UNIVERSITY EXAMINATIONS

UNIVERSITEITSEKSAMENS

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COS3751

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TECHNIQUES OF ARTIFICIAL INTELLIGENCE

Duration 2 Hours

100 Marks

EXAMINATION PANEL AS APPOINTED BY THE DEPARTMENT

Use of a non-programmable pocket calculator is permissible

Closed book examination

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Examiners :	
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Second	Prof E van der Poel
External	Dr WS Leung (UJ)

Instructions

1 Answer all questions

2 Write neatly and legibly

3 The table in the appendix is provided to help during your entropy and information gain calculations

4 This paper consists of 7 pages including Appendix A (page 7)

[TURN PAGE]

Question 1	State Spaces	[14]

(a) Differentiate between an *agent function* and an *agent program* (2)

(b) Differentiate between discrete and continuous environments Provide an example of each (4)

(c) Consider a game in which two players take turns to remove items from a heap of items Each player can only take from 1 to 3 items from the heap The goal of the game is to be the last player to take something from the heap (i e the winner is the player that takes the last items from the heap, and there are no more items to take once this move has been made)

Suppose the game is set up to start with 5 items in the heap, the two players are player A and player B, and player A should move first

i Define a state representation for the game (2)

ii Using this representation define an applicable action for a state in the game, also define what the action will return (3)

iii Suppose a player wants to take 2 items from the heap at the start of the game Codify (translate/implement) this using the action you defined in the previous question Clearly show the state resulting from the application of the action (3)

Question 2	Searching	[19]

(a) Explain how a uniform cost search differs from a breadth first search Pay attention to the data structure that is used in each (4)

(b) Consider figure 1

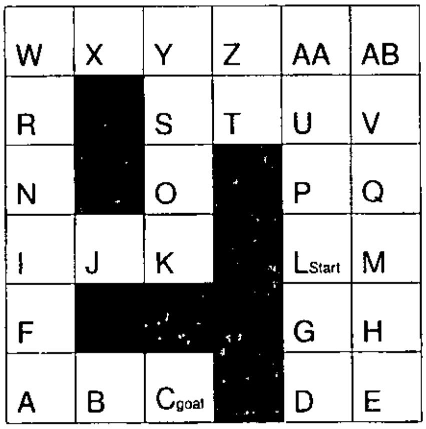

Figure 1 A* Search

In the above figure, black squares represent obstacles, and the open squares (those with letters in them) represent moveable areas for an agent An agent is placed in an open square and may move to any other open square adjacent to that square The agent cannot move to a black square

i Assume that an A-star search is employed, and C is the goal An agent can move either vertically, horizontally, or diagonally The step cost for a vertical or horizontal move to an adjacent square is 1, while the cost for a diagonal move to an adjacent square is 2 The search employs the Manhattan-distance heuristic This heuristic

counts the number of horizontal and vertical moves (no diagonal moves are considered in the application of the heuristic) that should be made from one square to another, and ignores obstacles, i e every square is considered to be a valid place to move to, whether there is an obstacle there or not
Suppose the start is L Show the frontier after L is expanded Include $\hat{f}, \hat{g}$, and $\hat{h}$ values for each node (path) you place in the frontier (8)

ii Is the heuristic employed in the previous question admissible? Justify your answer (2)

(c) Consider the state-space graph in figure 2

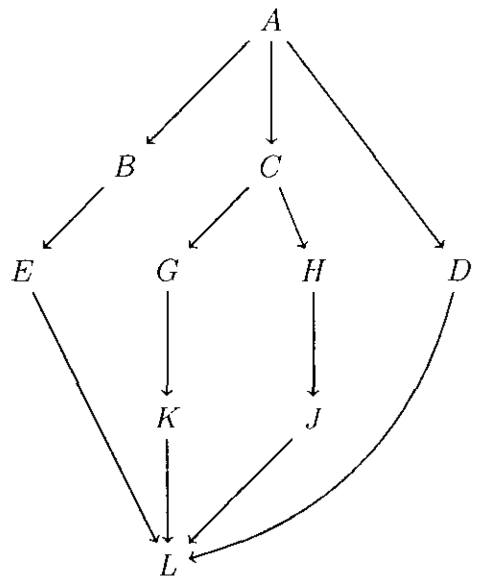

Figure 2 State-space graph

Assume that a breadth first search is employed, and that the start node is A and the goal node is J Write down the order in which the nodes are generated (expansion proceeds in a left to right fashion) Continue until the goal test is successful (5)

