CSIS0270 Artificial Intelligence, 2003–2004
Assignment 4
Exercise, no need to handin

1. *(Representation of Planning problems)* In STRIPS, we only allow positive literals in preconditions of actions, in state description, and in goals. Also, the close world assumption holds, i.e., if something is not known to be true, it is assumed to be false.

   a. Explain how one can mechanically convert a planning problem with negated literals and open-world assumption to STRIPS. Illustrate this by converting the tire domain to STRIPS mechanically.

   b. When working on First-Order logic inference, we say that Horn clauses are clauses with at most one positive literal. But with the conversion in part (a), we can convert any clause to take exactly one positive literal. Why the expressive power of Horn clause is still weaker than that of full CNF? Why such problem does not exist in planning?

2. *(Planning languages, Adapted from textbook 11.4)* The monkey-and-banana problem is faced by a monkey in a laboratory with some bananas hanging out of reach from the ceiling. A box is available that will enable the monkey to reach the bananas if he climbs on it. Initially, the monkey is at A, the bananas at B, and the box at C. The monkey and box have height *Low*, but if the monkey climbs onto the box he will have height *High*, the same as the bananas. The actions available to the monkey include *Go* from one place to another, *Push* an object from one place to another, *ClimbUp* onto or *ClimbDown* from an object, and *Grasp* and *Ungrasp* an object. Grasping results in holding the object if the monkey and object are in the same place at the same height.

   a. Write down the initial state description.

   b. Write down STRIPS-style definition of the six actions.

   c. Suppose the monkey wants to fool the scientists, who are off to tea, by grabbing the bananas, but leaving the box in its original place. Specify the goal in the STRIPS language.

   d. Using ADL notations, modify the initial state description in part (a) and the actions in part (b) to allow for the possibility that an object is too heavy for push, and at such cases the *Push* operator should do nothing.

3. *(Planning Graphs)* There are two primary relaxations done when constructing the planning graph: that “mutexes” we consider concerns only two propositions, and that we will not allow mutexes to be “added” or proposition to be “removed” in a step. For each of the two relaxations, give an example problem and draw the corresponding planning graph completely, to show how the number of steps predicted by the planning graph is less than the actual number of steps.

4. *(Inferences in belief networks, Adapted from textbook 14.2)* In your local nuclear power station, there is an alarm that senses when a temperature gauge exceeds a given threshold. The gauge measures the temperature of the core. Consider the Boolean variables A (alarm sounds), F_A (alarm is faulty), and F_G (gauge is faulty) and the multivalued nodes G (gauge reading) and T (actual core temperature).

   a. Draw a belief network for this domain, given that the gauge is more likely to fail when the core temperature gets too high.

b. Suppose there are just two possible actual and measured temperatures, normal and high; the probability that the gauge gives the correct temperature is x when it is working, but y when it is faulty. Give the conditional probability table associated with G.

c. Suppose the alarm works correctly unless it is faulty, in which case it never sounds. Give the conditional probability table associated with A.

d. Suppose the alarm and gauge are working and the alarm sounds. By enumeriation, calculate an expression for the probability that the temperature of the core is too high, in terms of the various conditional probabilities in the network.

e. Give the procedure if variable elimination is used for the computation.

5. *(Clustering)* In the last question, the network is not a polytree.

a. Convert it into a polytree by merging two nodes.

b. Suppose you need to perform inference in the polytree network. Explain how you can compute the probability that the gauge is faulty, given that the alarm does not sound.

6. *(Conditional Independences in belief networks)* Suppose a belief network has variables X_1, $\ldots, X_n$, in top-to-bottom ordering (i.e., X_i is not a decendent of X_j for all $i < j$). In the lecture, we show why we believe $\mathbf{P}(X_i \mid Parents(X_i)) = \mathbf{P}(X_i \mid Prec(X_i))$, where $Parents(X)$ is the set of parents of X, and $Prec(X_i)$ is set containing $X_1, X_2, \ldots, X_{i-1}$. Use basic axioms and theorems of probabilities and conditional probabilities to answer the following questions:

a. Explain why this implies X_i is independent of any subset S of $Prec(X_i) \setminus Parents(X_i)$ given $Parents(X_i)$, i.e., $\mathbf{P}(X_i \mid S, Parents(X_i)) = \mathbf{P}(X_i \mid Parents(X_i))$.

b. Suppose X has only one child, Y, and in converse, Y has only one parent, X. Let S denotes the set of all descendents of Y and their ancestors, except those through Y. Show that if S does not include any ancestor of X, then $\mathbf{P}(X \mid Y) = \mathbf{P}(X \mid Y, S)$, i.e., given Y, X is independent of all other decendents and their ancestors not through Y.

c. Now we relax part (b) by allowing Y to have multiple parents, while all other conditions are not changed. Show that if S does not include any ancestor of X, then $\mathbf{P}(X \mid Y, Parents(Y) \setminus X) = \mathbf{P}(X \mid (Parents(Y) \setminus X), S)$, i.e., given Y and all other parents of Y, X is independent of all descendents of Y and their ancestors not through Y.