CSCE476/876 **Spring 2010**

Homework 8

Assigned on: Monday April 5, 2010.

Due: Friday April 16, 2010.

This is a pen-and-paper homework, to be returned in class or with web handin.
The homework is worth 111 points for ugrads and 127 points for grads (+41 bonus points for ugrads and +25 bonus points for grads).

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1. **Bonus** *Researching Description Logic* **(Bonus 25 points)**
   Description Logic is a cornerstone of the Semantic Web technology. In this question, you are asked to research Description Logic *beyond what is in your textbook*. Write a two-page (typed) structured summary about DL addressing whatever aspects you find meaningful and interesting. Below is a list of ideas *you may want to include*, they are mere suggestions. Make sure you cite all your references.

   (a) What is the goal of DL?

   (b) To the extent possible, explain/state the syntax and semantics of DL.

   (c) How does DL relate to other types of Logic that we may or may not have studies?

   (d) Explain some proof techniques used for DL and give their complexity.

   (e) Briefly describe the history/evolution of DL.

   (f) Discuss and compare various implementations of DL.

   (g) Investigate the industrial impact of DL: list practical systems implements some version of DL; are they public domain; have they generated economic growth/benefit, etc.

2. *Algorithms for Propositional Logic*
   (Mandatory for grad, bonus for ugrads 16 points)

   Consider the following algorithms:

   (a) TT-ENTAILS?, AIMA Figure 7.10 page 248.

   (b) PL-RESOLUTION, AIMA Figure 7.12 page 255.

   (c) PL-FC-ENTAILS?, AIMA Figure 7.15 page 258.

   (d) DPLL-SATISFIABLE?, AIMA Figure 7.17 page 261.

   (e) WALKSAT, AIMA Figure 7.18 page 263.

   For each of the above algorithms, carefully study the algorithm and explain how it operates (e.g., clearly stating the input, the representation on which it operates, when and the algorithm stops, what mechanism the algorithm implements for example by relating it to a known theorem. (4 points for each algorithm)

3. *Using the inference rules for logic* **(10 points)**
prove that "$\exists x Z(x)$ follows from the givens." Be sure to justify your steps by stating the inference rule used, along with the previous line(s) to which it was applied and the unifications used.

(a)	$P(1)$	given
(b)	$W(1) \wedge W(2) \wedge W(3)$	given
(c)	$\forall x[P(x) \Rightarrow \neg R(x)]$	given
(d)	$\forall x[Q(x) \vee R(x)]$	given
(e)	$\forall x[(Q(x) \wedge W(x)) \Rightarrow Z(x)]$	given

4. AIMA 8.4, page 315. **(2 points)**

5. AIMA 8.9, page 316. **(19 points)**

6. AIMA 8.24, page 319. **(12 points)**

7. *Axioms in FOL (Adapted from AIMA, first edition)* **(15 points)**

   Using the following:
   `Child(x,y)`, `Sibling(x,y)`, `Female(x)`, `Male(x)`, and `Spouse (x, y)`:

   - (10 points) Write axioms describing the predicates: `GrandChild`, `GreatGrandParent`, `Brother`, `Sister`, `Daughter`, `Son`, `Aunt`, `Uncle`, `BrotherInLaw`, `SisterInLaw`, and `FirstCousin`. We want these axioms to be definitions, so use $\Leftrightarrow$ instead of $\Rightarrow$.
   - (5 points) Knowing that a second cousin is a child of one's parent first cousin, write the definition of a N^{th}`-cousin`, as a recursive expression in terms of the predicates defined above. Hint: Let N^{th}`-cousin` be a ternary predicate, that takes as input n, and two persons p_1 and p_2.

8. AIMA 9.3, page 361. **(3 points)**

9. AIMA 9.4, page 361. **(4 points)**

10. AIMA 9.6, page 361. **(12 points)**

11. AIMA 9.13, page 363. **(12 points)**

    For question (d), it is useful to check the following reference: Smith, D.E., Genesereth, M.R., and Ginsberg, M.L. (1986). *Controlling recursive inference.* Artificial Intelligence, Volume 30 (3), pages 343–389. (Page 1036, AIMA2e)

12. First-Order Logic **(20 points)**

    Consider the following axioms:

    (a) Anyone who rides any Harley is a rough character.

(b) Every biker rides [something that is] either a Harley or a BMW.

(c) Anyone who rides any BMW is a yuppie.

(d) Every yuppie is a lawyer.

(e) Any nice girl does not date anyone who is a rough character.

(f) Mary is a nice girl, and John is a biker.

(g) (Conclusion) If John is not a lawyer, then Mary does not date John.

- Choose appropriate predicates to write the above axioms in first-order logic, clearly indicating the arguments and arity of each predicate: (2 points)
- Write each of the above axioms in first-order logic. Use scratch paper if necessary, and *neatly* report your results below. (10 points)

  (a)

  (b)

  (c)

  (d)

  (e)

  (f)

  (g)

- Transform each of the above sentences into a conjunctive normal form. Clearly state the Skolem functions and clearly number the statements. (4 points)
- Establish the conclusion using the axioms by applying refutation resolution. Clearly show the variable bindings at each step and clearly number the statements. (4 points)

  Negation of conclusion: