

15-381: Artificial Intelligence

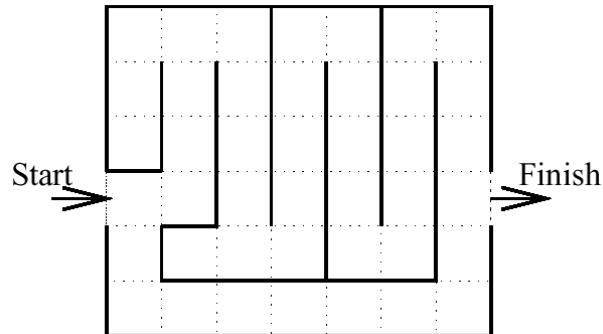
Assignment 3: Midterm Review

Handed out: Tuesday, October 2nd, 2001

Due: Tuesday, October 9th, 2001 (in class)

Solutions will be posted October 10th, 2001: No late homeworks will be accepted!

Problem 1: Informed Search (20 points)



An informed search engine can easily solve this maze, getting from the start location to find the finish location. The possible operators are up, down, left, right, which are only valid if there is a dashed line between the grid boxes in the map of the maze. Consider that the heuristic used is the straight-line distance between the current position in the maze and the exit from the maze.

1. Show that hill-climbing search will fail to find an optimal solution. (Your answer should make it clear why it fails to find the optimal solution).

Hill climbing will choose the first move to position (1,3) and stop there as this is a local optimum.

2. Name at least one other informed search algorithm that would not guarantee finding the optimal solution in this problem.

Greedy best search.

3. Which search algorithm would guarantee finding the optimal solution?

A* would find the optimal solution.

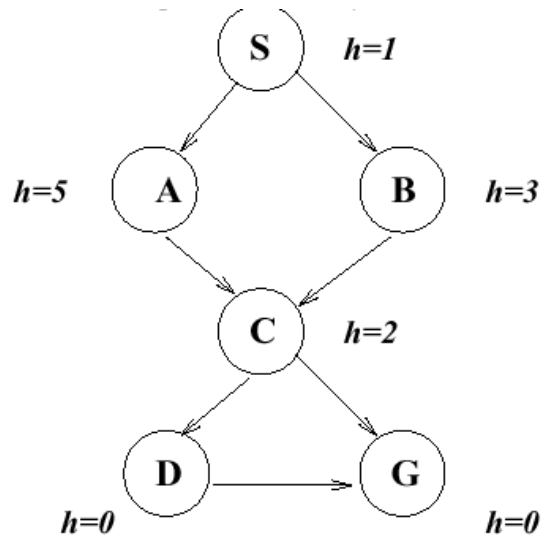
4. Number the 6 first squares searched in this maze using A*, with the given heuristic, and a unit cost for each move.

Start at (1, 3), then search (2, 3), (1, 2), (2, 4), (1, 1), (2, 1), (3, 1), (4, 1), (5, 1), (6, 1), (7, 1), (7, 2), (7, 3) in turn.

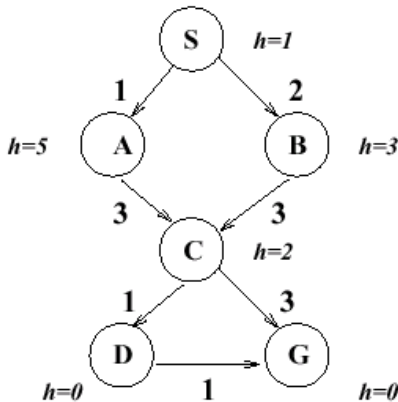
Problem 2: Heuristic Search (20 points)

Consider the search problem below with start state S and goal state G. The heuristic values are shown. Unfortunately we do not know the transition costs, and we really would like to know them. However we know that the given heuristic is admissible. Furthermore we know what was the priority queue of A* after each node expansion, namely:

1. $\{(S, f=1)\}$
2. $\{(B, f=5), (A, f=6)\}$
3. $\{(A, f=6), (C, f=7)\}$
4. $\{(C, f=6)\}$
5. $\{(D, f=5), (G, f=7)\}$
6. $\{(G, f=6)\}$



Fill in the transition costs for all the edges. Briefly explain your reasoning.



