



SNS COLLEGE OF ENGINEERING



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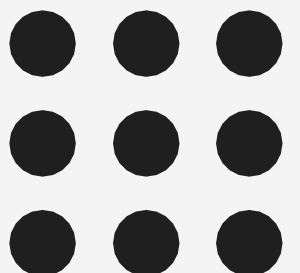
Course Name – 23ADT201 ARTIFICIAL
INTELLIGENCE

II Year / III Semester

UNIT 4

LOGICAL REASONING

Topic: Inferences in first-order logic





Inference in First Order Logic

- Inference in FOL is used to generate new sentences from existing sentences.
- **Definition:**
- An expression X logically follows from a set S , if every interpretation that satisfies S also satisfies X
- The function of logical inference is to produce **new sentence** that **logically follow** a given set of FOL sentence.



Universal Instantiation (UI) / Universal Elimination *✓ FOL rule -*

- UI says that we can infer (produce) any sentence obtained by substituting a **ground term** for the variable.
- we use the notion of **Substitutions** for these instantiations.
- Let **SUBST(θ, a)** denote the result of applying the **substitution θ** to the **sentence a**

$$\frac{\forall v a}{\text{SUBST}(\{v/g\}, a)}$$

for any variable v and ground term g .



Substitutions

- E.g., KB contains “all greedy kings are evil”
- $\forall x \text{ King}(x) \wedge \text{Greedy}(x) \Rightarrow \text{Evil}(x)$ yields (eliminate \forall)
- $\text{SUBST}(x/\text{John})$
- $\text{King}(\text{John}) \wedge \text{Greedy}(\text{John}) \Rightarrow \text{Evil}(\text{John})$
- $\text{SUBST}(x/\text{Richard})$
- $\text{King}(\text{Richard}) \wedge \text{Greedy}(\text{Richard}) \Rightarrow \text{Evil}(\text{Richard})$
- $\text{SUBST}(x/\text{Father}(\text{John}))$
- $\text{King}(\text{Father}(\text{John})) \wedge \text{Greedy}(\text{Father}(\text{John})) \Rightarrow \text{Evil}(\text{Father}(\text{John}))$

Existential Instantiation (EI) / Existential Elimination

- For any sentence a , variable v , and constant symbol k that does **not** appear elsewhere in the knowledge base:

$$\frac{\exists v a}{\text{SUBST}(\{v/k\}, a)}$$

- E.g., $\exists x \text{Crown}(x) \wedge \text{OnHead}(x, \text{John})$ yields: (eliminate \exists)

$$\text{Crown}(C_1) \wedge \text{OnHead}(C_1, \text{John})$$

- Skolem Constant
provided C_1 is a **new** constant symbol which is not in KB but satisfy all properties of 'x', called a **Skolem constant**
(skolemization – replacing variables with ground terms)



Reduction to Propositional Inference

Suppose the KB contains just the following:

$\forall x \text{ King}(x) \wedge \text{Greedy}(x) \Rightarrow \text{Evil}(x)$

$\text{King}(\text{John})$

$\text{Greedy}(\text{John})$

$\text{Brother}(\text{Richard}, \text{John})$

- Instantiating the universal sentence in **all possible ways**, we have:

$\text{King}(\text{John}) \wedge \text{Greedy}(\text{John}) \Rightarrow \text{Evil}(\text{John})$

$\text{King}(\text{Richard}) \wedge \text{Greedy}(\text{Richard}) \Rightarrow \text{Evil}(\text{Richard})$

$\text{King}(\text{John})$

$\text{Greedy}(\text{John})$

$\text{Brother}(\text{Richard}, \text{John})$

- The new KB is **Propositionalized**: proposition symbols are $\text{King}(\text{John})$, $\text{Greedy}(\text{John})$, $\text{Evil}(\text{John})$, $\text{King}(\text{Richard})$, etc.



Problems with Propositionalization

- Propositionalization seems to generate lots of irrelevant sentences.
- with function symbols, there are infinitely many ground terms,
 - e.g., $Father(Father(Father(John)))$



Inferences in first-order logic



THANK YOU