Assignment 1
CSE 473 Autumn 2010

October 6, 2010

The assignment is graded out of 100 points and is due October 22 on paper in class. Please type your answers or print clearly.

Search (40 points)

Problem 1. (16 points) Chapter 3 of the text shows that bidirectional breadth first search uses space and time complexity $O(b^{d/2})$ as opposed to $O(b^d)$ for standard breadth first search. Consider an algorithm that takes as input a start node, a goal node, and an additional "middle" node. The algorithm then performs breadth first search from each of these three nodes in parallel, stopping when either (1) the frontiers for the start node and goal node overlap or (2) the frontier for the "middle" node overlaps with the frontier for the start node and the frontier for the goal node.
A. (4 points) What is the time and space complexity of this method, assuming nothing about the "middle" node?
B. (4 points) Assuming unit-cost edges, does this method find a shortest path? If no, under what additional assumptions does this method find the shortest path? Under what assumptions might it find a path that is near optimal?
C. (4 points) What is the time and space complexity of this method if we assume the "middle" node is distance d' from the start node and d'' from the goal node? Write the complexity in terms of b, d, d', and d''.
D. (4 points) Can you think of an application for which this algorithm might be a good idea (i.e. for which we could easily find a good "middle" node)?

Problem 2. (14 points) Consider a search problem like the Bucharest travel problem in the lectures and text book: nodes correspond to locations on a map and edge costs correspond to distances. Which of the following are admissable heuristics? Here we use the notation that $n.x$ and $n.y$ are the coordinates of node n and x^* and y^* are the coordinates of the goal.
A. (2 point) $h(n) = \sqrt{(x^* - n.x)^2 + (y^* - n.y)^2}$
B. (2 points) $h(n) = |x^* - n.x| + |y^* - n.y|$
C. (2 points) $h(n) = \min(|x^* - n.x|, |y^* - n.y|)$
D. (2 points) $h(n) = \max(|x^* - n.x|, |y^* - n.y|)$

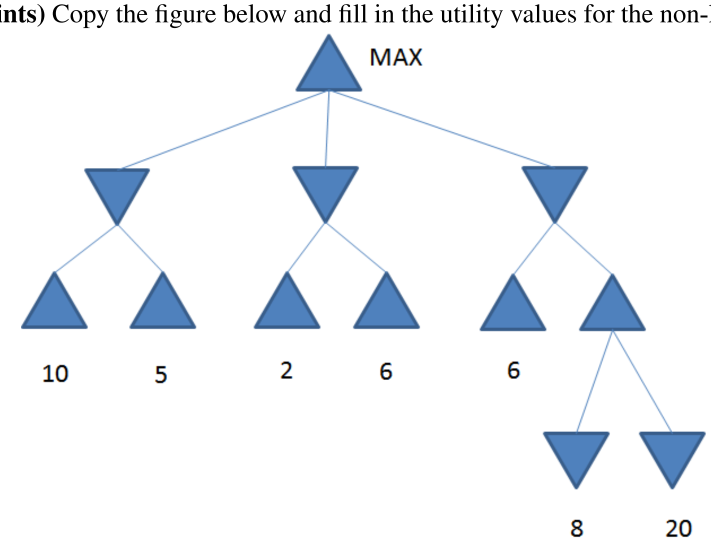
E. (2 point) $h(n)$ = shortest path distance from n to the goal in the original search graph
F. (2 points) $h(n)$ = shortest path distance from n to the goal in a graph consisting of the original search graph with additional edges added
G. (2 point) $h(n)$ = shortest path distance from n to the goal in a graph consisting of the original search graph with some edges removed

Problem 3. (10 points) Prove that if a heuristic is consistent it must be admissable.

Problem 4. Extra Credit (10 points) Read the sections of chapter 4 about genetic algorithms. A set of artistic photos is to be arranged on a web page. Assume the goal is to place n images on a page of a given width w and with height as small as possible such at all n images (which are rectangular and whose widths and heights are given but vary from one photo to another) are placed on the page with no images overlapping or going off the page. Formulate a genetic search for solving the problem. Be sure to explain how each of the following aspects figures into your formulation:
A. (2 points) representation of individuals (i.e., states)
B. (2 points) a suitable crossover operator
C. (2 points) a suitable mutation operator
D. (4 points) a suitable fitness function.

Adversarial Search (30 points)

Problem 5. (12 points)
A. (6 points) Copy the figure below and fill in the utility values for the non-leaf nodes.



B. (6 points) Cross out the nodes which the alpha-beta algorithm does not visit.

Problem 6. (18 points) Consider a two player game like Othello where the winner is the player who has the most pieces on the board at the end of the game.
Consider two different evaluation functions:

- A which returns 1 if the MAX player has more pieces, 0 if the players have an equal number pieces, and -1 otherwise
- B which returns the number of pieces MAX has on the board minus the number of pieces MIN has on the board.

A. (6 points) Assuming we search the entire game tree, which evaluation function is better? Why?
B. (6 points) If we use alpha-beta search, which evaluation function results in a faster search? Why?
C. (6 points) If we can't search the entire game tree, which evaluation function do you expect to perform better? Why?

Constraint Satisfaction (30 points)

Problem 7. (20 points) You're ordering a pizza for friends, and your friends have a few constraints.

- Bill wants peperoni and/or sausage on the pizza
- Thomas wants sausage or green peppers but not both
- If the pizza doesn't have Canadian bacon, then Jill wants green peppers
- If the pizza has Canadian bacon, then Jessica wants green peppers
- Bob wants Candian bacon or peperoni but not both
- If the pizza has green peppers, then Susan also wants onions

A. (5 points) Formulate the problem of ordering a pizza as a constraint satisfaction problem. Give variables, domains, and constraints.
B. (5 points) Draw the constraint graph for this problem.
C. (5 points) What about this constraint graph structure makes the problem easy or hard? (For this question, ignore the content of the constraints and just consider the structure of the constraint graph.)
D. (5 points) Trace the execution of the AC3 algorithm on this problem. Write down the order in which the variables are eliminated. What is the result?

Problem 8. (10 points) Explain why it is a good heuristic to choose the variable that is most constrained but the value that is least constraining in a CSP search.