UNIT-3

Objectives

- To understand the importance of knowledge representation in intelligent agents .
- To understand the use of formal logic as a knowledge representation language.
- The student should be familiar with the following concepts of logic, 1) syntax 2) semantics 3) validity 4) satisfiability 5) interpretation and models 6) entailment
- To understand each of the above concepts in propositional logic .
- To Students should learn different inference mechanisms in propositional logic.

Knowledge Representation and Reasoning

- Intelligent agents should have capacity for:
  - Perceiving, that is, acquiring information from environment,
  - Knowledge Representation, that is, representing its understanding of the world,
  - Reasoning, that is, inferring the implications of what it knows and of the choices it has, and
  - Acting, that is, choosing what it want to do and carry it out.

- The primary component of a knowledge-based agent is its knowledge-base.
- A knowledge-base is a set of sentences.
- Each sentence is expressed in a language called the knowledge representation language.
- Sentences represent some assertions about the world.
- There must mechanisms to derive new sentences from old ones.
- This process is known as inferencing or reasoning.
- Inference must obey the primary requirement that the new sentences should follow logically from the previous ones

Logic

- Logic is the primary vehicle for representing and reasoning about knowledge.
- Formal language-The advantage of using formal logic as a language of AI is that it is precise and definite. This allows programs to be written which are declarative - they describe what is true and not how to solve problems.
- Limitations of formal language: large portion of the reasoning carried out by humans depends on handling knowledge that is uncertain.
- A logic consists of two parts-------**language** and a **method of reasoning.**

- **Syntax**: Syntax specifies the symbols in the language and how they can be combined to form sentences.
- facts about the world are represented as sentences in logic.
- **Semantics**: It specifies what facts in the world a sentence refers to.
- also specifies how you assign a truth value to a sentence based on its meaning in the world.
- A fact is a claim about the world, and may be true or false.

- **Syntactic Inference Method**: It refers to mechanical method for computing (deriving) new (true) sentences from existing sentences.
- *Facts* are claims about the world that are True or False.
- *representation* is an expression (sentence) in some language that can be encoded in a computer program and stands for the objects and relations in the world.

```
                        entails
Representation:   Sentences -------------> Sentences
                  |                        |
                  |                        |
                  | Semantics              | Semantics
                  | refer to               | refer to
                  |                        |
                  \/       follows         \/
World:          Facts -----------------> Facts
```

- There are a number of logical systems with different syntax and semantics.

  - Propositional logic

    All objects described are fixed or unique

    "John is a student" student(john)

    Here John refers to one unique person.

- First order predicate logic

  Objects described can be unique or variables to stand for a unique object

  "All students are poor"

  ForAll(S) [student(S) -> poor(S)]

  Here S can be replaced by many different unique students.

  This makes programs much more compact:

    eg. ForAll(A,B)[brother(A,B) -> brother (B,A)]

    replaces half the possible statements about brothers

- Temporal

  Represents truth over time.

- Modal

  Represents doubt

- Higher order logics

  Allows variable to represent many relations between objects

- Non-monotonic

  Represents defaults

Propositional is one of the simplest systems of logic.

Propositional Logic

- In propositional logic (PL) an user defines a set of propositional symbols, like P and Q.
- User defines the semantics of each of these symbols.
  - P means "It is hot"
  - Q means "It is humid"
  - R means "It is raining"
  -

- A **sentence** (also called a formula or well-formed formula or wff) is defined as:
  1. A symbol
  2. If S is a sentence, then ~S is a sentence, where "~" is the "not" logical operator
  3. If S and T are sentences, then (S v T), (S ^ T), (S => T), and (S <=> T) are sentences, where the four logical connectives correspond to "or," "and," "implies," and "if and only if," respectively
  4. A finite number of applications of (1)-(3)

- Examples of PL sentences:
  - (P ^ Q) => R (here meaning "If it is hot and humid, then it is raining")
  - Q => P (here meaning "If it is humid, then it is hot")
  - Q (here meaning "It is humid.")

- Given the truth values of all of the constituent symbols in a sentence, that sentence can be "evaluated" to determine its truth value (True or False). This is called an **interpretation** of the sentence.

A **model** is an interpretation (i.e., an assignment of truth values to symbols) of a set of sentences such that each sentence is True. A model is just a formal mathematical structure that "stands in" for the world.

A **valid** sentence (also called a **tautology**) is a sentence that is True under *all* interpretations. Hence, no matter what the world is actually like or what the semantics is, the sentence is True. For example "It's raining or it's not raining."

An **inconsistent** sentence (also called **unsatisfiable** or a **contradiction**) is a sentence that is False under *all* interpretations. Hence the world is never like what it describes. For example, "It's raining and it's not raining."

