Week 9 FOL Resolution

* Create a knowledge base consisting of first order logic statements and prove the given query using Resolution.

Basic steps for proving conclusion S given premises

Premise$_1$, ... Premise$_n$
(all expressed in FOL).

1. Convert all sentences to CNF
2. Negate conclusion S & convert result to CNF.
3. Add negated conclusion S to the premise clauses.
4. Repeat until contradiction or no progress is made:
   a. Select 2 clauses (call them parent clauses)
   b. Resolve them together, performing all required unifications.
   c. If resolvent is the empty clause, a contradiction has been found (i.e., S follows from the premises)
   d. If not, add resolvent to the premises.

If we succeed in Step 4, we have proved the conclusion.

Given KB or premises:

a John likes all kind of food
b Apple and vegetables are food
c Anything anyone eats ~~and~~ not killed is food.
d Anil ~~eats~~ peanuts and still alive.
e Harry eats everything that Anil eats.
f Anyone who is alive implies not killed.
g Anyone who is not killed implies alive.
h. John like peanuts.

h has to be proved.

Representation in FOL

a. $\forall x: food(x) \rightarrow likes(John, x)$
b. ~~Food(x) ∧ food~~ $food(Apple) \wedge food(vegetables)$
c. $\forall x \forall y: eats(x,y) \wedge \neg killed(x) \rightarrow food(y)$
d. $eats(Anil, Peanuts) \wedge alive(Anil)$
e. $\forall x: eats(Anil, x) \rightarrow eats(Harry, x)$
f. $\forall x: \neg killed(x) \rightarrow alive(x)$
g. $\forall x: Alive(x) \rightarrow \neg killed(x)$
h. $likes(John, Peanuts)$

Eliminate implication: (b, d, h dont have any implications) and are already in CNF
$\alpha \Rightarrow \beta$ with $\neg\alpha \vee \beta$

a. $\forall x \neg food(x) \vee likes(John, x)$
c. $\forall x \forall y \neg[eats(x,y) \wedge \neg killed(x)] \vee food(y)$
e $\forall x \neg eats(Anil, x) \vee eats(Harry, x)$
f $\forall x \neg[\neg killed(x)] \vee alive(x)$
g $\forall x \neg alive(x) \vee \neg killed(x)$

Move Negation inwards

a. $\forall x: \neg food(x) \vee likes(John, x)$
c. $\forall x \forall y: \neg eats(x,y)$ ~~∀~~ $killed(x) \vee food(y)$
e. $\forall x: \neg eats(Anil, x) \vee eats(Harry, x)$
f. $\forall x: \neg alive(x) \vee \neg killed(x)$
g. $\forall x: killed(x) \vee alive(x)$

Rename variables ~~with~~ or standardize variables.

a. $\forall x \neg food(x) \vee likes(John, x)$
b. $food(Apple) \wedge food(vegetables)$
c. $\forall y \forall z: \neg eats(y,z)$ ~~∀~~ $killed(y) \vee food(z)$

d. $eats(Anil, Peanuts) \land alive(Anil)$

e. $\forall w : \neg eats(Anil, w) \lor eats(Harry, w)$

f. $\forall k : \neg alive(k) \lor \neg killed(k)$

g. $\forall q : killed(q) \lor alive(q)$

h. $likes(John, Peanuts)$

<u>Drop Universal Quantifier.</u>

a. $\neg food(x) \lor likes(John, x)$

b. $food(Apple) \land food(vegetables)$ — $food(Apple)$, $food(vegetables)$

c. $\neg eats(y, z) \lor killed(y) \lor food(z)$

d. $eats(Anil, Peanuts) \land alive(Anil)$ — $eats(Anil, Peanuts)$, $Alive(Anil)$

e. $\neg eats(Anil, w) \lor eats(Harry, w)$

f. $killed(q) \lor alive(q)$

g. $\neg alive(k) \lor \neg killed(k)$

h. $likes(John, Peanuts)$

<u>For Proof, Negate the conclusion i.e, $\neg h$</u>

$\neg h$ $\neg likes(John, Peanuts)$

Proof by Resolution.

$\neg$ likes (John, Peanuts) $\qquad$ $\neg$ food(x) V likes (John, x)

{Peanuts/x}

$\neg$ food (Peanuts) $\qquad$ $\neg$ eats(y, z) V killed(y) V food(z)

{peanuts/z}

$\neg$ eats(y, A) V killed(y) $\qquad$ eats (Anil, Peanuts)

Peanuts

{Anil/y}

killed (Anil) $\qquad$ $\neg$ alive(k) V $\neg$ killed(k)

{Anil/k}

$\neg$ alive (Anil) $\qquad$ alive (Anil)

{ }

Hence proved that
John likes Peanuts.

03-12