VANCOUVER ISLAND UNIVERSITY
CSCI 485 — FINAL EXAMINATION
13 DECEMBER 2010, 9:00 - 12:00

TO BE ANSWERED IN BOOKLETS DURATION: 3 Hours

INSTRUCTOR: H. Liu

Instructions

- Students must count the number of pages in this examination paper before beginning to write, and report any discrepancy immediately to the invigilator.
- This examination paper consists of 7 pages.
- This is a CLOSED BOOK examination. Only one piece of double-sided, Letter-sized note is allowed.
- Remember to state any assumptions and show rough work.
- Note carefully the weight of each question, and answer appropriately.
- Attempt all questions. All questions relate to material covered in the lectures, labs, assignments and student presentations.

1. (15 marks) Given the following definition of a standard search problem:

States: $A, B, C, D, E,$ and F
Actions: e_i, i from 1 to 14
Successor functions:
Successor function of A: $\{< e_1, B >, < e_2, C >, < e_3, D >\}$
Successor function of B: $\{< e_4, C >, < e_5, F >\}$
Successor function of C: $\{< e_6, B >, < e_7, E >, < e_8, F >\}$
Successor function of D: $\{< e_9, A >, < e_{10}, B >, < e_{11}, E >\}$
Successor function of E: $\{< e_{12}, B >, < e_{13}, F >\}$
Successor function of F: $\{< e_{14}, C >\}$

Initial State: A

Goal State: F

Step cost matrix (The first column denotes the from-state):

	A	B	C	D	E	F
A	0	15	4	18	-	-
B	-	0	30	-	-	50
C	-	9	0	-	8	14
D	17	12	-	0	11	-
E	-	7	-	-	0	6
F	-	-	5	-	-	0

Heuristics for each state:

	A	B	C	D	E	F
h	17	33	11	12	3	0

Your tasks:

(a) Draw the state space graph for the breaths-first search, the depth-first search (avoiding the repeated states), the greedy search and the A* search. While drawing the graph, indicate in which order the nodes would be expanded respectively for each search strategy.

(b) Is the heuristics provided admissible? Why or why not?

2. (15 marks) Cyclic ordering problem is defined below:

> Given a finite set, A, and a collection, C, of ordered triples $\langle x_1, x_2, x_3 \rangle$ of distinct elements from A, find a one-to-one mapping function $f : A \to \{1, 2, 3, \ldots, |A|\}$ such that for each $\langle x_1, x_2, x_3 \rangle$ in C, one of
>
> $$f(x_1) < f(x_2) < f(x_3);$$
> $$f(x_2) < f(x_3) < f(x_1);$$
> $$f(x_3) < f(x_1) < f(x_2)$$
>
> holds.

Here is an instance of the cyclic ordering problem:

$A = \{\text{a, b, c, d, e, f, g}\}$
$C = \{\langle \text{c, e, f} \rangle, \langle \text{f, d, e} \rangle, \langle \text{e, a, g} \rangle\}$

(a) Define this instance of cyclic ordering problem as a constraint satisfaction problem.

(b) If we decide to use backtracking algorithm plus variable and value ordering heuristics to solve this problem, which variable should we pick first to assign a value, and why?

(c) Suppose we already mapped d to 5 and f to 3, which values would remain in the domains of e and c?

(d) Describe the forward checking heuristic and briefly explain why using this heuristics would help to improve the efficiency of backtracking search.

3. (10 marks) PR2 is a two-armed, wheeled robot. It is being developed by Willow Garage, a robotics research lab in California. The name stands for "Personal Robot". Each of the robot's two arms can lift up to 1.8 kilograms. It has two cameras and a 3D laser scanner to help it picture the world and to identify objects.
   In the future, it is hoped that this machine could assist with a number of household tasks, e.g., cleaning carpets or mowing the lawn, turning on microwave ovens, washing machines and toasters, and picking up sandwiches, cups, etc. A prototype version of PR2 has already demonstrated the folding of towels.
   Discuss the AI components used in PR2. Do you think this kind of projects meaningful? Why or why not?

4. (10 pts) Below is the pseudo code of the minimax algorithm:

```
utilityValue MinimaxValue(state, game)
{
    if TerminalTest(state) then
       return Utility(state);
    else if MAX is to move in state then
       return the highest MinimaxValue of Successors(state, game);
    else
       return the lowest MinimaxValue of Successors(state, game);
}
```

   (a) Briefly explain why this algorithm works well in a two-player, turn-taking and zero-sum game.

   (b) How would you change the above mentioned minimax algorithm so that it would work reasonably well in a two-player, turn-taking and **non-zero-sum** game? Assuming that each player has its own utility function and each player knows the other's utility function.

5. (20 marks) The following sentences describe an extremely simplified knowledge base about an academic institute:

   (a) There are the following courses offered: CS120, CS240, CS360, CS454, CS462.

   (b) A person must register to become a student in the institute.

   (c) Only students can enroll in the courses offered.

   (d) For a student to get the credit of a course, he/she must enroll in the course in a term and then pass the course in that term.

   (e) For a student to graduate, he/she must have the credits of CS120, CS240, CS360, and either CS454 or CS462.

   (f) Glenn Mellon has registered in the institute since 2007.

   (g) Glenn Mellon enrolled in CS120 in Fall 2007 and passed.

   (h) Glenn Mellon enrolled in CS240 in Winter 2008 and failed.

   (i) Glenn Mellon enrolled in CS240 in Spring 2008 and passed.

   (j) Glenn Mellon enrolled in CS360 in Fall 2008 and passed.

   (k) Glenn Mellon enrolled in CS454 in Winter 2009 and failed.

   (l) Glenn Mellon enrolled in CS462 in Spring 2009 and passed.

   Your tasks:

   (a) Using First-Order Logic, write down logical representations for the knowledge base, suitable to be used in inference using Generalized Modus Ponens.

   (b) Using either the lifted forward-chaining or the lifted backward-chaining algorithm, prove that Glenn Mellon can graduate now. Draw the proof tree.

6. (10 marks) In the following pairs of First-Order Logic sentences, P, R, S, T and Q are predicates, F and G are function, A, B and C are constants and x, y, and z are variables.

   (a) P(A, B, C), P(x, y, C)

   (b) R(x, F(x, x)), R(F(A, B), z)

   (c) S(F(x, x), F(A, B)), S(F(y, z), F(y, z))

   (d) T(F(x, y), G(x, y)), T(x, G(A, B))

   (e) Q(F(A, x), B), Q(F(x, y), z)

   For each pair of the sentences, give the most general unifier (substitution list) if it exists. If the unification is not possible, explain the reason briefly.

7. (10 marks) The following table shows the statistical growth data about a type of tree:

age	height
10	10.8
20	15.5
30	20.1
40	24.9
50	29.7

   (a) Draw a rough graph about the relationship of a tree's age and height, and describe what kind of functions could be used to predict a tree's height based on its age. Justify your answer.

   (b) If you are asked to use the formula you just found to predict the height of three trees that are 2 years old, 35 years old and 100 years old respectively, are you confident that the predictions would be reasonable for all of them or any of them? Why or why not?

8. (10 marks) The following table summarizes a data set with three attributes A, B, C and two class labels + and -.

			Number of Instances	
A	B	C	+	-
T	T	T	5	0
F	T	T	0	20
T	F	T	20	0
F	F	T	0	5
F	T	F	25	0
F	F	F	0	25

(a) Draw a decision tree according to the data provided above.

(b) How do you decide which attribute to be chosen as the first attribute to build your decision tree?

********** END OF QUESTIONS **********