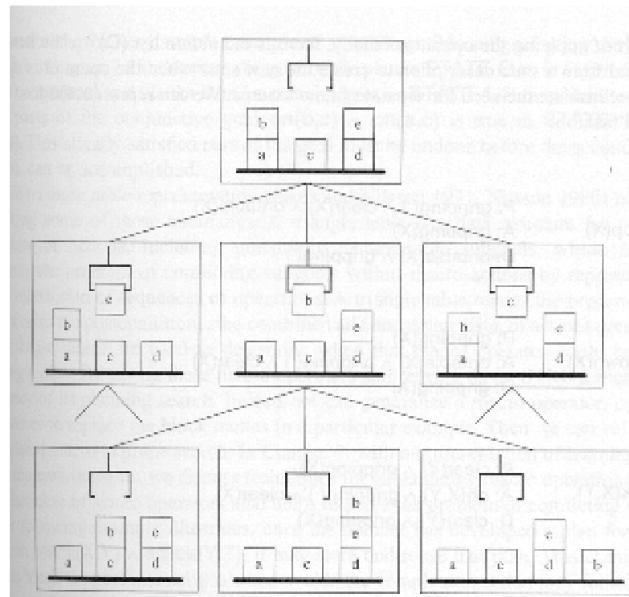


Tutorial Sheet 7 Automated Planning

1. Explain informally but precisely:

- Closed world assumption.
- The frame problem.
- Fluent.
- How do you define an action using STRIPS (give an example).
- How do you define an action using PDDL (give an example).

2. Consider the following blocks world scenario:



Suppose that we want to represent the blocks world scenario using “logical”¹ causal rules of the form $A : (C \Rightarrow E)$ with the intended meaning that “Action A will have effect E when condition C holds true”. For example, $drop(x) : Fragile(x) \Rightarrow Broken(x)$ states that dropping an object results in the object being broken when the object in question is fragile.

- (a) Specify the initial state in logical representation, that is, using conjunction of atoms and relying on the close world assumption.
- (b) Create the “logical” causal rules for the four operators in the blocks world domain, namely, actions $pickUp(x)$, $putDown(x)$, $stack(x, y)$, and $unstack(x)$. Also give the representation for action $dropAll$ which “resets” the domain by putting all blocks on the table.

¹We say “logical” because these are not logical formula per se, but just specification “rules” written with a logical flavour.

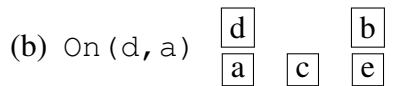
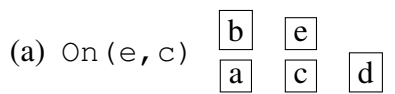
(c) Provide at least 5 frame axioms required in this domain. What issue can you see here when the domain is complex?

3. Provide the STRIPS representation of all four actions.

4. Use the operators and frame axioms of the previous question to generate the search state space of the blocks world given in the figure above. The root of the tree should be the logical initial state representation and edges should represent application of ground operators. You do not need to show the whole tree!

5. Translate at least two of the operators into PDDL representation (check PDDL quick tutorial notes on the course web site, [here](#) and [here](#)).

6. Show how forward search (that is, search from the initial state) and backward driven (that is, search from the goal state) can be used to find a plan for the following goal states:



7. Suppose that each block has a new property of colour. What needs to be done to your representation/encoding?

8. Generate a plan to solve the following problem using

- Data driven search (from initial state).
- Goal driven search (from goal state).



9. Suppose you want to represent the action of dropping an object. Its effect is that the object is on the floor and depending on whether it is fragile or not, it may or may not be broken. Can you represent such action in STRIP representation? Either provide the representation or explain why not. Finally, give the representation of such action in PDDL format.

10.

11. What is the difference between path/motion planning and automated planning.

12. Explain what Graphplan is and what is it used for.

13. What predicates and actions would you use to model the Pacman projects? What would the goal be if you are planning for the Pacman? What would it be if you are planning for a ghost?

You say *more*?

1. Extend your Wumpus world description of previous tutorials with STRIPS descriptions for the operators *forward* (go one square in the current direction) and *left* (turn 90 degrees left, staying in the same square)
2. Give an outline of how to find a plan for getting the gold.
3. (Monkey and Bananas Problem) There is a monkey in a room with some bananas hanging out of reach from the ceiling. A box is available that will enable the monkey to reach the bananas if she climbs on it. Initially the monkey is at A, the bananas at B and the box at C. The monkey and the box have height *low*, but if the monkey climbs onto the box she will have height *high*, same as the bananas. The actions available to the monkey include *Go* from one place to another, *Push* an object from one place to another, *Climb* onto an object and *Grasp* an object. Grasping results in holding the object if the monkey and object are in the same place at the same height.
 - Write down the initial state description in predicate calculus.
 - Write down PDDL definitions of the four actions, providing at least the obvious preconditions.
 - Use data driven search to find a plan for getting the bananas.
 - Use goal driven search to find a plan for getting the bananas.