Exercises of AI

February 23, 2016

1 Production systems

1.1 Modeling

Model all components of the following problem spaces.

1.1.1 Port

The Port domain is inspired by a real world port. In this problem space, there is an area in the dock of a port with towers of containers placed in a grid of $n \times m$, where each tower has a height of at most k containers. The port has a set of hoists, one for each ship that is waiting to be loaded with containers. Initially, all containers are in the dock, and the goals are to load all of them in the ships; the goals establish to which ship each container should go and on top of which other container.

1.1.2 Depots-robots

This problem space is inspired by the Kiva robots.[1] These robots move in a grid inside a depot. They have to move inventory pods from their storage places (positions in the grid) to human workers that fill orders by picking up items from the pods. Robots can move to adjacent cells (vertical or horizontal movements only). They can move empty or with one pod (by placing themselves under the pod and taking it). Figure 1(left) shows an example of an initial state in this problem space with two robots (R1 and R2) and three pods (P1, P2 and P3). The goals (right) would be that pods are used by humans, so they have to be at the same locations where human workers (H1-H4) are.

1.2 Reasoning in propositional logic

Given the following set of rules:

R1. $v, q, r \rightarrow g, \neg t$

[1] `www.kivasystems.com`

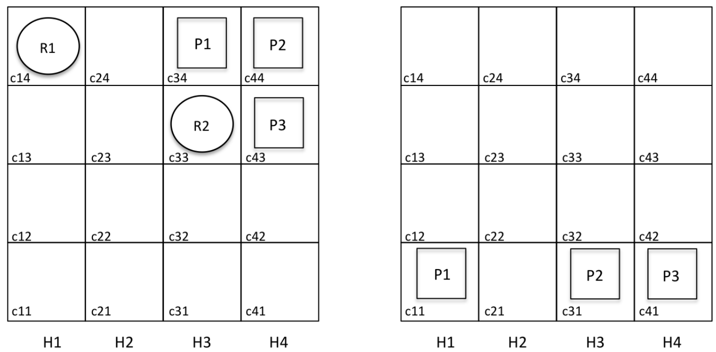

Figure 1: Example of an initial state (left) with two robots (R_i, circles), three pods (P_i, squares) and four human workers (H_i). The goals (right) would be that these three pods have been moved to service humans.

R2. $s, q, r \rightarrow t, \neg q$

R3. $t, q, \neg r \rightarrow v, \neg s$

R4. $p, q, \neg r \rightarrow s, \neg p$

- Can you achieve g if $WM_0 = \{p, q\}$? If yes, how should the control strategy select rules and how would it work in this example? If not, when (in which iteration) would the production system know that it cannot achieve it?
- Can you achieve g if $WM_0 = \{p, q, r\}$? If yes, how should the control strategy select rules and how would it work in this example? If not, when (in which iteration) would the production system know that it cannot achieve it?

1.3 Reasoning in predicate logic

Given the following set of rules:

R1. $h(X), c(Y) \rightarrow o(X, Y), a(), \neg h(X), \neg c(Y)$

R2. $h(X) \rightarrow t(X), a(), \neg h(X)$

R3. $o(X, Y), c(X), a() \rightarrow h(X), \neg a(), \neg o(X, Y), \neg c(X)$

R4. $t(X), c(X), a() \rightarrow h(X), \neg a(), \neg t(X), \neg c(X)$

- What would happen in the first two iterations if we use forward chaining, selecting the first rule and the $WM = \{o(A, B), o(B, C), c(A), t(C), a(), o(D, E), t(E), c(D)\}$?
- What would happen in the first two iterations if we use backward chaining, selecting the first rule, $WM = \{o(A, B), o(B, C), c(A), t(C), a(), o(D, E), t(E), c(D)\}$

and the goal is $G = \{h(B)\}$?

2 Search

2.1 Uninformed search

- Given the following initial state in 8-puzzle:

2	1	3
4	5	6
7	8	

  and the final state:

1	2	3
4	5	6
7	8	

  does it have a solution? Hint: you cannot find the answer in the slides

- Given the following initial state in 8-puzzle:

2	1	4
3	6	7
5	8	

  and the final state:

1	2	3
4	5	6
7	8	

  - show the first four iterations when using breadth-first search
  - show the first four iterations when using depth-first search
  - show the first four iterations when using Dijkstra
  - show the first four iterations when using branch-and-bound
  - show the first four iterations when using Dijkstra when the cost of moving up and right is 2 and the cost of moving down and left is 1
  - show the first four iterations when using branch-and-bound when the cost of moving up and right is 2 and the cost of moving down and left is 1

2.2 Informed search

- In a game similar to Minecraft, players have to compute the optimal path to move from one position to another one in the map. The map is 3D; each tile in the grid also has a height. The cost to go from one tile x to an adjacent one y (horizontal or vertical) is: 2 if both have the same height; 6 if x is lower than y (the player has to climb); and 1 if x is higher than y

(the player has to move downwards). Also, if the player carries a stair, the cost when x is lower than y gets reduced in 3 units. Stairs are placed at some specific tiles, so if players want to use them, they should first pick them up. When they carry a stair, the cost of any movement increases in 1, except when they are used to climb. Define functions $g(\cdot)$ and $h(\cdot)$ to use in combination to A* to find the optimal path.

- An UAV (Unmanned Aerial Vehicle) is taking images of an area to detect if rivers are flooding. The area has been divided in $N \times M$ tiles. At each time step, the UAV can move forward with a cost of 1, and right or left with a cost of 2. Define functions $g(\cdot)$ and $h(\cdot)$ to use in combination to A* to find the optimal path to go from one tile to another one.
  - Show an example of computation of the first five nodes in a given problem.
  - What would happen if it can also move in the two diagonals forward with a cost of 1.5?
  - What would happen if it can also move backwards and all costs are equal to 1?

3 Bayesian reasoning

- Answer the questions in the slides
- An UAV can be in a 3D position is space with a given orientation. Suppose that the area is $5 \times 5 \times 5$.
  - Define the appropriate random variables and their sample spaces.
  - If we know it is at position (3,2,1), define
    - the current probability distribution of position in the X axis
    - the current probability distribution of position in the Y axis
    - the current probability distribution of position in the Z axis
    - the current probability distribution of orientation
    - the current joint probability distribution of X and Y
  - What would be the probability distribution of X if we know that $X < 3$?
  - What would be the joint probability distribution of X and Y if we know that $X < 3$ and $Y > 4$?

4 Bayesian networks

- Using the example in class, compute the $P(X_1 = 1, X_2 = 1 \mid C = y)$

- Suppose you want to estimate the cost of a software project by computing the probability of being high, medium, or low, as well as que quality of the generated code as high or low. Both variables depend on the experience of the developers (very-high, high, medium, low), the number of similar projects (many, few, none) and programming language to be used (java, C++, python). Also, the experience of the developers depends on the hiring process (good, medium, bad). Design an appropriate Bayesian Network and fill in the CPTs.

- In the previous Bayesian Network, how would you compute
  $P(\text{Experience} = \text{high} \mid \text{SimilarProjects} = \text{none})$