CS472 Foundations of Artificial Intelligence
Fall 2000
Assignment 3

Due Monday, October 23 at the beginning of class.

Collaboration: You are allowed to work in groups of 2-4 students for this assignment. Collaboration between groups is not allowed. Working alone is fine. In all cases, you must write up the solutions yourself; no collaboration is allowed for the write-up.

1. **Representing Sentences in First-Order Logic (35 pts.)**

   Express each of the following things in first-order logic, using a consistent vocabulary which you must define. As an example of the level of detail expected, here is how "In all CS472 classes there is a student who has not finished the assignment" might be expressed:

   $$\forall x \exists z : \mathit{CS472Class}(x) \ \wedge \ \mathit{assignmentForClass}(z, x) \ \rightarrow$$
   $$\exists y \mathit{student}(y) \ \wedge \ \mathit{inClass}(y, x) \ \wedge \ \neg \mathit{finishedAssignment}(y, z)$$

   where $\mathit{CS472Class}(x)$ means 'x is a CS472 class', $\mathit{assignmentForClass}(x, y)$ means 'x is an assignment for class y', $\mathit{student}(x)$ means 'x is a student', $\mathit{inClass}(x, y)$ means 'x is in class y', and $\mathit{finishedAssignment}(x, y)$ means 'x has finished assignment y'.

   (a) Fred did something to annoy Wilma.

   (b) If you push anything hard enough, it will fall over.

   (c) If I'm ugly, then you're a monkey's uncle.

   (d) It takes two to start a fight.

   (e) Every person who dislikes all vegetarians is stupid.

   (f) No person likes a smart vegetarian.

   (g) There is a barber who shaves all men in town who do not shave themselves.

2. **Unification (20 pts.)**

   Compute the most general unifier (mgu) of p and q in each of the following situations, or say why no mgu exists. Simplify your substitutions: $\{y/A, x/A\}$ is better than $\{y/x, x/A\}$ from a computational point of view. (You should look at the unification algorithm on p. 303 of R & N; in particular, make sure you understand the "occur-check".)

   (a) $p = r(f(x, x), A)$ and $q = r(f(y, f(y, A)), A)$

   (b) $p = f(g(v), h(u, v))$ and $q = f(g(w), h(w, j(x, y)))$

   (c) $p = f(g(v), h(u, v))$ and $q = f(g(w), h(w, j(x, u)))$

   (d) $p = f(x, f(u, x))$ and $q = f(f(y, A), f(z, f(B, z)))$

3. **Clausal Form (20 pts.)**

   Convert each of the following to clausal form.

   (a) $\forall x : [P(x) \rightarrow P(x)]$

   (b) $\neg[\forall x : P(x)] \rightarrow [\exists x : \neg P(x)]$

   (c) $\neg\forall x : (P(x) \rightarrow \forall y : [P(x) \rightarrow P(f(x,y))] \wedge \neg\forall y : [Q(x,y) \rightarrow P(y)])$

   (d) $\forall x \exists y : ([P(x,y) \rightarrow Q(y,x)] \wedge [Q(y,x) \rightarrow S(x,y)]) \rightarrow \exists x \forall y : [P(x,y) \rightarrow S(x,y)]$

4. **Modes of Inference (40 pts.)**

   (a) Give three everyday examples of each of the following:

      i. Deductive inference ($A \rightarrow B$, given A conclude B)

      ii. Abductive inference ($A \rightarrow B$, given B conclude A)

      iii. Plausible inference in social interactions (e.g., if A secretly loves B and C criticizes B, then A will be mad at C.)

   (b) It's not always clear what determines the credibility of these kinds of inferences: credibility isn't always guaranteed by the inference method itself, and may depend on other factors. For each of the three kinds of inferences in part (a), say whether the method guarantees credibility and, if not, what factors make the inference more or less credible. For the inference methods that do not themselves guarantee credibility, illustrate the factors that determine credibility by giving one example of a credible inference and one example of a not-so-credible inference. (Be sure to discuss the factors that determine the credibility of this *kind* of inference in general, not only for the specific illustrating examples.)

What to turn in: You'll have to turn in BOTH a paper and an electronic copy of the assignment.

- **On paper:** All assignments for this course must be typewritten. (Those portions of any assignment that are easier to draw by hand can be drawn in by hand.) For this assignment, turn in the answers to each question separately. (We'll have separate boxes in which to deposit your assignment: one box for solutions to question 1, one box for solutions to question 2, etc.) At the top of the first page of the solution for each question, include (1) your name, (2) your e-mail address, and (3) an alphabetically ordered list of everyone in your homework group.

- **Electronic:** To protect you in the unlikely case that your homework is lost after you turn it in, we also require that you submit an electronic copy of your work (by the date and time shown above).

  1. Create a single ZIP file that contains all of the files connected with your homework solution. If you have only one file, please still create a ZIP file for it anyway (because the default transfer mode for the ftp server is binary). Unix users can use *tar* and *gzip*.
  2. Name your file with your e-mail address followed by an underscore and the assignment number. The final filename extension will be either ZIP or *gz* depending on what you did in step 1. So aaa999@cornell.edu_1.ZIP or aaa999@cornell.edu_1.tar.gz would be two possible filenames for this assignment.

3. Next, FTP the file to "playpen.cs.cornell.edu" with username "cs472" and password "deepblue". Note that this directory provides write-only, no-overwrite access. This means that you get to upload exactly one version of your assignment.

Please see the course web site for more details on electronic submission and for instructions for what to do if you need to submit a revised version of the assignment.