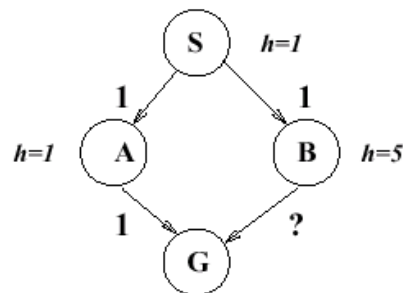
In A*, the evaluation function $f = g + h$, therefore $g = f - h$. The order of expansion tells which edge was followed when there are loops in the search. Note that $g(n)$ is the cost of the path from the root to node n .

- $\{(S, f=1)\}$ this is fine as $h(S)=1$ and $g(S)=0$.
- $\{(B, f=5), (A, f=6)\};$
 - $h(A) = 5$ and $h(B) = 3$, then $c(A,S) = 6 - 5 = 1$ and $c(B,S) = 5 - 3 = 2$.

- $g(A) = c(A, S) = 1$ and $g(B) = c(B, S) = 2$.
- { $(A, f=6), (C, f=7)$ }
 - $h(C) = 2$, then $c(C, B) = f(C^B) - g(B) - h(C) = 7 - 2 - 2 = 3$:
 - $g(C) = c(C, B) + g(B) = 3 + 2 = 5$:
- { $(C, f=6)$ }
 - $h(C) = 2$, then $c(C, A) = f(C^A) - g(A) - h(C) = 6 - 1 - 2 = 3$:
 - update $g(C) = c(C, A) + g(A) = 3 + 1 = 4$:
- { $(D, f=5), (G, f=7)$ }
 - $h(D) = 0$, then $c(D, C) = f(D^C) - g(C) - h(D) = 5 - 4 - 0 = 1$:
 - $g(D) = c(D, C) + g(C) = 1 + 4 = 5$:
 - and $h(G) = 0$, then $c(G, C) = f(G^C) - g(C) - h(G) = 7 - 4 - 0 = 3$:
 - $g(G) = c(G, C) + g(C) = 3 + 4 = 7$:
- { $(G, f=6)$ }
 - and $h(G) = 0$, then $c(G, D) = f(G^D) - g(D) - h(G) = 6 - 5 - 0 = 1$:
 - $g(G) = c(G, D) + g(D) = 1 + 5 = 6$:

Chris claims that: In general, if we are given an arbitrary search problem, for which we know: (i) the heuristic value of all the nodes; (ii) that the heuristic is admissible; (iii) the solution found by A* is given; and (iv) all the values of the priority queue of A*'s search performance, then the costs of all the edges in this arbitrary search problem can be uniquely determined. Is Chris correct? If yes, then prove it informally. Otherwise, give an example of a state graph (similar to part A) that shows that Chris is incorrect.

Chris is not correct. A* does not necessarily visit *all* the nodes in a search problem and therefore also not *all* the edges may be computed. Consider:



1. { $(S, f=1)$ }
2. { $(A, f=2), (B, f=6)$ }
3. { $(G, f=2), (B, f=6)$ }

A* terminates without visiting the edge B,G. As h is admissible, we can only say that $c(B, G) \geq 5$.

Problem 3: Logic and Resolution (10 points)

You are sitting at home on a Monday night, trying frantically to finish your AI assignment. There is not much time left and you decide to order pizza. You call Pizza Palace and find out that they have only two pizzas left:

1. $\text{True} \Rightarrow \text{Pizza}(\text{Olives}) \vee \text{Pizza}(\text{Anchovies})$

We should check if you like the toppings, cause we don't want to order something you will not eat:

2. $\text{Pizza}(\text{Olives}) \wedge \text{Puke}(\text{Me}, \text{Olives}) \Rightarrow \text{Hungry}(\text{Me})$
3. $\text{Pizza}(\text{Anchovies}) \wedge \text{Puke}(\text{Me}, \text{Anchovies}) \Rightarrow \text{Hungry}(\text{Me})$

You are a picky eater and will not eat some toppings:

4. $\text{True} \Rightarrow \text{Puke}(\text{Me}, \text{Olives})$
5. $\text{True} \Rightarrow \text{Puke}(\text{Me}, \text{Anchovies})$

