CSE 4308 / CSE 5360 - *Artificial Intelligence I*

Homework 3- Fall 2013

Due Date: Oct. 15 2013, 12:30 pm

Problems marked with a * are required only for students in the graduate section (CSE 5360). They will be graded for extra credit for students of CSE 4308.

Propositional Logic

1. Translate the following facts into propositional logic sentences. Make sure you list all the propositions and their meanings.

   a) Insects have six legs.

   b) If insects had eight legs they would be related to spiders.

   c) Animals that are related to Spiders are also related to Scorpions.

   d) If insects are six legged animals then they are not related to scorpions.

2. Show that the following sentences follow from the given knowledge base using equivalence and inference rule. (Give all the steps of your proof and indicate what rule you used).

   $KB:$ $P \wedge Q$

           $P \Rightarrow (R \vee S)$

           $(A \vee Q) \Rightarrow (P \Rightarrow S)$

           $\neg((A \wedge S) \vee (A \wedge P)) \vee (Q \wedge R)$

           $A \vee (\neg P \wedge \neg Q)$

           $TRUE \Rightarrow (A \wedge (P \Rightarrow Q))$

           $V \vee \neg P \vee \neg U$

   a) $P \wedge A$

   b) $V \Rightarrow S$

   c)* $TRUE \Rightarrow Q$

   d)* $(Q \wedge U) \Rightarrow V$

First-order Logic

3. Translate the following facts into sentences in first-order logic.

   a) Dogs and cats eat meat.

   b) Every bottle that is filled contains liquid.

   c) Since Jim and Jack take the same classes, Jack works on the same assignments as Jim.

   d) If Mary is John's daughter then Mary is younger than John.

4. Determine for each of the following pairs of sentences if they can be unified and if they can, give the most general unifier.

   a) $(Aunt(x, y) \land \neg Man(x) \lor Uncle(x, y))$
      $(Aunt(Mary, z) \lor \neg Man(John) \lor Uncle(v, z))$

   b) $((Father(x, Jack) \land Mother(y, Jack)) \Rightarrow Married(x, y))$
      $((Father(y, z) \land Mother(Mary, z)) \Rightarrow Married(y, Mary))$

   c) $((Son(x, x) \land Sister(Mary, Jack)) \Rightarrow (Daughter(x, Mary) \land Brother(Jack, Mary)))$
      $((Son(Jack, x) \land Sister(z, x)) \Rightarrow (Daughter(z, f(x)) \land Brother(y, z)))$

   d) $((Married(x, y) \land Father(x, Mary)) \Rightarrow Man(x))$
      $((Married(z, f(Jack)) \lor Father(z, v)) \Rightarrow Man(z))$

5. Transform the following sentences into conjunctive normal form.

   a) $P(John) \Rightarrow \exists x(Q(x) \land R(John, x))$

   b) $\forall x(\exists y(P(x) \land \neg Q(x, y) \land R(y))) \Rightarrow \forall y \neg S(x, y))$

   c) $\neg(\exists x \forall y(P(x) \Rightarrow \forall y Q(y)) \land \forall z R(z))$

   d)* $\exists x(\neg \forall y(P(x, y) \Rightarrow Q(x)) \land \forall y(R(y) \Rightarrow \exists z P(y, z)))$

6. Use resolution with refutation to show that the following queries can be inferred from the given knowledge base. At each resolution step also indicate the corresponding unifier.

   $KB:$ $Father(John, Jack)$

   $Married(John, Jane)$

   $Man(Jack)$

   $Father(x_1, y_1) \Rightarrow Man(x_1)$

   $Mother(x_2, y_2) \Rightarrow Woman(x_2)$

   $Married(x_3, y_3) \wedge Father(x_3, z_3) \Rightarrow Mother(y_3, z_3)$

   $Father(x_4, y_4) \wedge Mother(z_4, y_4) \Rightarrow Married(x_4, z_4) \vee Divorced(x_4)$

   $Divorced(John) \Rightarrow False$

   $Mother(Mary, Jack)$

   $Married(x_5, y_5) \wedge Son(z_5, x_5) \Rightarrow Son(z_5, y_5)$

   $Father(x_6, y_6) \wedge Man(y_6) \Rightarrow Son(y_6, x_6)$

   a) $Married(John, Mary)$

   b) $Woman(Mary) \wedge Woman(Jane)$

   c)* $Son(Jack, Mary) \wedge Son(Jack, Jane)$

7. Translate the knowledge base of problem 6 into a formula list for *Prover9* (a common theorem prover) and use it to perform a proof by refutation of the following queries. You can download and install *Prover9* and access on-line documentation at *http://www.cs.unm.edu/~mccune/prover9*. To install it on omega, download the Linux code and compile it using the given instructions. The install directory will also contain examples (additional ones can be found on the web site). For each proof, include a printout of the output of *Prover9*.

   a) $Woman(Mary) \wedge Son(Jack, Mary)$

   b) $Married(John, Mary) \wedge Married(John, Jane)$

   c)* $\forall x (Married(John, x) \Rightarrow Mother(x, Jack))$

   d)* $Son(Jack, Jane) \vee \neg Married(John, Jane)$