Question 3	Adversarial Search	[12]

Consider the game tree in figure 3 and then answer the questions that follow (the static utility values for the leaf nodes are provided below each leaf node) Circles represent MAX level nodes, and squares represent MIN level nodes

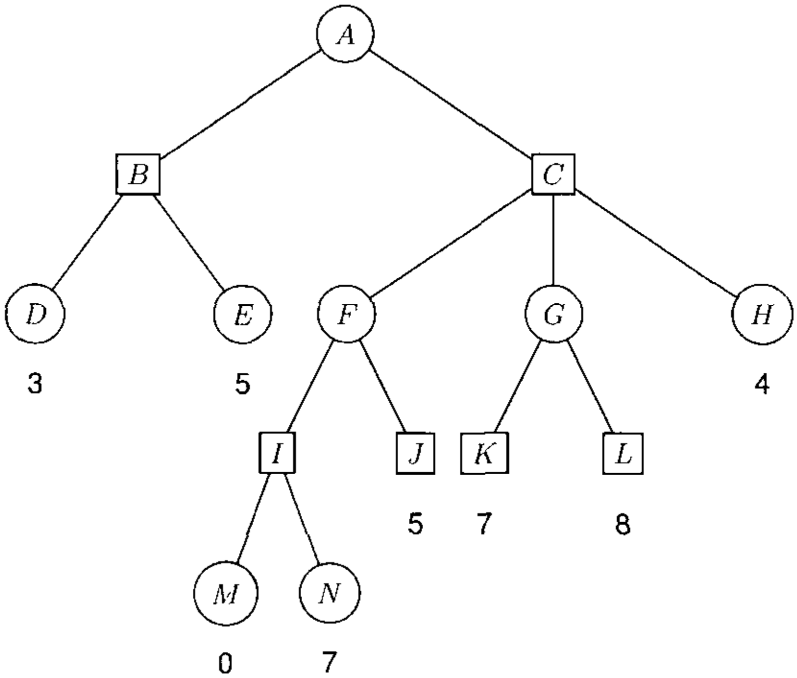

Figure 3 Adversarial Search Tree

(a) Suppose a Minimax search is performed on the tree Provide the min-max values for nodes A B C, and F (4)

(b) Suppose a Minimax search with Alpha/Beta pruning is done in a left-to-right fashion on the tree Provide the α and β values for nodes A, B, C, and F which would have been recorded during the search (the values when the search terminates) (8)

Question 4	Constraint Satisfaction Problems	[15]

(a) Consider a slightly relaxed version of the Magic Square (figure 4)

M_{11}	M_{12}	M_{13}
M_{21}	M_{22}	M_{23}
M_{31}	M_{32}	M_{33}

Figure 4 Magic Square for $n = 3$

For this magic square, each cell can be assigned the value 1, 2, or 3 The values should be assigned to the cells in such a way that the values for each row adds up to 6, the values for each column adds up to 6, and at least one of the diagonals should add up to 6

This problem can easily be presented as a Constraint Satisfaction Problem

i Define the variables for this problem Provide appropriate notation for your answer. (2)

ii Define the domains for the variables of this puzzle (2)

iii Provide the constraints for this problem (7)

iv If the value 1 is assigned to entry M_{11} then make the remaining variables domain consistent (4)

Question 5	Propositional Logic	**[3]**

(a) Explain what is meant by the **resolution closure** of a set of clauses, and how it can be used to show that a set of clauses is not satisfiable (3)

Question 6	Resolution Refutation	**[23]**

The following English statements are given

1 Anything that anyone eats and is not killed by eating it, is food

2 John eats any kind of food

3 Apples are food

4 Chicken is food

5 Bill eats peanuts, and is not killed by eating it

6 Sue eats everything that Bill eats

(a) Convert the statements to First Order Logic statements The first statement has been provided already, convert the rest Remember to standardise your variables (7)

1 $\forall y, z[eats(y, z) \wedge \neg killedfromeating(y\ z) \Rightarrow food(z)]$

(b) Convert all of the FOL statements above to Conjunctive Normal Form (including the statement that was provided) **Hint:** First think carefully what it means for a statement to be in conjunctive normal form (7)

(c) Use resolution refutation to prove that John eats peanuts, using the assumptions in the paragraph above (9)

Question 7	Machine Learning	[14]

(a) Software engineering projects are notorious for failure. Project management consultants are often requested to take over projects, which means they need to decide if the project is a risk, or not. Consider table 1 (which is used to determine if a project can safely be taken over).

Project Nr	Budget	Time-line	Resources	Sentiment	Take over?
1	Under	Ahead	Available	Positive	Yes
2	Over	Late	Available	Positive	Yes
3	On Target	Ahead	Available	Positive	No
4	Over	Late	Understaffed	Negative	No
5	On Target	On-time	Understaffed	Negative	Yes
6	On Target	Late	Available	Positive	Yes
7	Over	Ahead	Available	Negative	Yes
8	Under	On-time	Available	Negative	No
9	On Target	Ahead	Available	Negative	Yes
10	Over	Late	Available	Positive	No

Table 1: Project Take-over

i. Using the entropy table on page 7, calculate the entropy for the 'Take Over' variable (show your calculations). (2)

ii. Using the principles of Information Gain when building a search tree, it has been determined that the first node of the tree should be *Time-Line*. The tree will thus have three branches under the Time-line node: Ahead, Late, and On-time, as presented in figure 5.

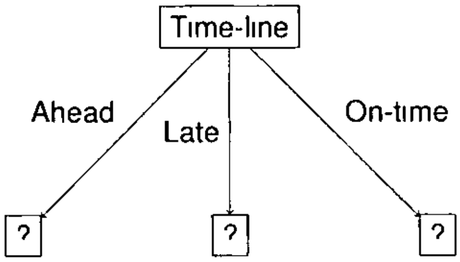

Figure 5: Partial decision tree

Which attribute should be chosen for the Ahead branch under Time-line? Show all your calculations. Refer to the table on page 7 for entropy values. Round the answers for your remainder calculations to the nearest two digits ($\frac{1}{100}$) (for example $0.984 \simeq 0.98$, and $0.986 \simeq 0.99$). (12)

Total: 100

A Entropy Table (Boolean valued variables)

p Ratio of positive examples
E Corresponding entropy $(-(plog_2 p + (1-p)log_2(1-p)))$

p	E
0 00	0 00
0 10	0 47
0 15	0 61
0 20	0 72
0 25	0 81
0 30	0 88
0 35	0 93
0 40	0 97
0 45	0 99
0 50	1 00
0 55	0 99
0 60	0 97
0 65	0 93
0 70	0 88
0 75	0 81
0 80	0 72
0 85	0 61
0 90	0 47
0 95	0 29
1 00	0 00

Example For a set of 4 positive examples, and 1 negative example (written $E[4,1]$), the ratio $p = \frac{4}{5}$, or $0\ 80$ The corresponding entropy value is given by the table as $0\ 72$

Always round the ratio to the nearest value on the table, for example For $E[2,1]$, the ratio is $p = \frac{2}{3} \simeq 0\ 67 \simeq 0\ 65$, which makes the $E[2\ 1] = 0\ 93$