Use resolution to show, unfortunately, that you will go hungry tonight:

6. $\text{True} \Rightarrow \text{Hungry}(\text{Me})$

Resolve 3 & 5, resulting:

7. $\text{Pizza}(\text{Anchovies}) \Rightarrow \text{Hungry}(\text{Me})$

Resolve 2 & 4, resulting:

8. $\text{Pizza}(\text{Olives}) \Rightarrow \text{Hungry}(\text{Me})$

Resolve 1 & 7, resulting:

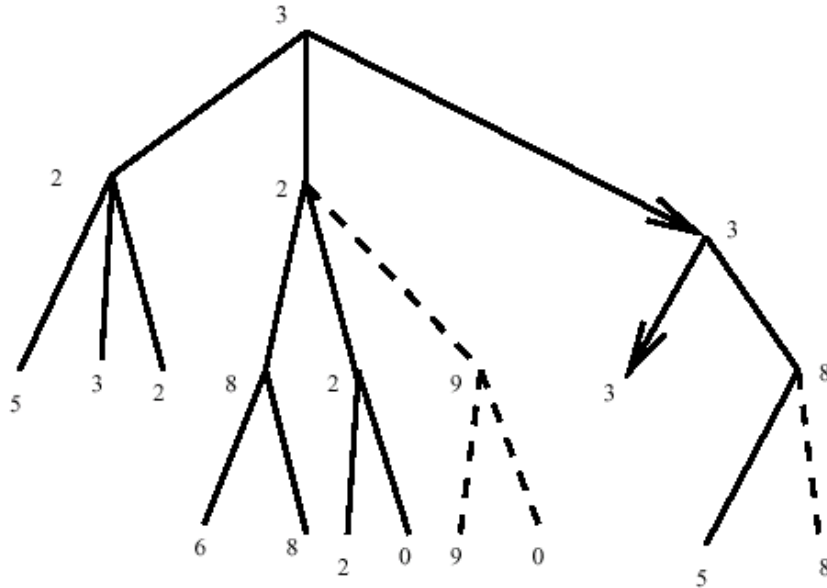
9. $\text{True} \Rightarrow \text{Hungry}(\text{Me}) \vee \text{Pizza}(\text{Olives})$

Resolve 8 & 9, resulting:

10. $\text{True} \Rightarrow \text{Hungry}(\text{Me})$

Problem 4: Games (20 points)

1. Apply minimax to show which move A selects for the following game tree. Be sure to indicate which moves are expected to be made.

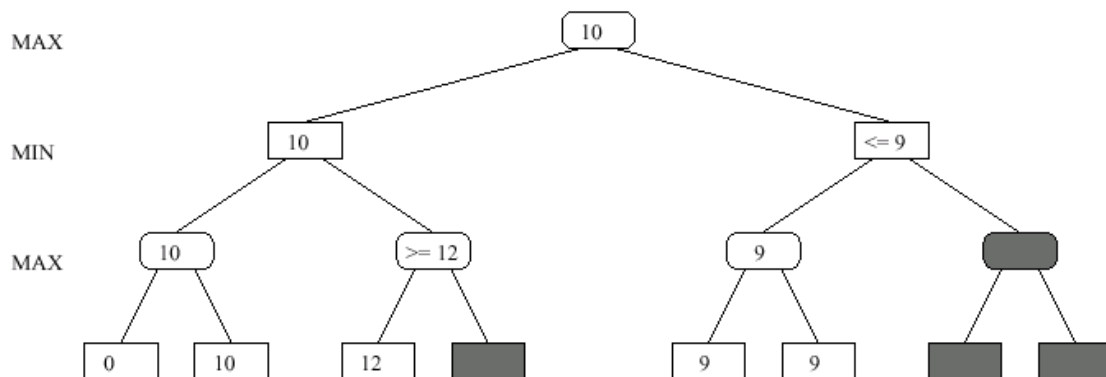


2. Show which branches (if any) would be cut off during an alpha-beta search for the same game tree.

The dashed lines above represent the cut edges.

3. Fill in terminal values for the following game tree that will result in alpha-beta doing the maximum number of cut-offs possible. Assume that nodes are always considered left-to-right.

