# 6.825 Exercise Problems

Weeks 1 and 2

September 23, 2004

## 1 A Problem-Solving Problem

A Mars rover has to leave the lander, collect rock samples from three places (in any order) and return to the lander.

Assume that it has a navigation module that can take it directly to places of interest. So it has primitive actions *go-to-lander*, *go-to-communications-location*, *go-to-rock-1*, *go-to-rock-2*, and *go-to-rock-3*.

We know the time it takes to traverse between each pair of special locations. Our goal is to find a sequence of actions that will perform this task in the shortest amount of time.

1. (10 points) Formulate this problem as a problem-solving problem by specifying the search space, initial state, path-cost function, and goal test. Assume that the world dynamics are deterministic.
2. (5 points) Say what search technique would be most appropriate, and why. If your search technique requires a heuristic, give an appropriate one.
3. (5 points) Now assume that, in addition, on every day that it is not at the lander, the rover needs to be at a special communications location at 3PM. Any plan that misses a communications rendezvouz is unsatisfactory. How would you modify the search space, path-cost function, and/or goal-test to handle this additional requirement? Assume that there's an additional action, called *communicate*, which can only be executed when the rover is at the communications location, and which waits until 3PM, and then executes a communications sequence that takes an hour.

## 2 AIMA Problem 2.4

**Let us examine the rationality of various vacuum-cleaner agent functions.**

1. **Show that the simple vacuum-cleaner function described in Figure 2.3 is indeed rational under the assumptions listed on page 36.**
2. **Describe a rational agent function for the modified performance measure that deducts one point for each movement. Does the corresponding agent program require internal state?**
3. **Discuss possible agent designs for the cases in which clean squares can become dirty and the geography of the environment is unknown. Does it make sense for the agent to learn from its experience in these cases? If so, what should it learn?**

## 3 Propositional Logic

Which of these are legal sentences? Give fully parenthesized expressions.

- $P \rightarrow Q \rightarrow R$
- $P, R \rightarrow Q$
- $A \wedge (B \vee C \vee \neg D) \leftrightarrow \neg\neg Z$
- $\neg P(Q)$

# 4 DPLL

1. How would you modify DPLL so that it
   - returns a satisfying assignment if there is one, and false otherwise?
   - returns *all* satisfying assignments?
2. Would using DPLL to return all satisfying assignments be any more efficient that simply listing all the assignments and checking to see whether they're satisfying? Why or why not?

# 5 State Spaces and Search

A robot has to deliver identical packages to locations A, B, and C, in an office environment. Assume it starts off holding all three packages. The environment is represented as a grid of squares, some of which are free (so the robot can move into them) and some of which are occupied (by walls, doors, etc.). The robot can move into neighboring squares, and can pick up and drop packages if they are in the same square as the robot.

1. Formulate this problem as a search problem, specifying the state space, action space, goal test, and cost function.
2. Give a non-trivial, polynomial-time, admissible heuristic for this domain, or argue that there isn't one.
3. Package A has to be delivered to the boss, and it's important that it be done quickly. But we should deliver the other packages promptly as well. How could we encode this in the problem?
4. Now, consider the case where the robot doesn't start with the packages, but it has to pick up a package from location 1 to deliver to location A, a package from location 2 to deliver to B, and from 3 to deliver to C. What is an appropriate state space for this problem?
5. What is a good admissible heuristic?