CS472 Foundations of Artificial Intelligence
Fall 2000 Assignment 4

Due Monday, November 6 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 to the problem set yourself; no collaboration is allowed for the write-up. The last part of this assignment involves programming, full instructions for which are available at the web site. **As noted below, only one member of the group should turn in the programming portion for the group.**

1. **Situation Calculus (15 Points)** Using the Situation Calculus as described in R&N beginning on p. 204 you are to formalize the blocks world domain. The objects in this domain are blocks, tables, and situations. The predicates are:

   On(x,y,s) ClearTop(x,s) Block(x) Table(x)

   The only action is PutOn(x,y) where x must be a block whose top is clear of other blocks, and y is either the table or a different block with a clear top.

   (a) (2 pts) Write an axiom or axioms describing the action PutOn.

   (b) (2 pts) Describe the initial state S_0 where two blocks A, B are on the table T, and a third block C is on top of A.

   (c) (2 pts) Generate a query to a theorem prover that will generate a plan to create a three-block stack where C is on top of B, and B is on top of A.

   (d) (4 pts) Give a plan generated by the query above.

   (e) (5 pts) Show formally that the plan above follows from the situation S_0 and the axiom(s) for PutOn.

2. **Knowledge Base Design (40 Points)**

   (a) Design a knowledge base to capture, in logical form, the knowledge of the following sentence in order to answer a series of questions about it.

   > Yesterday John went to the Lansing Tops and bought two pounds of potatoes and a steak.

   The sentences in the knowledge base should have a straightforward logical structure (e.g. statements that objects have certain properties, that objects are related in a certain way, that all objects satisfying one property also satisfy another, etc.). Hint: Consider the following when designing your knowledge base:

   - What classes, individuals, relations, and so on would you need? (You will need events and temporal ordering, among other things.)
   - Where does everything fit in a more general hierarchy?

- What are the constraints and interrelationships among them?
- How detailed must you be about each of the various concepts?

The knowledge base that you construct must be capable of answering a list of questions given below. Not every question deals with information explicitly stated in the sentence above. As a result, you will have to add to the knowledge base enough background knowledge to answer the questions. Try to make your representation be as general as possible: e.g. don't say "People buy food from Tops." because that doesn't help with people who shop at other supermarkets; don't say "Joe made stew with his steak and potatoes," because that doesn't generalize to anything else; and don't turn the questions into answers. Many of the additional assertions may be only approximately correct in reality, but the idea is to extract the common sense that lets a person answer the questions at all.

(b) Sketch the chains of reasoning that would be necessary to answer each of the following questions based on your knowledge base from part (a).

- Does John have money before going to the supermarket? [Yes]
- Does John have less money after going to the supermarket? [Yes]
- What does John plan to do with the potatoes? [Eat them]
- Did John buy any meat? [Yes]
- Is John a vegan? [No]
- Did John see anyone in the supermarket? [Yes]
- Does Tops sell toothpaste? [Yes]
- Is John a child or is he an adult? [An adult]

3. **Planning (25 Points)** Consider a version of the milk/bananas/drill shopping problem described in chapter 11 in R &N and in class.

   (a) (2 pts) Modify the description of the *Buy* action (p. 350) so that the agent needs to have a credit card to buy anyting.

   (b) (2 pts) Write a *PickUp* operator that enables the agent to *Have* an object if it is portable and at the same location as the agent.

   (c) (10 pts) Assume that CC is a credit card which is at home but *Have*(CC) is initially false. Construct a partially ordered plan that achieves the goal state from the initial state both of which are described on p. 341 of R &N.

   (d) (11 pts) Explain in detail what will happen during the planning process when the agent explores a partial plan in which it leaves home with out a credit card.

4. **Planning - Shakey's World (30 Points)** Shakey's World is described in R&N pp. 360 - 362.

   (a) (12 pts) Translate Shakey's six actions into STRIPS format.

   (b) (10 pts) Manually construct a plan for Shakey to get Box2 into Room2 from the starting configuration in Figure 11.5 on p. 361.

(c) (8 pts) Suppose Shakey has n boxes in a room and needs to move them all into another room. What is the complexity of the planning process in terms of n? Explain.

5. **Knowledge-Based Agent Design (100 Points)** This is the (Java) programming portion of the assignment. You will design agents to play capture-the-flag. Your agents will compete against the agents of other groups in the class and against agents designed by one of the TAs (Jason). Downloadable code, a description of the game, sample agents, a demo, and a description of what to turn in are available from the course web site. As noted at the top of this handout, each group should turn in only ONE version of this part of the assignment (in the format described at the web site).