The following tree is one example of a tree that works. The shaded nodes are cut.



Problem 5: Planning (12 points)

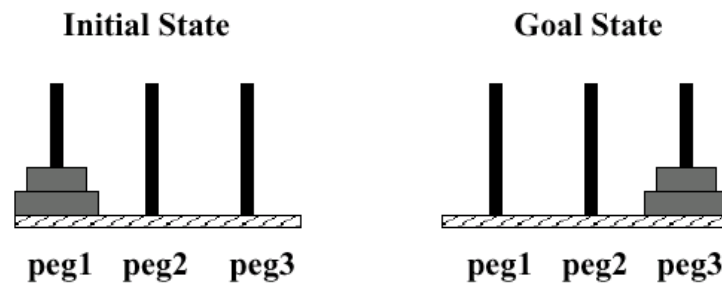
Consider the Tower of Hanoi task, with n disks and k pegs. The disks are of different sizes. A disk can only be moved if there are no other disks on it. A disk can only be moved to a peg that is empty or to a peg whose top disk is larger than itself. A problem consists of an initial and a final configuration of pegs and disks.

1. Complete the set of operators below to solve problems in a simple Tower of Hanoi domain with 2 disks - one large and one small and 3 pegs. (Variables are represented within angle brackets.)

```
operator MOVE-SMALL <peg-x> <peg-y>
preconds: on SMALL peg-y
          not (on SMALL peg-x)
add: (on SMALL <peg-x>)
del: on SMALL peg-y
```

```
operator MOVE-LARGE <peg-x> <peg-y>
preconds: on LARGE peg-y
          not (on LARGE peg-y)
          not (on SMALL peg-x)
          not (on SMALL peg-y)
add: (on LARGE <peg-x>)
del: on LARGE peg-y
```

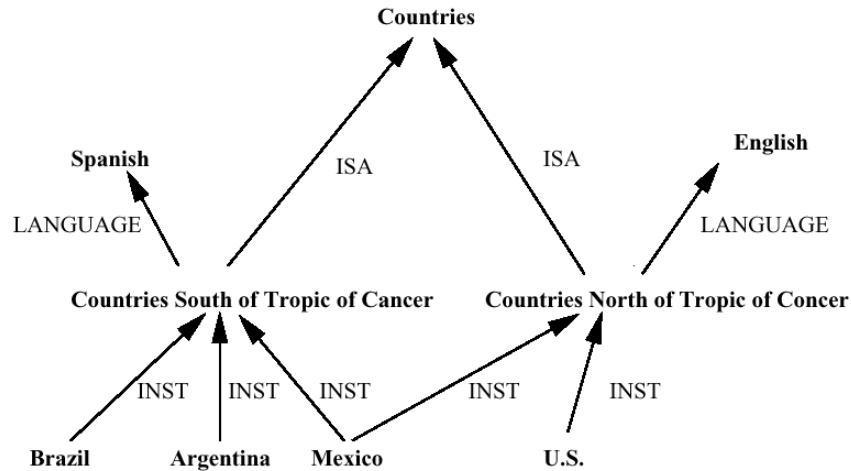
2. Using your set of operators what is an optimal plan to solve the problem shown in the figure below?



```
MOVE-SMALL peg2 peg1
MOVE-LARGE peg3 peg1
MOVE-SMALL peg3 peg2
```

Problem 6: Semantic Nets (18 points)

Consider the semantic network below. Use inferential distance and the information represented in the network to answer the value-query questions below.



1. State three facts that are represented in this semantic network.

The language in MOST Countries South of the Tropic of Cancer is Spanish. The US is a Country North of the Tropic of Cancer. Mexico is a Country North of the Tropic of Cancer.

2. What is the language spoken in Argentina?

Spanish

3. What is the language spoken in Mexico?

UNKNOWN - inferential distance finds a conflict between Spanish and English

4. What is the language spoken in Brazil?

Spanish

5. Insert into the network the fact that the language spoken in Brazil is Portuguese.

Attach a language arc directly to Brazil with value Portuguese.

6. State one fact that would be hard to represent in a general semantic network, and easy to represent in a frame system.

The number of Countries South of Tropic of Cancer. In general, properties that should not be inherited. Properties that would need functions to compute their values.