CS 540-3: Homework 1

Informed and Uninformed Search

40 pts total

Release date: February 1, 2016
Due date: February 9, 2016 at
11:59PM

Directions: Please submit *one* PDF file to Moodle by the deadline specified. Failure to convert your solutions to a single PDF file will result in the deduction of points. Please be sure you understand the course policies on plagiarism before consulting with other students. See either the TA or instructor if you have any questions.

1 Defining a Problem

Consider the farmer, sheep, dog, and cabbage problem we discussed in class. (Refer to the slides for the exact problem specification.) Answer each of the following.

1.1 State Space

(2 pts) Describe the state space to this problem. What would the initial state be?

- 1 pt: The set of all possible (valid) positions for the different objects.
- 1 pt: Initial state would be (FCSD,).

1.2 Possible Actions

(2 pts) Given a general state s, describe what an action means. Given the state (CD, FS) (i.e., the cabbage and the dog are on the left side of the river, and the farmer and sheep are on the right side), give a valid action.

- 1 pt: An action means the farmer going across the river, either alone or with one of objects.
- 1 pt: Valid actions are FS< and F< .

1.3 Transition Model

(2 pts) Given a general state s, describe what the transition model returns. Given the action you named above, what would the transition model return?

- 1 pt: Transition model returns new state after action is taken.
- 1 pt: If action is FS<, transition model returns (FSCD,), and if action is F<, (FCD, S) is returned.

1.4 Goal Test

(2 pts) Given a general state s, describe what the goal test returns.

- 2 pts: Goal test returns *true* if goal state reached, or *false* otherwise.

1.5 Path Cost

(2 pts) What would a potential path cost be, and what would it mean in terms of the search?

- 1 pt: One potential path cost could assign a value of *two* to trips that include the dog and *one* to everything else, assuming the farmer doesn't want to take the dog across the river too many times. (Answers will vary, but are fine as long as they're justified and make sense.)

- 1 pt: If values are assigned in this way, we would prefer to minimize the number of trips with the dog if we're given the choice.

2   Uninformed Search
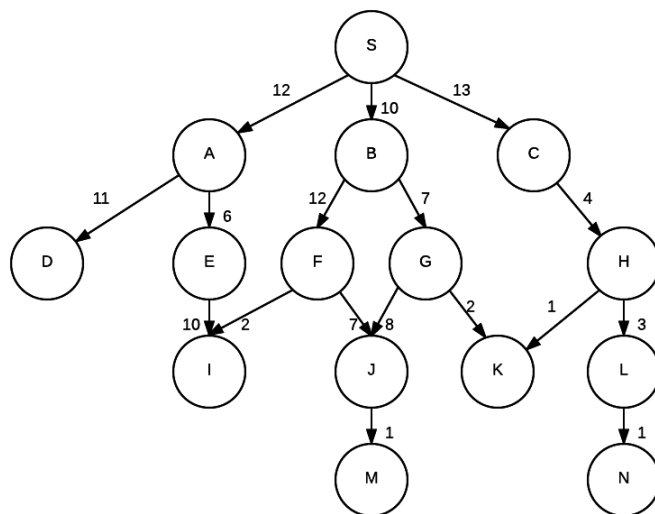

Figure 1: **Question 2, 3 Graph**

Given the above graph in Figure 1, assume node S is the start state and nodes K, M, and N are goal states. Execute each of the following search algorithms like we did in class. Assume expansion happens from left to right. If you encounter a tie, expand the node that comes first alphabetically (e.g., B before D). For full credit, be sure to show the *Expanded* (2 pts) and *Frontier* (2 pts) node lists at each step. Give the final path to the solution you found, along with the corresponding total cost (1 pt for both).

2.1

(5 pts) Breadth-First Search (BFS)

- 2 pts Expanded list, 2 pts Frontier list (see Table 1)

- 1 pt: Path S-B-G-K, Cost: $10 + 7 + 2 = 19$

Expanded	Frontier
	{S}
S	{ A, B, C}
A	{ B, C, D, E}
B	{ C, D, E, F, G}
C	{ D, E, F, G, H}
D	{ E, F, G, H}
E	{ F, G, H, I}
F	{ G, H, I, I, J}
G	{ H, I, I, J, J, K}
H	{ I, I, J, J, K, K, L}
I	{ I, J, J, K, K, L}
I	{ J, J, K, K, L}
J	{ J, K, K, L}
J	{ K, K, L, M}
K	{ K, L, M, M}

Table 1: **2.1 Expanded and Frontier Lists**

2.2

(5 pts) Depth-First Search (DFS)

- 2 pts Expanded list, 2 pts Frontier list (see Table 2)

- 1 pt: Path *S-B-F-J-M*, Cost: $10 + 12 + 7 + 1 = 30$

2.3

(5 pts) Uniform-Cost Search (UCS)

- 2 pts Expanded list, 2 pts Frontier list (see Table 3)

- 1 pt: Path *S-C-H-K*, Cost: 18

Expanded	Frontier
	$\{S\}$
S	{ A, B, C }
A	{ D, E, B, C }
D	{ E, B, C }
E	{ I, B, C }
I	{ B, C }
B	{ F, G, C }
F	{ I, J, G, C }
I	{ J, G, C }
J	{ M, G, C }
M	{ G, C }

