truth Table for Conjunction:
- Example

AND Truth Table

Inputs		Output
A	B	Y = A.B
0	0	0
0	1	0
1	0	0
1	1	1

p: Rameez is healthy   q:He has blue eyes

p: It is cold   q: It is raining

p:5x+6=26   q=x>3

- Write each of the following sentences symbolically,

letting h =“It is hot” and

s =“It is sunny.”

Make the propositional logic of following two statements

a. It is not hot and it is sunny.

b. It is neither hot nor sunny.

- The given sentence is equivalent to

"It is not hot and it is sunny," which can be written symbolically as $\sim h \wedge s$.

- To say it is neither hot nor sunny means that **it is not hot and it is not sunny**. Therefore, the given sentence can be written symbolically as $\sim h \wedge \sim s$

Mathematical Logic

- Disjunction
  - Let P and Q be statements. The **disjunction** of P and Q, denoted by $P \vee Q$, is the compound statement formed by joining statements P and Q using the word "or"
  - The statement $P \vee Q$ is true if at least one of the statements P and Q is true; otherwise $P \vee Q$ is false
  - The symbol v is read "or"
  - Truth Table for Disjunction:
  - Example $5<5 \vee 5<6$
  - Example $5 \times 4=21 \vee 9 + 7 =17$
  - Example $6+4=10 \vee 0 > 2$

OR Truth Table

Inputs		Output
A	B	Y = A+B
0	0	0
0	1	1
1	0	1
1	1	1

Example Cont'

- p: It is cold
- q: It is raining

Write simple verbal sentences which describes each of the following statements

$\sim p$ $\quad$ $\sim q$

$p \wedge q$ $\quad$ $p \vee q$

$\sim p \wedge \sim q$ $\quad$ $\sim p \vee \sim q$

Mathematical Logic

- Implication
  - Let P and Q be statements. The statement "if P then Q" is called an **implication or conditional proposition**.
  - The implication "if P then Q" is written $P \to Q$
  - P is called the hypothesis or antecedent, Q is called the conclusion or consequent

Conditional Statements

Implication

Definition: Let p and q be propositions. The *conditional statement* $p \to q$, is the proposition "*If p, then q*".

The *conditional statement* $p \to q$ is false when p is true and q is false and is true otherwise.

where p is called hypothesis, antecedent or premise.

q is called conclusion or consequence

Implication

- If p and q are propositions, then $p \to q$ is a *conditional statement* or *implication* which is read as "if p, then q" and has this truth table:

p	q	$p \to q$
T	T	T
T	F	F
F	T	T
F	F	T

- **Example**: If p denotes "I am at home." and q denotes "It is raining." then $p \to q$ denotes "If I am at home then it is raining."
- In $p \to q$, p is the *hypothesis* (*antecedent* or *premise*) and q is the *conclusion* (or *consequence*).

Example of Implication

Which of the following propositions are true and which are false?

a) If earth is round, then earth travels around the sun.

b) If Alexander Graham Bell invented telephone, then tigers have wings

c) If tigers have wings, then RDX is dangerous

Mathematical Logic

- Implication
  - Let P: Today is Sunday and Q: I will wash the car.
  - $P \to Q$:

    If today is Sunday, then I will wash the car
  - The **converse** of this implication is written $Q \to P$

    If I wash the car, then today is Sunday
  - The **inverse** of this implication is $\neg P \to \neg Q$

    If today is not Sunday, then I will not wash the car
  - The **contrapositive** of this implication is $\neg Q \to \neg P$

    If I do not wash the car, then today is not Sunday

Mathematical Logic

- Biimplication
  - Let P and Q be statements. The statement "P if and only if Q" is called the **biimplication or biconditional** of P and Q
  - The biconditional "P if and only if Q" is written $P \leftrightarrow Q$
  - "P if and only if Q"

p	q	$p \leftrightarrow q$
T	T	T
T	F	F
F	T	F
F	F	T

Predicate Logic

- Propositional logic combines atoms
  - An atom contains no propositional connectives
  - Have no structure (today_is_wet, john_likes_apples)
- **Predicates** allow us to talk about objects
  - Properties: is_wet(today)
  - Relations: likes(john, apples)

First Order Logic

- **Constants** are objects: john, apples
- **Predicates** are properties and relations:
  - likes(john, apples)
- **Computable Predicates**

  gt(1,0) lt(0,1)
- **Functions** transform objects:
  - likes(john, fruit_of(apple_tree))
- **Variables** represent any object: likes(X, apples)

Predicates

Marcus was a man

man (Marcus)

Marcus was a Pompeian

Pompeian(Marcus)

Caesar was a ruler

Ruler(Caesar)

Marcus tried to assassinate Caesar

Tryassassinate(Marcus, Caesar)

FOL

- **Quantifiers** qualify values of variables
  - True for all objects (Universal): $\forall X.\ likes(X, apples)$
  - Exists at least one object (Existential): $\exists X.\ likes(X, apples)$

Example: Quantifiers Sentence

- Write WFF(well formed formula) for the following statements
- “Every Student likes AI”
- “Some students like AI”

Difference Between PL and FOL

- It uses prepositions in which complete sentence is denoted by symbol
- PL cannot represent individual entities e.g. John is tall
- FOL uses predicates which involves constants variables, functions and relations.
- FOL can represent individual properties e.g. Tall(John)

Cont’

- It cannot express generalization and specialization.

e.g. Triangle has 3 sides

- It can express generalization , specialization or pattern.

e.g. no_of_sides(triangle,3)