Heuristics and A* implementations

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Abstract

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Domains

Six domains were tested in the implementations. In this section, I explain this domains.

Blocksworld

Dinner

Dompteur

DWR - Dock Worker Robots

Logistics

TSP - Travel Sales Person

Heuristics

In this section, I discuss the different heuristics implemented in the Jupyter notebook. The implementation uses the *pddl* package to parse the tested PDDL domains and problems.

h_{max} heuristic

In a nutshell, this heuristic returns the maximum cost to achieve a goal. From an initial state, the heuristic returns the longest path to reach all goals.

```
1  from pddl.heuristic import Heuristic
2
3  class MaxHeuristic(Heuristic):
4    def h(self, actions, state, goals):
5      reachable = state
6      goals_missing = goals[0]
7      max_cost = 0
8      while not goals_missing.issubset(reachable):
9        last_state = frozenset(
10         [a for a in actions if a.positive_preconditions.issubset(reachable)]
11       )
12       new_reachable = reachable.union([pre for a in last_state for pre in a.add_effects])
13       if new_reachable == reachable:
14         return float("inf")
15       reachable = new_reachable
16       max_cost += 1
17     return max_cost
```

Listing 1: h_{max} implementation

In the Listing 1, the function *h* returns the maximum cost to reach the *goals* from an initial *state*, considering a set of possible *actions*.

The first reachable states are the initial states, as shown in line 5. The next two lines define the goals[1] and the maximum cost to achieve the goals from the reachable state. Therefore, if all goals are in the initial state, the maximum cost is 0 and the return in line 8 is *False*.

When the goals are not in the reachable state, the algorithm takes two step:

- line 9: get all actions in which the preconditions are applicable to the current set of reachable actions.
- line 12: get the effects from the actions applicable to the current reachable state. Each time the algorithm performs this step, the reachable state becomes larger, that is, it is more likely that the goals are in the reachable state.

At least, in line 13, it is tested whether the new reachable states are the same as the current reachable state. If true, there are no more states to reach and the heuristic has not achieved the goals. Therefore, $\inf$ is returned. When there are more states to test, the maximum cost is increased until all goals are reached.

h_{add} heuristic

In a nutshell, this heuristic returns the sum of all the costs to reach the goals. The Listing 2 shows the algorithm that performs this heuristic.

[1] The goals received as a parameter are divided into positive and negative. Negative goals are those with the negative sign (*not*) in the PDDL. To perform the heuristic I only consider the positive goal.

```python
1 from pddl.heuristic import Heuristic
2
3 class AdditiveHeuristic(Heuristic):
4   def h(self, actions, state, goals):
5     reachable = state
6     goals_missing = goals[0]
7     goals_reached = None
8     last_state = None
9     add = 0
10    costs = {p: 0 for p in state}
11    while last_state != reachable:
12      goals_reached = goals_missing.intersection(reachable)
13      if goals_reached:
14        add += sum(costs[g] for g in goals_reached)
15        goals_missing = goals_missing.difference(goals_reached)
16      if not goals_missing:
17        return add
18      last_state = reachable
19      for action in actions:
20        if action.positive_preconditions.issubset(last_state):
21          new_reachable = action.add_effects.difference(reachable)
22          for effect in new_reachable:
23            costs[effect] = sum(costs[pre] for pre in action.positive_preconditions) + 1
24          reachable = reachable.union(new_reachable)
25    return float("inf")
```

Listing 2: h_{add} implementation

Similar to the h_{max} heuristic, the first reachable state will be the initial state and the cost of reaching goals that are in the initial state, is 0 (line 10). As we need to add the cost of reaching all goals, it is necessary to maintain a set of all goals that have not yet been achieved.

When a goal is reached in the current reachable state (line12), the cost of all goals reached is added to the variable *add*, as shown in line 14.

After reaching all the goals, the variable *add* is returned (line 17). If some goal cannot be reached, at some point in the execution, the previous state will be equal to the reachable state, and then return $\inf$ (line 25).

The first step to get the next reachable state is to filter only the actions applicable to the current state and obtain the effects of those actions (line 21). After that, the cost of each effect is calculated and added to the variable *cost* (line 23).

Plan Validation

In some scenarios, it is necessary to validade whether a given plan is valid or not. Listing 3 shows a Python code for performing plan validation.

```python
1 def validate(self, actions, initial_state, goals, plan):
2   state = initial_state
3   for line in plan:
4     for action in actions:
5       if line.parameters == action.parameters:
6         if applicable(
7           state, (action.positive_preconditions, action.negative_preconditions)
8         ):
9           state = apply(state, (action.add_effects, action.del_effects))
10          break
11
12  goals_reached = goals[0].intersection(state)
13  return goals_reached == goals[0]
```

Listing 3: Plan validation implementation

The function *validate* takes as parameters the actions that can be applied to the state, the initial state, the goals and the plan to be validated. An example of a plan to be validated is shown in Listing 4.

```
(take k1 cc cb p1 l1)
(load k1 r1 cc l1)
(move r1 l1 l2)
...
```

Listing 4: Example of a plan

The main idea of validation is to apply each line of the plan to the state and test whether the goals have been reached or not. In lines 3 and 4 of Listing 3, I search for the action that is applicable to the current line of the plan. When the plan line and an action have the same parameters (line 5), I apply the action on the state, interrupt the search for another action and move to the next plan line.

After all the effects of the plan line are applied to the state, I search in the state for the goals. If all goals can be found in the state, the plan is valid.

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```

```
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% and change the 0 to a 1 or 2
% \setcounter{secnumdepth}{0}
%%%%%%%%%%
% Title, Author, and Address Information
\title{Title}
\author{Author 1 \and Author 2\\
Address line\\
Address line\\
\And
Author 3\\
Address line\\
Address line}
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% Body of Paper Begins
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Hasling, D. W.; Clancey, W. J.; and Rennels, G. R. 1983. Strategic Explanations in Consultation. *The International Journal of Man-Machine Studies* 20(1): 3–19.

Proceedings Paper Published by a Society
Clancey, W. J. 1983b. Communication, Simulation, and Intelligent Agents: Implications of Personal Intelligent Machines for Medical Education. In Proceedings of the Eighth International Joint Conference on Artificial Intelligence, 556–560. Menlo Park, Calif.: International Joint Conferences on Artificial Intelligence, Inc.

Proceedings Paper Published by a Press or Publisher
Clancey, W. J. 1984. Classification Problem Solving. In *Proceedings of the Fourth National Conference on Artificial Intelligence,* 49–54. Menlo Park, Calif.: AAAI Press.

University Technical Report
Rice, J. 1986. Poligon: A System for Parallel Problem Solving, Technical Report, KSL-86-19, Dept. of Computer Science, Stanford Univ.

Dissertation or Thesis
Clancey, W. J. 1979b. Transfer of Rule-Based Expertise through a Tutorial Dialogue. Ph.D. diss., Dept. of Computer Science, Stanford Univ., Stanford, Calif.

Forthcoming Publication
Clancey, W. J. 1986a. The Engineering of Qualitative Models. Forthcoming.

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Additional Resources

LaTeX is a difficult program to master. If you've used that software, and this document didn't help or some items were not explained clearly, we recommend you read Michael Shell's excellent document (testflow doc.txt V1.0a 2002/08/13) about obtaining correct PS/PDF output on LaTeX systems. (It was written for another purpose, but it has general application as well). It is available at www.ctan.org in the tex-archive.

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