is a direct route. *DirectRoute*(x, y) is true if and only if there is a direct route from x to y; you can assume that all such facts are already in the KB (see the map on page 62). The robot begins in Arad and must reach Bucharest.

a. Write a suitable logical description of the initial situation of the robot.

b. Write a suitable logical query whose solutions will provide possible paths to the goal.

c. Write a sentence describing the *Go* action.

d. Now suppose that following the direct route between two cities consumes an amount of fuel equal to the distance between the cities. The robot starts with fuel at full capacity. Augment your representation to include these considerations. Your action description should be such that the query you specified earlier will still result in feasible plans.

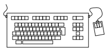
e. Describe the initial situation, and write a new rule or rules describing the *Go* action.

f. Now suppose some of the vertices are also gas stations, at which the robot can fill its tank using the *Fillup* action. Extend your representation to include gas stations and write all the rules needed to completely describe the *Fillup* action.

7.12 In this exercise, you will extend situation calculus to allow for actions that take place simultaneously. You will use a function called *Simultaneously*, which takes two actions as arguments and denotes the combined action. Consider a grid world containing two agents. Write axioms describing the effects of simultaneous *Forward* actions:

a. When two agents move at once, unless they are both trying to move to the same location, the result is the same as if one had moved and then the other had moved.

b. If the agents are trying to move to the same location, they remain in place.



7.13 Using the wumpus world simulator and the logical reasoning system in the code repository, implement a working agent for the wumpus world. You will need all of the wumpus-related axioms in the chapter, and perhaps more besides. Evaluate the performance of your agent.

7.14 How hard would it be to build a successful wumpus world agent by writing a program in your favorite programming language? Compare this to the logical reasoning agent.

7.15 Sketch an argument to the effect that a logical agent using the axioms and action preferences given in the chapter will always succeed in finding the gold safely whenever there is a safe sequence of actions that does so.

7.16 A reflex agent is one whose action is always a function of its percepts in the current time step. That is, the agent's action cannot be based on anything it learned in the past, and it cannot carry over any internal state information from one time step to the next. In the wumpus world, there are 32 different possible percepts and 6 different actions.

a. How many different reflex agents can there be in the wumpus world?

b. How many different 4×4 wumpus worlds are there? How many 10×10 worlds?

c. What do you think the chances are that a reflex agent can be successful in a majority of wumpus worlds? Why?