SNS COLLEGE OF ENGINEERING

Kurumbapalayam(Po), Coimbatore – 641 107
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Department of AI &DS

Course Name – 23ADT201 ARTIFICIAL INTELLIGENCE

II Year / III Semester

UNIT 4

LOGICAL REASONING

Topic:FIRST ORDER LOGIC,SYNTAX AND SEMANTICS

Tesla’s Autopilot System: Tesla uses advanced logic-based systems to navigate autonomously. It applies rules similar to those described, ensuring compliance with traffic laws, safe interaction with pedestrians, and obstacle avoidance. This system continually updates its knowledge base to handle new driving situations effectively.

Drawbacks of Propositional Logic

- Propositional logic is very simple and declarative, in which knowledge and inference are separate, and inference is entirely domain independent
- Propositional logic has lack of data structure in programming.
- Propositional logic is not sufficient for complex or natural language sentences.
  - E.g. Some students in KEC are intelligent
- Propositional logic has very limited expressive power
  - E.g., cannot say "pits cause breezes in adjacent squares“ except by writing one sentence for each square

First Order Logic (FOL)

- First-order logic is also known as Predicate logic or First-order predicate logic.
- First-order logic, like natural language has well defined syntax and semantics.
- It assumes the world contains
  - Objects: people, houses, numbers, colors, baseball games, wars, …
  - Relations: red, round, prime, brother of, bigger than, part of, comes between, …
  - Functions: father of, best friend, one more than, plus, …

Properties of FOL

- It has ability to represent facts about some or all of the objects and relations in the universe
- Represent law and rules extracted from real world
- Useful language for Maths, Philosophy and AI
- Represent facts in realistic manner rather than just true / false
- Makes ontological commitment

Syntax of FOL: Basic Elements

- Constants — KingJohn, 2, NUS,...
- Predicates — Brother, >,...
- Functions — Sqrt, LeftLegOf, ...
- Variables — x, y, a, b,...
- Connectives — ¬, ∧, ∨, ⇒, ⇔
- Equality — =
- Quantifiers — ∀, ∃
- Sentences — Atom / complex sentences
- Atom — True / False / AP (atomic proposition)
- Complex sentence — (sentence) / connective sentence / ¬ sentence

Atomic sentences

- Atomic sentence = *predicate* ($term_1$,...,$term_n$) or $term_1$ = $term_2$
- Term = *function* ($term_1$,...,$term_n$) or *constant* or *variable*

- Example.
- *Brother(KingJohn,RichardTheLionheart)*
- *> (Length(LeftLegOf(Richard)), Length(LeftLegOf(KingJohn)))*

Complex sentences

- Complex sentences are made from atomic sentences using five logical connectives
- S1 and S2 are two atomic statements then
- $\neg S1$, $S_1 \wedge S_2$, $S_1 \vee S_2$, $S_1 \Rightarrow S_2$, $S_1 \Leftrightarrow S_2$,

E.g. *Sibling(KingJohn,Richard)* $\Leftrightarrow$ *Sibling(Richard,KingJohn)*

$>(1,2) \vee \leq (1,2)$

$>(1,2) \wedge \neg >(1,2)$

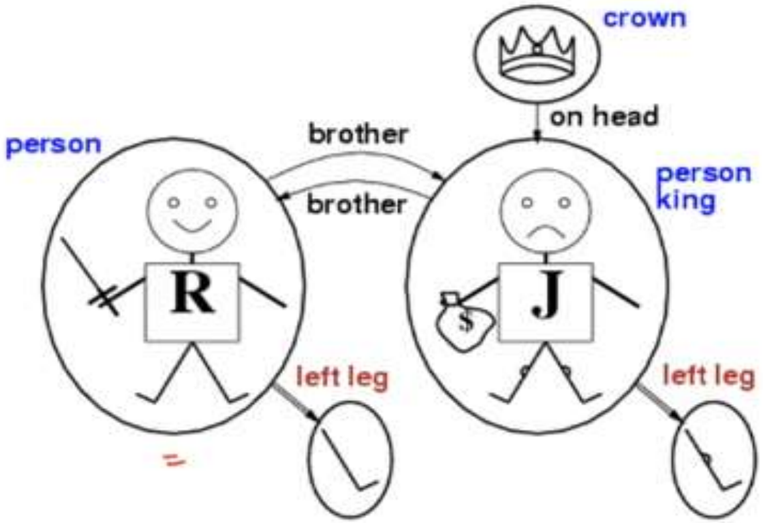
Truth in FOL

- Sentences are true with respect to a model and an interpretation
- Model contains objects (domain elements) and relations among them
- Interpretation specifies referents for
  - Constant Symbols → Objects
  - Predicate Symbols → Relations
  - Function Symbols → Functional relations
- An atomic sentence $predicate(term_1,\ldots,term_n)$ is true iff the objects referred by $term_1,\ldots,term_n$ are in the relation referred by *predicate*

Models for FOL: Example

- Richard the Lionheart was a King of England from 1189 to 1199;
- his younger brother was the evil King John, who ruled from 1199 to 1215;
- The left legs of Richard and John were different;
- and John had a crown (Because he was king).

Models for FOL: Example



- Objects :
  - Person king John
  - Person Richard
  - Crown
  - Left leg of John
  - Left leg of Richard
- Relation :
  - “onhead” <the crown, king John>
  - “brother” <John, Richard >
  - “person” <John>
  - “person” <Richard>
  - “king” <John>
- Function:
  - [no other person wears crown except the king]
  - <John the king> - on-head(crown)
  - <John the king> - shoe(left-leg)

THANK YOU