

# Artificial Intelligence First Order Logic ①

- FOL is built around objects and relations:
- The primary difference bet<sup>w</sup> PL & FOL is in the ontological commitment made by each language - what it assumes to be nature of reality.
- PL assumes there are facts that are true/false
- FOL assumes objects & certain relations ~~which~~ bet<sup>w</sup> them which hold true or not
- A logic can also be characterized by its epistemological commitments - the possible states of knowledge

\* Models of a logical language: Formal structures that constitute the possible worlds under consideration.

- Modes for FOL:

+ Have objects

+ Domain of a model is set of objects it contains.

+ Relation: Set of tuples of objects that are related.

## Symbols

- 3 kinds of symbols
  - + Constant symbols - stand for objects
  - + Predicate symbols - stand for relations
  - + Function symbols - stand for functions.
- Each predicate & function symbol comes with arity, - no. of arguments.
- Interpretation specifies ~~what~~ exactly which objects, relations & functions are referred to by constant, predicate & function symbols.
- \* Truth of any sentence is determined by a model & interpretation of sentence's symbol.
- Term: A logical expression that refers to an object
  - Constant symbols  $\therefore$  are terms.
  - + A complex term is formed by a functional symbol followed by a parenthesized list of terms as

as arguments to functional symbols. If functional symbols are not subroutines that takes an I/P & returns an O/P. Eg  $\text{leftleg of}(\text{John})$ .

- Atomic sentences: State facts.
  - + Formed from a predicate symbol followed by parenthesized list of terms: Eg.  $\text{Brother}(\text{Richard}, \text{John})$
  - + An atomic sentence is true in a given model, under a given interpretation, if the rel<sup>n</sup> referred to by the predicate symbols holds among the objects referred to by the arguments.
- Complex Sentences: Logical connectives can be used to form complex sentences.
- Quantifiers: ~~Can~~ Allows to express properties for entire collection of objects.
  - + Universal Quantifiers: Allows to express for all ( $\forall$ )
    - +  $\forall x P$ , where  $P$  is any logical expression, say that  $P$  is true for all  $x$ .
  - + Existential Quantification ( $\exists$ ): There exists an  $x$  such that ... " or "For some  $x$ ..."
    - \* There exists <sup>at least</sup> one object ' $x$ ' for which  $P$  is true
- + order of quantification is imp
- +  $\forall$  &  $\exists$  are connected through negation.

### Using FOL

- Sentences are added using TELL & are called assertions.
- Questions are asked using ASK & are called queries or goals.
- Axioms: - Provide basic factual info from which useful conclusion can be derived.
- Theorem: logical sentences of domain that are entailed by the axioms.



- List & set are also used in FOL.  
Difference list & set is that lists are ordered.  
& same elements can appear more than once in a list.
- Diagnostic rules: Diagnostic rules lead from observed effects to hidden causes. (If a pit is breezy, some adj. square must be having a pit (hidden cause))
- Causal Rules: Reflect the assumed direction of causality in the world: some hidden property of the world causes certain percepts to be generated. System that reason with causal based reasoning is called model based reasoning system.

## Knowledge Engineering in FOL

- Steps included are
  1. Identify the task
  2. Assemble the relevant knowledge
  3. Decide on a vocabulary of predicates, functions & constants
  4. Encode general knowledge about the domain
  5. Encode a desc<sup>n</sup> of the specific problem instance
  6. Pose queries to the inference-procedure & answers
  7. Debug the KB.
- Special purpose KB: Whose domain is carefully circumscribed & whose range of queries are known in advanced.
- General Purpose KB - which are intended to support queries across the full range of human KB.

## Artificial Intelligence Planning ~~cup~~ 11-1

- A task of coming up with a sequence of actions that will achieve a goal is called planning.
- An agent can be overwhelmed by irrelevant actions.
  - + has to be find good heuristic function
  - + is inefficient if it cannot take adv. of problem decomposition

- Ashish R. Gavande