Lecture 11: Conditional planning with full observability

- an algorithm for constructing plans with loops
Need for plans with loops

- Action may fail to have any effect.
  AN EXAMPLE: Trying to break a coconut.

- Action may fail and take us away from the goals.
  AN EXAMPLE: Building a house of cards.
Algorithm

1. Do distance computation with strong preimages as long as possible.

2. Do distance computation with weak preimages until a set $S$ of states is found so that for every state in $S$ there is an action that
   - takes us closer to goal states, or
   - takes us to another state in $S$.

3. Continue from 1.
Example
Example: strong preimages
Example: weak preimages 1
Example, weak preimages 2, loop found
Example: continued with strong preimages
Example: weak preimages 1
Example: weak preimages 2
Example: weak preimages 3, loop found
Example: continued with strong preimages
Example: strong preimages, plan found
Plans with loops

Action selection:

- States not part of a loop: reduce distance by at least 1.
- States in a loop: reduce distance by 1 or go to another state in the loop.
Algorithm

PROCEDURE FOplanL(I,O,G)

\[ D_0 := G; i := 0; \]

REPEAT

WHILE \( I \not\subseteq D_i \) AND \( i = 0 \) OR \( D_{i-1} \neq D_i \) DO

\[ i := i + 1; \]

\[ D_i := D_{i-1} \cup \bigcup_{o \in O} spreimg_o(D_{i-1}); \]

END

IF \( I \not\subseteq D_i \) THEN

find a loop (next slide)

UNTIL \( I \subseteq D_i \) OR \( D_i = D_{i-1} \);
Algorithm: cont’d, detect a loop

BEGIN
  \[i := i - 1;\]
  \[W := D_i;\]
  \textbf{REPEAT}
  \[W' := W;\]
  \[W := W \cup \bigcup_{o \in O} \text{wpreimg}_o(W);\]
  \[L := \text{prune}(W, D_i);\]
  \textbf{UNTIL} \ L \neq \emptyset \ OR \ W = W';
  \textbf{IF} \ L \neq \emptyset \ \textbf{THEN}
  \[\text{assign distances to states (next slide)}\]
END
Algorithm: cont’d, distances for loop states

BEGIN

$W := D_i$;

REPEAT

$W' := W$;

$W := W \cup \bigcup_{o \in O}(\text{wpreimg}_o(W) \cap \text{spreimg}_o(W \cup L))$;

$i := i + 1$;

$D_i := L \cap W$;

UNTIL $W = W'$

END
Algorithm: do preimages form a good loop?

PROCEDURE prune\((W, G)\);

REPEAT
  \( S := G \); \( S' := \emptyset \);
  WHILE \( S \neq S' \) DO
    \( S' := S \);
    \( S := S \cup \bigcup_{o \in O} (wpreimg_o(S) \cap spreimg_o(W \cup G)) \);
  END
  \( W' := W \);
  \( W := W \cap S \);
UNTIL \( W = W' \);
RETURN \( W \);
The procedure *prune*: example
The procedure *prune*: iteration 1
The procedure *prune*: iteration 1, 1 preimage
The procedure \textit{prune}: iteration 1, 2 preimages
The procedure *prune*: iteration 1, bad states
The procedure *prune*: iteration 2
The procedure *prune*: iteration 2, 1 preimage
The procedure *prune*: iteration 2, 2 preimages
The procedure *prune*: iteration 2, bad states
The procedure *prune*: example, loop identified