CMSC 471/671 -- Artificial Intelligence

Midterm Exam

October 20, 1998

"MIND, n. A mysterious form of matter secreted by the brain. Its chief activity consists in the endeavor to ascertain its own nature, the futility of the attempt being due to the fact that it has nothing but itself to know itself with. From the Latin mens, a fact unknown to that honest shoe-seller, who, observing that his learned competitor over the way had displayed the motto "Mens conscia recti," emblazoned his own front with the words "Men's, women's and children's conscia recti."
-- Ambrose Bierce (1842-1914), "The Devil's Dictionary", 1911.

This exam is closed book. The points sum to 100. Good luck.

1. Unification in Prolog [10]

For each of the following pairs of Prolog terms, say whether or not the unification would succeed and, if it does, what the most general common instance would be. Assume that the same variable name in two different terms in a given pair represents the same variable.

TERM1	TERM2	Unify?	MGI if any
X	loves(john,mary).		
p(X, q(Y), r(Z))	p(r(a), q(X), r(b))		
loves(john, X)	loves(Y,Y)		
and(father(P1, P2), brother(P1, P3))	and(father(X, john), brother(john, john))		
foo(X)	X		
[X, Y | Z]	[a, b, c, d, e, f, g]		
[ ]	X		
[X, Y]	[a, b | Z]		
A + B - C	'+'(1, '-'(2, 3))		
2+3	3+2		

2. *Prolog mystery predicate [15]*

Consider the following mystery predicate:

```
p([ ],[ ]).
p([A|B], C) :-  p(B, D),  append(D, [A], C).
```

where append has the usual definition.

(a) [10] Describe what would happen for each of the following queries in terms of the kinds of errors that would result or the solutions(s) that would be found. If more than one solution would be found, characterize them all.

- p([a,b,c,d,e],X).

- p(X,[a,b,c,d,e])

- p(X,Y).

(b) [5] Describe what this predicate does in a simple sentence.

3. *Cut in Prolog [15]*

Let the predicate $\min(N1,N2,Min)$ be true if Min is the smaller of N1 and N2. Assume all three arguments are integers.

Consider the following definition of min/3:

        min(N1, N2, N1) :- N1 =< N2, !.
        min(N1, N2, N2).

(a) [6] Describe what will happened for each of the following goals:

- min(1,2,X).

- min(1,2,2).

- min(X,3,3).

(b) [9] Write the min/3 predicate without using the cut symbol. Make sure your predicate works whenever the first two arguments are instantiated to integers. The third argument can be either an integer or an uninstantiated variable. That is, the mode would be described as min(+N1,+N2,?N3).
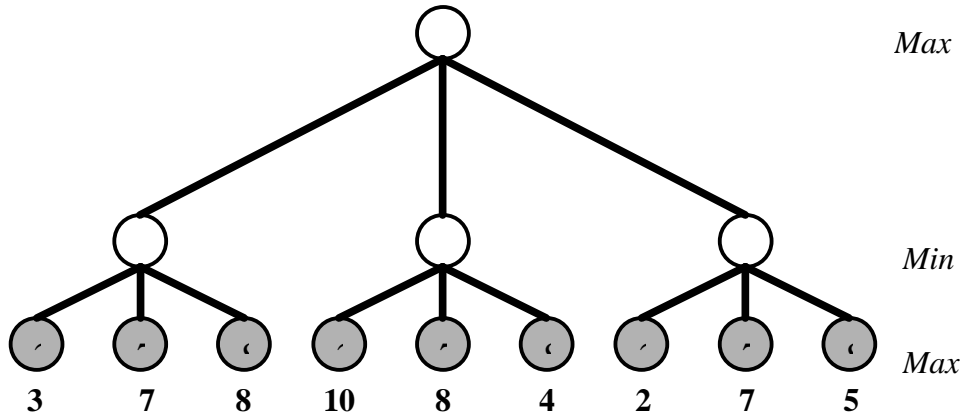
4. *Hill-Climbing Search [10]*

(a) [2] True or False: Given the appropriate evaluation function, hill-climbing search can be made both complete and admissible for some problem domains.

