Planning: Regression Planning

CPSC 322 Lecture 16

February 8, 2006
Textbook §11.2

Lecture Overview

Recap

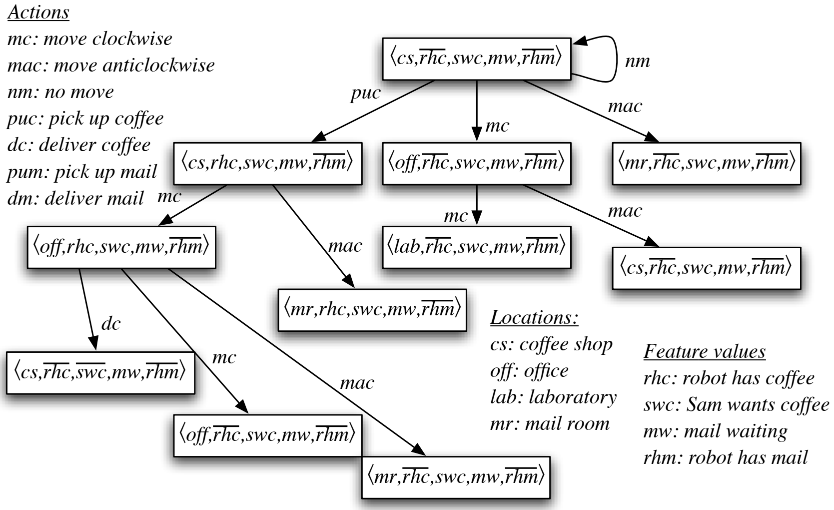
Regression Planning

Forward Planning

Idea: search in the state-space graph.

- The nodes represent the states
- The arcs correspond to the actions: The arcs from a state s represent all of the actions that are legal in state s.
- A plan is a path from the state representing the initial state to a state that satisfies the goal.

Example state-space graph



Improving Search Efficiency

Forward search can use domain-specific knowledge specified as:

- a heuristic function that estimates the number of steps to the goal
- domain-specific pruning of neighbors:
  - don't go to the coffee shop unless "Sam wants coffee" is part of the goal and Rob doesn't have coffee
  - don't pick-up coffee unless Sam wants coffee
  - unless the goal involves time constraints, don't do the "no move" action.

Lecture Overview

Recap

Regression Planning

Regression Planning

Idea: search backwards from the goal description: nodes correspond to subgoals, and arcs to actions.

- Nodes are propositions: partial assignments to state variables
- Start node: the goal condition
- Arcs correspond to actions
- A node that neighbours N via arc A is a variable assignment that specifies what must be true immediately before A so that N is true immediately after.
- The goal test is true if N is a proposition that is true of the initial state.

Defining nodes and arcs

- A node N is a partial assignment of values to variables:

$$[X_1 = v_1, \ldots, X_n = v_n]$$

- An action which can be taken to this node is one that achieves one of the $X_i = v_i$, and does not achieve any $X_j = v_j$ where v_j' is different from v_j.
- Any node that neighbours N via arc A must contain:
  - The prerequisites of action A
  - All of the elements of N that were not achieved by A

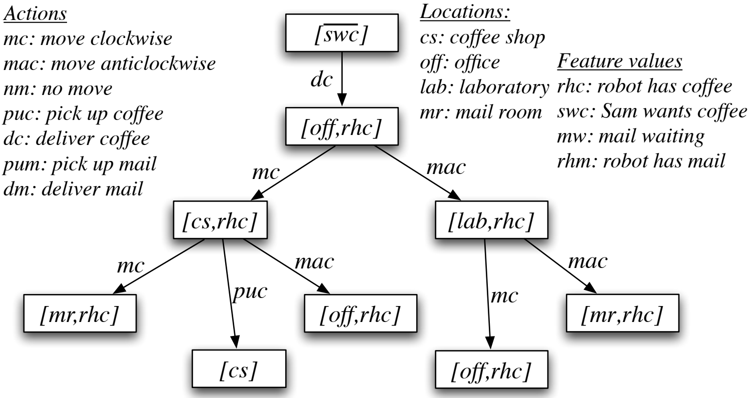
  N must be consistent.

Formalizing arcs using STRIPS notation

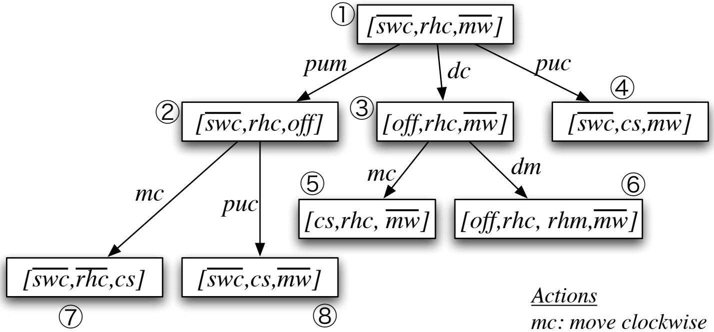
If we're currently at a node $[X_1 = v_1, \ldots, X_n = v_n]$ then an arc labeled A exists to another node N if

- There exists some i for which $X_i = v_i$ is on the effects list of action A
- For all j, $X_j = v'_j$ is not on the effects list for A, where $v'_j \neq v_j$
- N is $preconditions(A) \cup \{X_k = v_k : X_k = v_k \notin effects(A)\}$ and N is consistent in that it does not assign multiple values to any one variable.

Regression example



Find the errors (none involve room locations)



Locations:
cs: coffee shop
off: office
lab: laboratory
mr: mail room

Feature values
rhc: robot has coffee
swc: Sam wants coffee
mw: mail waiting
rhm: robot has mail

Actions
mc: move clockwise
mac: move anticlockwise
nm: no move
puc: pick up coffee
dc: deliver coffee
pum: pick up mail
dm: deliver mail

Loop detection and multiple-path pruning

- Goal G_1 is simpler than goal G_2 if G_1 is a subset of G_2.
  - It is easier to solve $[cs]$ than $[cs, rhc]$.
- Loop detection: if during the search we encounter a node N, but one of its ancestors N' is the same or simpler, you can prune N.
- Multiple path pruning: if during the search we encounter a node N, but elsewhere in the search tree (not as a descendent of N) we have encountered a node N' which is the same or simpler, you can prune N.

Improving Efficiency

- You can define a heuristic function that estimates how difficult it is to solve the goal from the initial state.
- You can use domain-specific knowledge to remove impossible goals.
  - E.g., it may not be obvious from the action description that the agent can only hold one item at any time.

Comparing forward and regression planners

- Which is more efficient depends on:
  - The branching factor
  - How good the heuristics are
- Forward planning is unconstrained by the goal (except as a source of heuristics).
- Regression planning is unconstrained by the initial state (except as a source of heuristics)