The University of Nottingham
Malaysia Campus

SCHOOL OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

A LEVEL B MODULE, AUTUMN SEMESTER 2005-2006

ARTIFICIAL INTELLIGENCE METHODS

Time allowed TWO Hours

Candidates must NOT start writing their answers until told to do so

Answer THREE questions out of FIVE.

No calculators are permitted in this examination.

Dictionaries are not allowed with one exception. Those whose first language is not English may use a standard translation dictionary to translate between that language and English provided that neither language is the subject of this examination. Subject specific translation dictionaries are not permitted.

No electronic devices capable of storing and retrieving text, including electronic dictionaries, may be used.

DO NOT turn examination paper over until instructed to do so

1. A population of 10 individuals in the first generation is tabulated in Table1.1. The first column of the table denotes the index number that identifies the individuals, the last column is their hypothetical fitness, while their genotypic structures are given in the other 9 columns. Two schemata H1 and H2 are defined in Table2.

index	1	2	3	4	5	6	7	8	9	fitness
1	0	1	1	0	0	1	1	0	1	2
2	0	0	**1**	1	0	1	0	1	0	20(H1)
3	1	1	1	1	1	1	1	1	0	1 (H2)
4	0	1	0	1	1	1	1	0	1	1
5	0	0	0	1	1	1	1	0	0	2
6	0	1	**1**	0	**0**	0	1	1	0	30
7	0	0	0	1	1	0	0	1	1	1
8	1	1	0	1	1	1	0	0	0	2 (H2)
9	0	1	0	1	0	1	0	1	0	10
10	0	0	**1**	1	**0**	0	1	1	0	25

Table1.1 A population of individuals in the 1st generation.

H1	*	*	**1**	*	**0**	*	*	**1**	**0**	
H2	**1**	**1**	*	**1**	**1**	*	*	*	*	

Table1.2. The structures of two schema H1 and H2.

(a) The purpose of this question is to calculate the estimate numbers of the two schemata.

i) Give the formula of the estimate growth of a schema and calculate the orders and the defining lengths of H1 and H2.

[2 marks]

ii) Estimate the expected number of the two schemata in generation 1 and discuss the results.
Assume that the probability of a schema (already in one parent) being also present in the corresponding mating parent is nil. