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 situa-
tion 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 exam-
ple 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 Box2 in Room2. 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 Box2 in Room2. 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 Box2, go is the only
acceptable action, and ii) once the robot is at the location of Box2, push of
Box2 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.