Table 2: **2.2 Expanded and Frontier Lists**

Expanded	Frontier
	$\{S\}$
S	{ B:10, A:12, C:13 }
B	{ A:12, C:13, G:17, F:22 }
A	{ C:13, G:17, E:18, F:22, D:23 }
C	{ G:17, H:17, E:18, F:22, D:23 }
G	{ H:17, E:18, K:19, F:22, D:23, J:25 }
H	{ E:18, K:18, L:20, F:22, D:23, J:25 }
E	{ K:18, L:20, F:22, D:23, J:25, I:28 }
K	{ L:20, F:22, D:23, J:25, I:28 }

Table 3: **2.3 Expanded and Frontier Lists**

2.4

(5 pts) Iterative-Deepening Search (IDS)

- 2 pts Expanded list, 2 pts Frontier list (see Table 4)

- 1 pt: Path *S-B-G-K*, Cost: 19

Expanded	Frontier
	$\{S\}$
S	$\{$ A, B, C$\}$
A	$\{$ B, C$\}$
B	$\{$ C$\}$
C	$\{$ $\}$
	$\{S\}$
S	$\{$ A, B, C$\}$
A	$\{$ D, E, B, C$\}$
D	$\{$ E, B, C$\}$
E	$\{$ B, C$\}$
B	$\{$ F, G, C$\}$
F	$\{$ G, C$\}$
G	$\{$ C$\}$
C	$\{$ H$\}$
H	$\{$ $\}$
	$\{S\}$
S	$\{$ A, B, C$\}$
A	$\{$ D, E, B, C$\}$
D	$\{$ E, B, C$\}$
E	$\{$ I, B, C$\}$
I	$\{$ B, C$\}$
B	$\{$ F, G, C$\}$
F	$\{$ I, J, G, C$\}$
I	$\{$ J, G, C$\}$
J	$\{$ G, C$\}$
G	$\{$ J, K, C$\}$
J	$\{$ K, C$\}$
K	$\{$ C$\}$

Table 4: **2.4 Expanded and Frontier Lists**

3 Informed Search

Refer once more to the graph in Figure 1. Assume the values for the heuristic function $h(n)$ are those listed in Table 5, where nodes K - N all have value 4. Assume once more that S is the start state. This time, assume node J is the goal state. Execute each of the following search algorithms like we did in class. Assume expansion happens from left to right. If you encounter a tie, expand the node that comes first alphabetically (e.g., B before D). For full credit, be sure to show the *Expanded* (2 pts) and *Frontier* (2 pts) node lists at each step. Give the final path to the solution you found, along with the corresponding total cost (1 pt for both).

Node	S	A	B	C	D	E	F	G	H	I	J	K - N
$h(n)$	5	1	7	1	3	4	1	1	4	1	2	4

Table 5: **Heuristic Function Values**

3.1

(5 pts) Greedy Best-First Search

- 2 pts Expanded list, 2 pts Frontier list (see Table 6)

- 1 pt: Path *S-B-F-J*, Cost: 29

3.2

(5 pts) A* Search

- 2 pts Expanded list, 2 pts Frontier list (see Table 7)

- 1 pt: Path *S-B-G-J*, Cost: 25

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Expanded	Frontier
	$\{S\}$
S	$\{$ A:1, C:1, B:7$\}$
A	$\{$ C:1, D:3, E:4, B:7$\}$
C	$\{$ D:3, E:4, H:4, B:7$\}$
D	$\{$ E:4, H:4, B:7$\}$
E	$\{$ I:1, H:4, B:7$\}$
I	$\{$ H:4, B:7$\}$
H	$\{$ K:4, L:4, B:7$\}$
K	$\{$ L:4, B:7$\}$
L	$\{$ N:4, B:7$\}$
N	$\{$ B:7$\}$
B	$\{$ F:1, G:1$\}$
F	$\{$ G:1, I:1, J:2$\}$
G	$\{$ I:1, J:2, J:2, K:4$\}$
I	$\{$ J:2, J:2, K:4$\}$
J	$\{$ J:2, K:4$\}$

Table 6: **3.1 Expanded and Frontier Lists**

Expanded	Frontier
	{S:5}
S	{ A:13, C:14, B:17}
A	{ C:14, B:17, E:22, D:26}
C	{ B:17, H:21, E:22, D:26}
B	{ G:18, H:21, E:22, F:23, D:26}
G	{ H:21, E:22, F:23, K:23, D:26, J:27}
H	{ E:22, K:22, F:23, L:24, D:26, J:27}
E	{ K:22, F:23, L:24, D:26, J:27, I:29}
K	{ F:23, L:24, D:26, J:27, I:29}
F	{ L:24, I:25, D:26, J:27}
L	{ I:25, N:25, D:26, J:27}
I	{ N:25, D:26, J:27}
N	{ D:26, J:27}
D	{ J:27}
J	{ }

Table 7: **3.2 Expanded and Frontier Lists**