Homework Assignment 4: Regression Planning

CSC 384 – Winter 2003

Out: March 12, 2003
Due: March 26, 2003

Be sure to include your name and student number with your assignment.

In this assignment, your job is to axiomatize two small planning domains using the STRIPS action representation (and address some difficulties with various aspects of STRIPS). For these two domains, you are asked to test your domain specifications using an iterative-deepening regression planner that will be made available on the course Web page.

The regression planner, `idrplan`, can best be understood by reading the documentation within the code. However, its use and its representations should be clear given our discussions in class. An encoding of the small domain we have been using in class (with the robot that fetches Craig's coffee) will be posted on the course Web site. You can "dabble" with that domain if you like.

1. Encode the following two planning domains. That is, develop a set of predicates, objects, and actions that describe these domains, and provide a specification of each action (i.e., precondition, add, and delete lists). You are to test your encoding of each domain using the `idrplan` algorithm on several test problems that will be posted on the course Web site about one week before the assignment is due (these will be described in English). **Hand in a clear description of your domain encodings, as well as a print out of the execution of your code on the test problems.**

   (a) **First domain**
   We have a parcel-delivery robot that can move parcels between the Sandford Fleming, Pratt and Bahen buildings. Assume the robot can carry an unlimited number of parcels and the only relevant locations are the Sandford Fleming, Pratt and Bahen buildings. When travelling between Bahen and the other two buildings, the robot must go outside. In contrast, it can travel indoors between Sandford Fleming and Pratt by using the bridge. If the robot goes outside when it's raining, it will get wet unless it has an umbrella. It can get an umbrella in Sandford Fleming. Our goals can specify things about the location of various parcels, the robot's location and the robot staying dry.

   (b) **Second domain**
   NASA needs to plan the mission of a group of rovers responsible for collecting data about the soil composition of Mars. Each rover possesses several *instruments* and each instrument can be used to perform various data collection *operations*. For example, an imaging instrument can be used to take both *spectrographic* and *thermographic* images of a rock of interest. Before performing an operation, a rover can *rotate* to face or to block the sun. The *orientation* of a rover can strongly influence the outcome of an operation because of the varying degrees of luminosity, heat and radiation. Since rovers have a limited power supply, a rover can only power up one instrument at a time. After an instrument is powered up, it must also be warmed up before it can be used. Again, due to the limited power supply, the warming up procedure only succeeds when the rover is facing the sun since it can take advantage of the heat of the sunlight. Once warmed up, an instrument stays warm until it is shut down. A rover can execute a specific data collection operation using any instrument that can perform it as long as it is powered up, warmed up and properly oriented with respect to the sun.
   Generally, a goal will require that we have a set of data collection operations completed, each in a certain orientation. For example, one may request a spectrographic image of the soil while facing the sun and a thermographic image of the soil while blocking the sun.

Note that the above domains are described at a high level. This may give the impression that the domains are not defined precisely enough for you to encode them, but that is not the case. Put yourself in the shoes of an engineer who must encode those planing domains based on an English description made by a domain expert that is not familiar with any planning formalism. Use your modelling skills to decipher what is relevant in the planning tasks and design an encoding. There are many good encodings.

Your actions and predicates should be general enough to deal with any collection of objects (parcels, buildings, umbrella, weather, etc. for the first domain and rovers, instruments, operations, orientations, etc. for the second domain). When describing your encodings, rather than state what specific objects you have, describe what information must be supplied about each *type* of objects. Your test case problems will specify a precise collection of objects. Your encodings should be powerful enough to be able to solve the types of planning problems mentioned, but not any more complex than necessary. Be sure to describe your representation very clearly in English, as well as providing the formal STRIPS encoding of the domain.

2. In question 1a, the robot's move action has "conditional effects". That is, the effect of `move(X,Y)` varies depending on the properties of the starting state (if it's raining and the robot has no umbrella, it gets wet; otherwise it does not). This is somewhat inconvenient to represent in STRIPS (though you probably discovered a way to get around this problem). Suggest a variant of STRIPS action representation that would allow an action with conditional effects to be represented more "naturally". Describe how you would change the definition of regression to handle actions with conditional effects (you may refer to your proposed representation).

3. Suppose you have a STRIPS representation for actions a_1 and a_2, and you want to define the STRIPS representation for the composite action $a_1; a_2$, which means that you do a_1 then a_2.

   (a) What are the preconditions, add list and delete list of the composite action `getkeys;move(o,l)` in the example of the coffee-fetching robot?

   (b) What are the preconditions, add list and delete list of the composite action `makecoffee;grabcoffee` in the example of the coffee-fetching robot?

   (c) Devise general rules to construct the preconditions, add list, and delete list of composite actions from the preconditions, add list and delete list of the individual actions?

   (d) What do think would be the advantages and disadvantages of introducing composite actions in a planning problem? Explain.