CSE 3402 3.0 Intro. to Concepts of AI
Winter 2012

Dept. of Computer Science & Engineering
York University

Assignment 3

Total marks: 100.

Out: March 15
Due: April 2 at 2:30pm

Note: Your report for this assignment should be the result of your own individual work. Take care to avoid plagiarism ("copying"). You may discuss the problems with other students, but do not take written notes during these discussions, and do not share your written solutions.

1. [30 points] (Adapted from Genesereth and Nilsson (1987))

   Victor has been murdered, and Arthur, Bertram, and Carleton are the only suspects (meaning exactly one of them is the murderer). Arthur says that Bertram was the victim's friend, but that Carleton hated the victim. Bertram says that he was out of town the day of the murder and besides, he did not even know the guy. Carleton says that he saw Arthur and Bertram with the victim just before the murder. You may assume that everyone, except possibly the murderer, is telling the truth.

   a) Write sentences in first-order logic that represent this knowledge. Also provide a glossary where you indicate the intended meaning of your predicate, function, and constant symbols in English.

   b) Convert the sentences into clausal form and give the resulting set of clauses.

   c) Use resolution with answer extraction to find the murderer. State how you represent the query in first-order logic and what clause (with an answer predicate) is added to the theory. Show the complete resolution derivation (in sequence or tree form), clearly indicating which literals/clauses are resolved and the unifier used.

   d) Suppose that we can no longer assume that there was only a single murderer. What sentences must you remove from the theory? Show that the modified theory no longer entails that the answer you obtained in c) is the murderer. Do this by specifying an interpretation where the answer in c) is not the murderer and showing that it satisfies all the axioms of the theory.

2. [70 points]

   a) Develop a Prolog implementation of a situation calculus action theory for Shakey's world as described in Exercise 10.4 of the Russell and Norvig 3rd edition textbook (also appearing as Exercise 11.13 in the 2nd edition of the book). Use the primitive action names that appear in the exercise. For the fluents, use $RobotLoc(location, situation)$, meaning that the robot is at $location$ in situation s, $BoxLoc(box, location, situation)$, meaning that box is at $location$ in situation s, $OnTop(box, situation)$, meaning that the robot is on top of box in situation s, $Up(switch, situation)$, meaning that $switch$ is up in situation s, and $LightOn(light, situation)$, meaning that $light$ is on in situation s. Also, use the non-fluent predicates $In(location, room)$ and $Controls(switch, light)$, and possibly others to specify the types of entities in the domain, e.g. $IsBox(b)$. Write a precondition axiom for each action and a successor state axiom for each fluent. Also write axioms describing the initial state pictured in Figure 11.17. Assume there is a light in each room (except the corridor), and that it is on if the switch is up. For the initial location of the robot, use a constant such as $locInitRobot$, and similarly for the boxes and switches. There is an example Prolog implementation of a situation calculus action theory for an "elevator control" application domain on the course web site.

b) Suppose that we want to achieve the goal of having Box_2 in $Room_2$. Express this goal as a situation calculus sentence. Also write a ground situation term that represents a plan that achieves this goal when executed in the initial state of Figure 11.17. Use your Prolog implementation of the action theory in a) to confirm that the plan is executable (legal) and achieves the goal.

c) Write a Golog program that represents the plan in b) and show that it can be executed successfully. Use the Golog interpreter on the course web site.

d) Write a Golog procedure $allLightsOn$ that can be executed to turn on all the lights. The procedure should always terminate successfully and should succeed in turning on all the lights as long as a there is a box in some room that can be used by the robot to reach the switch. Run your procedure and show that it can be executed successfully in the initial situation of Figure 11.17 and that all the lights are on in the resulting situation. Your code should define subprocedures as appropriate and not be unnecessarily complex.

(e) Use the Golog iterative deepening planning procedure (in the Golog interpreter file) to generate a plan to achieve the goal of having Box_2 in $Room_2$. For the search procedure to find a solution, you will have to define the forward filtering fluent $Acceptable(a, s)$ appropriately. Try using the following task-specific heuristics: i) until the robot is at the location of Box_2, go is the only acceptable action, and ii) once the robot is at the location of Box_2, $push$ of Box_2 is the only acceptable action.

Document your code appropriately.

To hand in your report for this assignment, submit your code and test results electronically and deliver a printout together with your answers to question 1 in the 3402 drop box in CSE building by the deadline. To submit electronically, use the following Prism lab command:

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submit 3402 a3 a3.pl a3tests.txt
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Your Prolog code should work correctly on Prism.