NLP

Introduction to NLP

Inference

Modus Ponens

- Modus ponens:

$$\frac{\begin{array}{l}\alpha \\ \alpha \Rightarrow \beta\end{array}}{\beta}$$

- Example:

Cat(Martin)

∀ x: Cat(x) ⇒ EatsFish(x)

EatsFish(Martin)

Inference

- Forward chaining
  - as individual facts are added to the database, all derived inferences are generated
- Backward chaining
  - starts from queries
  - Example: the Prolog programming language
- Prolog example
  - ```
    father(X, Y) :- parent(X, Y), male(X).
    parent(john, bill).
    parent(jane, bill).
    female(jane).
    male (john).
    ?- father(M, bill).
    ```
    ```

Examples

The kinship domain:

- Brothers are siblings

  $\forall x,y\ Brother(x,y) \Rightarrow Sibling(x,y)$

- One's mother is one's female parent

  $\forall m,c\ Mother(c) = m \Leftrightarrow (Female(m) \wedge Parent(m,c))$

- “Sibling” is symmetric

  $\forall x,y\ Sibling(x,y) \Leftrightarrow Sibling(y,x)$

Universal Instantiation

- Every instantiation of a universally quantified sentence is entailed by it:

$$\frac{\forall v\ \alpha}{\mathrm{Subst}(\{v/g\}, \alpha)}$$

for any variable *v* and ground term *g*

- E.g., $\forall x\ Cat(x) \wedge Fish(y) \Rightarrow Eats(x,y)$ yields:

  $Cat(Martin) \wedge \mathrm{Fish(Blub)}$

Existential Instantiation

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

$$\frac{\exists v\ \alpha}{\mathrm{Subst}(\{v/k\}, \alpha)}$$

- E.g., $\exists x\ Cat(x) \wedge EatsFish(x)$ yields:

$$Cat(C_1) \wedge EatsFish(C_1)$$

provided C_1 is a new constant symbol, called a Skolem constant

Unification

- If a substitution θ is available, unification is possible
- Examples:
  - p=Eats(x,y), q=Eats(x,Blub), possible if θ = {y/Blub}
  - p=Eats(Martin,y), q=Eats(x,Blub), possible if θ = {x,Martin,y/Blub}
  - p=Eats(Martin,y), q=Eats(y,Blub), fails because Martin≠Blub
- Subsumption
  - Unification works not only when two things are the same but also when one of them subsumes the other one
  - Example: All cats eat fish, Martin is a cat, Blub is a fish

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