(b) [4] What is a main advantage of A* search over hill-climbing search?

(c) [4] What is a main advantage of hill-climbing search over A* search?

5. *Game Playing [20]*

Consider the following tree for a game

(a) [4] In the figure above, fill in the backed-up values that are computed by the minimax algorithm for the four nodes at depths 0 and 1. The leaf nodes show the values of the evaluation function applied at those nodes.

(b) [8] Now circle the nodes that would not be generated (i.e., would be pruned) by the alpha-beta algorithm assuming children are visited left-to-right.

(c) [8] Reorder the children of the root node and the children of the three nodes at depth 1 so that alpha beta prunes the **maximum** number of possible nodes. Assume children are visited left-to-right. Do not change any node's parent when you reorder..Again, circle the nodes that would not need to be generated
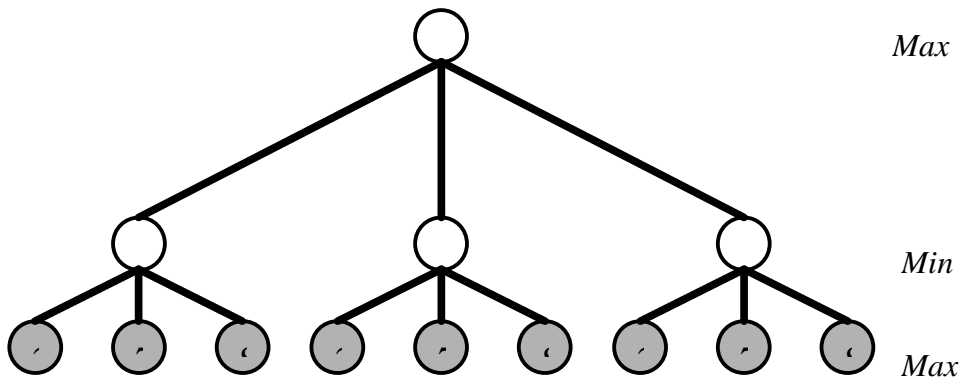
6. Comparing Search Strategies [10]

Four criteria were defined for comparing search strategies: completeness, optimality (or admissibility) , time complexity, and space complexity.   For each of the following statements, specify which of these four criteria best explains why it is true. Note -- each statement should get only one of the four criteria and they can be different.

(a) Iterative-Deepening search is usually preferred over Breadth-First search.

(b) Iterative-Deepening search is usually preferred over Depth-First search.

(c) Alpha-Beta search is usually preferred over Minimax search.

(d) A* search is usually preferred over Greedy search.

(e) Algorithm A might be preferred over A* search.

(f) Bidirectional search is usually preferred over Breadth-First search.

7. *Game Trees [20]*

The game of Nim2 is played as follows: Initially, there are two piles, each containing two sticks. Two players alternate turns, and at each turn the current player removes any positive number of sticks from any one pile. At least one stick must be removed during a turn. The player who's turn it is when there are no more sticks to remove wins. Say we represent a state in this game as a triple:

<div align="center">StickInPile1 / SticksInPile2 / Player</div>

where Player is either A or B and indicates which player's move is next. Player A goes first, so the initial state is 2/2/A.

(a) [12] Draw the complete game tree for Nim2. Show this as a tree, so states may be repeated.

(b) [6] Assume you are Player A, and a winning state for A is assigned a utility value of +1, and a winning state for B is assigned a utility value of -1. Compute the minimax values for each of the states in the tree shown in your answer in (a). Write the values next to the nodes in your answer in (a).

(c) [2] Note that the **complete game tree** was used in to compute the minimax values at all nodes based on true utility values at **final game positions**. What can we therefore conclude about the game of Nim2?