Artificial Intelligence - Midterm Examination Solutions

Winter 2010

1. [15 points] **Small questions**

   (a) Can iterative deepening be used in game tree search? If yes, explain how, and what would be its advantages/disadvantages. If no, explain why not. (3 sentences)

   (b) True or false: Alpha-beta pruning with a heuristic evaluation function yields an optimal playing strategy against an optimal opponent

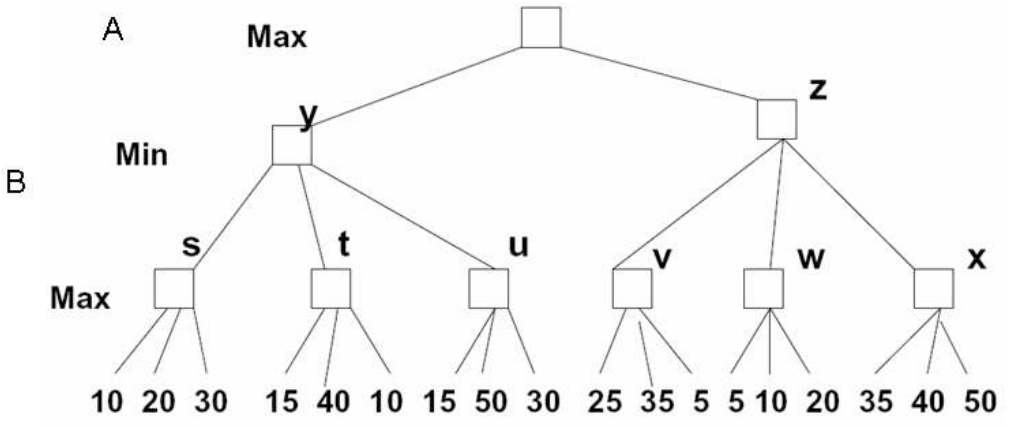
   (c) True or false: Monte Carlo tree search yields an optimal playing strategy against an optimal opponent

(d) Suppose you do simulated annealing and lower the temperature parameter very quickly. Will you find the optimal solution? Explain why or why not.

(e) Consider the following two bit strings: 01100000 and 10110111. Suppose that the fitness function is given by the number of bits that are 1. What should the crossover point be, in order to get in the next generation an individual with the highest possible fitness? Show the result of the crossover.

2. [10 points] **Game tree search**

   Consider the game tree below.



   (a) Use minimax to determine the best strategy for both players, and give the actions that would be chosen and their values.

   (b) How would you re-order the nodes in order to get maximal pruning when using the alpha-beta algorithm? Feel free to use the figure to show the re-ordering

3. [30 points] **Problem formulation**

   At the Olympic games, the organizers have to transport all the athletes from the hotel to the opening ceremony. To make things organized, they want to issue for each athlete a ticket with a given shuttle number. They use shuttles which can each carry 10 athletes. A shuttle cannot leave until it is full (we assume the number of athletes is a multiple of 10). Each athlete has to be assigned to exactly one shuttle. Athletes have a strong preference to travel with their team mates; so if an athlete travels with k athletes who are not from their own team, a cost of k is incurred. Costs incurred for all athletes are cumulated. So, for example, in a shuttle with 7 athletes from team A and 3 athletes from team B, the cost incurred for the shuttle would be $7 * 3 + 3 * 7$.

   (a) Formulate this as a search problem, specifying precisely all required components.

   (b) Explain what search method you would use to solve this problem, and why. Describe how your search method would be implemented for this problem.

(c) Suppose that instead of optimizing this cost function, the organizers just want to make sure that no shuttle has more than 3 teams inside. How does this change the type of search problem, and what search methods would you be using now?

4. [10 points] **Propositional Logic**

   Alice, Bob, Camilla and Dan are making plans for spring break. They go to the travel agency, but there are only 2 tickets left. Alice will only go if Bob goes too. Dan will only go if Camilla goes too. Bob has found out that he has to work on the AI project, so he cannot go.

   (a) Using 4 literals, write the propositional logic formulas corresponding to this text

   (b) Find (through a formal proof) who will go on vacation.

5. [15 points] **First-order Logic**

   Consider the following sentences. For each of them, explain if it can be written out in first-order logic. If your answer is yes, give the corresponding logical statement. If the answer is no, explain the difficulty.

   (a) All the existing kinds of birds can fly

   (b) Some existing kinds of birds can fly

   (c) At least two existing kinds of birds can fly

   (d) Most existing kinds of birds can fly

   (e) All existing kinds of birds can fly, except two.

6. [10 points] **STRIPS**

   A Mars rover can pick up a rock if its gripper is empty, and if it has room in its carrying container. The carrying container has a limited capacity of 2 rocks. Once a rock is picked up, it is put in the carrying container and the capacity of the container decreases by 1 unit. The rover can drop off a rock only at the base. To reach the base, the rover needs to have enough fuel. To refuel, the rover must be at the base. After refueling, the tank is full again. Write the descriptions of the PickUp, DropOff, Refuel and ReturnToBase actions in the STRIPS planning language Specify clearly the literals you use, as well as the preconditions and postconditions (add-lists and delete-lists) for each action.

7. [10 points] A^* **search**

Suppose you have a heuristic function h such that $h(n) \geq h^*(n)/2$ (but h is not necessarily admissible). Let c^* be the cost of the optimal path to goal, and assume all costs are positive. Prove that if A^* search with the heuristic h expands a node n_1 , then this node must lie on a path from the initial state to some goal node with total path cost $f^*(n_1) \leq 2c^*$. (Or equivalently, prove that A^* search never expands a node n_2 such that all paths from the initial state to a goal node via node n_2 have path cost greater than $2c^*$).