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A.I. D.A (Theory)

1) Explain the concept of unification in FOL with the help of an example

Ans) Unification is a process of making two different logical atomic expressions identical by finding a substitution. Unification depends on the substitution process.
It takes two literals as input and makes them identical using substitution.
Let Ψ_1 and Ψ_2 be two atomic sentences such that $\Psi_1 \sigma = \Psi_2 \sigma$, then it can be expressed as UNIFY(Ψ_1, Ψ_2).

Example :

Find the most general unifier of $\{p(b, x, f(g(z)))$ and $p(z, f(y), f(y))\}$?

~~Here~~
Here,

$$\Psi_1 = p(b, x, f(g(z)))$$

and

$$\Psi_2 = p(z, f(y), f(y))$$

$S_0 \Rightarrow \{ p(b, x, f(g(z))) \;;\; p(z, f(y), f(y)) \}$

SUBST $\theta = \{ b/z \}$

$S_1 \Rightarrow \{ p(b, x, f(g(b))) \;;\; p(b, f(y), f(y)) \}$

SUBST $\theta = \{ f(y) / x \}$

$S_2 \Rightarrow \{ p(b, f(y), f(g(b))) \;;\; p(b, f(y), f(y)) \}$

SUBST $\theta = \{ g(b)/y \}$

$S_2 \Rightarrow \{ p(b, f(g(b)), f(g(b))), f(g(b))) \}$

UNIFIED SUCESSFULLY

UNIFIER $\Rightarrow$ $\{ b/z, f(y)/x, g(b)/y \}$

2) Demonstrate the conversion of FOL formula to CNF with the help of an example.

Ans) Knowledge Base

(1) John likes all kind of foods
(2) Apple and vegetables are food.
(3) Anything anyone eats and not killed is food
(4) Anil eats peanuts and still alive
(5) Harry eats everything that Anil Eats.
(6) John likes peanuts.

* Converting the ~~FOL~~ facts above to CNF, we follow the following steps.

STEP 1

Facts to FOL

(1) $\forall x : food(x) \longrightarrow likes(John, x)$
(2) $food(Apple) \wedge food(vegetables)$
(3) $\forall x \forall y : eats(x, y) \wedge \sim killed(x) \longrightarrow food(y)$
(4) $eats(Anil, Peanuts) \wedge alive(Anil)$
(5) $\forall x : eats(Anil, x) \longrightarrow eats(Harry, x)$
(6) $\forall x : \sim killed(x) \rightarrow alive(x)$
(7) $\forall x : alive(x) \rightarrow \sim killed(x)$
(8) $likes(John, Peanuts)$

STEP 2

FOL to CNF

→ Eliminate all implication & rewrite

(1) $\forall x \sim food(x) \vee likes(John, x)$
(2) $food(Apple) \wedge food(vegetables)$
(3) $\forall x \forall y \sim [eats(x, y) \wedge \sim killed(x)] \vee food(y)$
(4) $eats(Anil, Peanuts) \wedge alive(Anil)$
(5) $\forall x \sim eats(Anil, x) \vee eats(Harry, x)$
(6) $\forall x \sim [\sim killed(x)] \vee alive(x)$
(7) $\forall x \sim alive(x) \vee \sim killed(x)$
(8) $likes(John, Peanuts)$

→ Move negation inwards & rewrite

(1) $\forall x \sim food(x) \vee likes(John, x)$
(2) $food(Apple) \wedge food(vegetables)$
(3) $\forall x \forall y \sim eats(x, y) \vee killed(x) \vee food(y)$
(4) $eats(Anil, Peanuts) \wedge alive(Anil)$
(5) $\forall x \sim eats(Anil, x) \vee eats(Harry, x)$
(6) $\forall x \sim killed(x)] \vee alive(x)$
(7) $\forall x \sim alive(x) \vee \sim killed(x)$
(8) $likes(John, Peanuts)$

→ Rename / Standardize Variables.

(1) $\forall x \sim food(x) \vee likes(John, x)$
(2) $food(Apple) \wedge food(vegetables)$
(3) $\forall y \forall z \sim eats(y, z) \vee killed(y) \vee food(z)$
(4) $eats(Anil, Peanuts) \wedge alive(Anil)$
(5) $\forall w \sim eats(Anil, w) \vee eats(Harry, w)$
(6) $\forall g \sim killed(g)] \vee alive(g)$
(7) $\forall k \sim alive(k) \vee \sim killed(k)$
(8) $likes(John, Peanuts)$

→ Eliminate existential instantiation quantifier by elimination and Drop Universal quantifiers to get CNF.

(1) $\sim food(x) \vee likes(John, x)$
(2) $food(Apple)$
(3) $food(Vegetables)$
(4) $\sim eats(y, z) \vee killed(y) \vee food(z)$ ⇒ CNF obtained
(5) $eats(Anil, Peanuts)$
(6) $alive(Anil)$
(7) $\sim eats(Anil, w) \vee eats(Harry, w)$
(8) $killed(g) \vee alive(g)$
(9) $\sim alive(k) \vee \sim killed(k)$
(10) $likes(John, Peanuts)$

Q3) Explain resolution in FOL with an appropriate example.

Ans) Resolution is a theorem proving technique that proceeds by building refutation proof, ie, proofs by contradiction.

Resolution is used, if there are various statements given, and we need to prove a conclusion of those statements. Unification is a key concept in proofs by resolution. Resolution is a single inference rule which can efficiently operate on the conjunctive normal form or clausal form.

Example:

Consider the following Knowledge Base

1. The humidity is high or the sky is cloudy.
2. If the sky is cloudy, then it will rain
3. If the humidity is high, then it is hot
4. It is not hot.

Goal: It will rain.

P : Humidity is high
Q : Sky is cloudy

$$\boxed{1. \quad P \vee Q}$$

R : It will rain

$$\boxed{2. \quad Q \rightarrow R}$$

S : It is hot

$$\boxed{3. \quad P \rightarrow S}$$

$$\boxed{4. \quad \sim S}$$

Applying resolution method :

In (2) $Q \rightarrow R$ will be $(\sim Q \vee R)$
In (3) $P \rightarrow S$ will be $(\sim P \vee S)$

Negation of goal $(\sim R)$: It will not rain

Finally, applying the rule as shown below:

$P \vee Q$ $\quad$ $\sim Q \vee R$

$P \vee R$ $\quad$ $\sim P \vee S$

$R \vee S$ $\quad$ $\sim S$

R $\quad$ $\sim R$

ϕ (Null)

After applying Proof by Refutation (Contradiction) on the goal, the problem is solved, and it has terminated will a Null Clause. Hence goal is achieved.

Q4) Write short notes on Reinforcement Learning.

Ans) Reinforcement Learning is area of machine learning. It is about taking suitable action to maximize reward in a particular situation. It is employed by various software and machines to find the best possible behaviours or path it should take in a specific situation.

In reinforcement learning, the agent decides what to do to perform a given task. In the absence of a training data set, it is bound to learn ~~for~~ from experience.

~~Example of reinforcement learning would be the WAMPUS problem.~~

Example of reinforcement learning would be the game of CHESS.

Main components of reinforcement learning are:

(i) Input : The input should be an initial state from which the model will start

(ii) Output : There are many possible output as there are variety of solution to a particular problem

(iii) Training : The training is based on the input, the model will return a state and the user will decide to reward or punish the model based on its output

(iv) The model continuously learns

(v) The best solution is decided based on the maximum reward.