CS4700 Foundations of Artificial Intelligence
Fall 2017
Assignment 1 (120 pts total)
Due Monday, October 2, 6pm on gradescope.com.
Start solution to each question on a new page.

You can discuss the hwk with other students but you need to write up the solution in your own words. Also, you can consult the textbook and the lecture slides but you are not allowed to search for a solution on-line.

1. **General AI (15 pts.)** Exercise 1.8 of Russell & Norvig (3rd edition).

2. **General AI (15 pts.)** Exercise 1.9 of Russell & Norvig.

3. **Uninformed search (20 pts.)** In the water-jug puzzle, we are given a 3-liter jug, named *Three*, and a 4-liter jug, named *Four*. Initially, *Three* and *Four* are empty. Either jug can be filled with water from a tap, *T*, and we can discard water from either jug down a drain, *D*. Water may also be poured from one jug into the other. There is no additional measuring device. We want to find a sequence of operations that will leave precisely two liters of water in *Four*. (First, convince yourself that this can be done!)

   a) **(10 pts.)** Formulate the water-jug problem as state-space search problem. That is, define the set of states, the operators, the start state, the goal test, and the path cost.

   b) **(10 pts.)** Draw a graph of all the distinct state-space nodes that are within three moves of the start node (state), label each node by its state description, and show at least one path to each node in the graph, by labeling each arc by the name of the appropriate operator. In addition to these nodes, draw also all of the nodes and arcs (properly labeled) on the path to the solution.

4. **Uninformed search (20 pts.)**

   a) **(5 pts.)** In your own words, state the difference between Tree search and Graph search in Fig. 3.7 from R & N.

   b) **(5 pts.)** Fig 3.14 shows uniform cost search. It’s almost identical to Graph search. Give a minimal size example to show why the final “else if” check is needed.

   b) **(10 pts.)** The algorithm selects a lowest-cost node from the frontier to expand. Suppose you want to find the longest possible path from start to end node (visiting each city at most once). Would selecting the highest-cost node on the frontier work? If so, why? If not, give an example of where this fails.
5. **Heuristic Search (15 pts.)**

See the graph in Figure 1. The start state is S and the goal state is Z. The numbers on the arcs indicate the cost of traversing that arc. Whenever the search algorithm requires a heuristic estimating function, use the following:

<table>
<thead>
<tr>
<th>n</th>
<th>S</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>h(n)</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

(a) **(5 pts.)** Using the graph in Fig. 1 and **uniform-cost search**: (1) list the nodes in the order they would be expanded; (2) list the nodes that lie along the final correct path to the goal.

(b) **(5 pts.)** Same as (a), but using **greedy search**.

(c) **(5 pts.)** Same as (a), but using **A* search**.

6. **Informed Search (10 pts.)** Construct an admissible heuristic that is not consistent.

7. **Game tree search α-β pruning (25 pts)**

These questions refer to the game tree in Figure 2.

(a) **(5 pts.)** What is the solution? That is, which move should be made next and what is the expected value of that move?

(b) **(5 pts.)** Using alpha-beta pruning (and standard left-to-right evaluation of nodes), how many of the leaves get evaluated? Indicate all parts of the tree that are cut off. Indicate the winning path or paths. Strike out all static evaluation values that do not need to be computed.
(c) (5 pts.) How does the answer to (b) change if right-to-left evaluation of nodes is used?

(d) (5 pts.) What do the answers to (b) and (c) imply about the benefit of choosing the right evaluation order for alpha-beta search? State a heuristic which can guide the search for the best evaluation-order; this may be domain-independent or specific to a particular game like chess. What would be the savings if the “perfect” evaluation order were used?

(e) (5 pts.) Explain why searches in game-playing programs generally go forward from the current position instead of backward from the goal.