Sentence P **entails** sentence Q, written $P \models Q$, means that whenever P is True, so is Q. In other words, all models of P are also models of Q

Propositions

sentence -- 

--→ *Proposition*

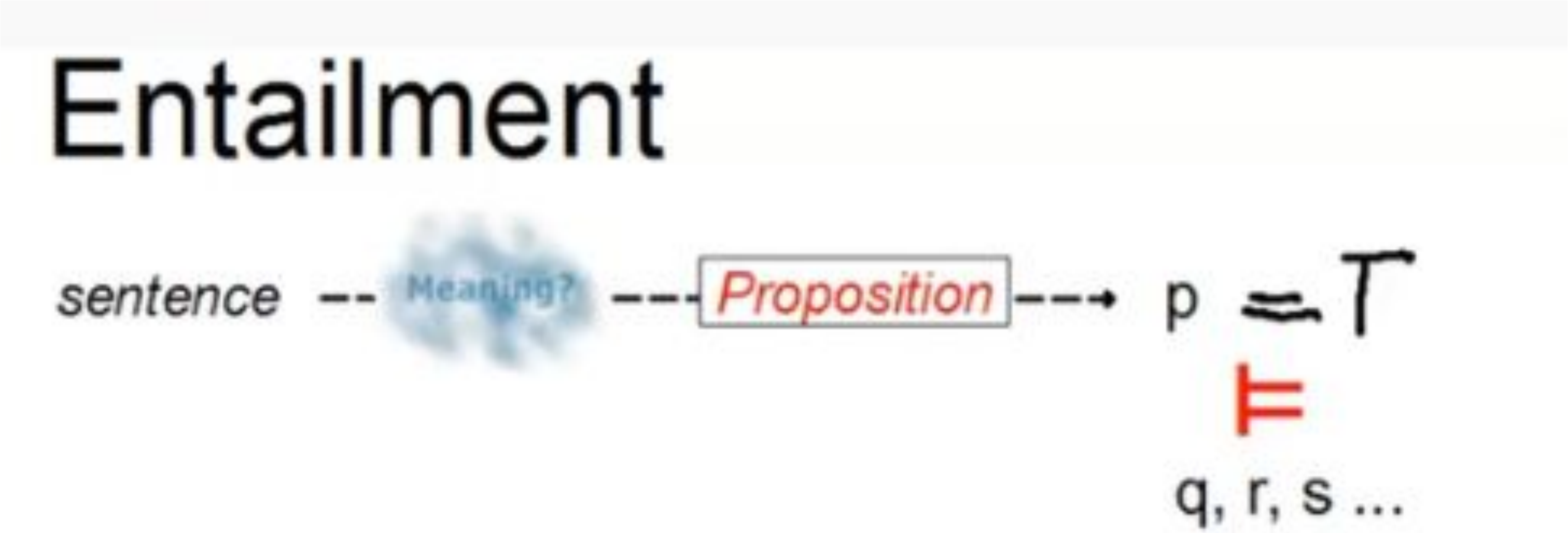
The sky is blue *and it is raining.*

 p  q p & q = F

Inference


The sky is blue
and it is raining.
p
q
p & q = F
The sun is shining.
There are clouds
in the sky.

Logical inference are called Entailment



Entailment $\models$

Brutus killed Caesar.

p = Brutus killed Caesar

q = Caesar died.

$$p \models q$$

Entailment $\vDash$

Brutus killed Caesar.

p = Brutus killed Caesar

q = Caesar died.

$p \vDash q$

p	q	$p \vDash q$
T	T	T
F	T v F	F

Entailment $\models$

Brutus killed Caesar.

p = Brutus killed Caesar

q = Caesar died.

$p \models q$

p	q	$p \models q$
T	T	T
F	T v F	F

q	p	$q \models p$
T	T v F	T
F	F	F

Entailment $\models$

All dogs are purple.

p = All dogs are purple.

q = My dog is purple.

$p \models q$

$p \models q$ iff $p = T$ & $q = T$

Entailment Test

Step 1 p

Step 2 $p \vDash q$

Step 3 $\neg q$

Step 4 $p \;\&\; \neg q$

$\rightarrow$ contradiction $p \vDash q$

$\rightarrow$ no contradiction $p \nvDash q$

1. p All dogs are purple.

2. $p \vDash \boxed{q \text{ My dog is purple.}}$

3. $\neg q$ My dog is NOT purple.

4. $p \ \& \neg q$

All dogs are purple and/but my dog is NOT purple.

contradiction: $p \vDash q$

1 p All dogs are purple.

2 $p \vDash \boxed{q \text{ My dog likes cats.}}$

3 $\neg q$ My dog does NOT like cats.

4 $p \;\&\; \neg q$

All dogs are purple and/but my dog does NOT like cats.

no contradiction: $p \nvDash q$

Reference

1) “Artificial Intelligence”,NPTEL,CSE,IIT,Khargpur

2)www.linguistics-online.com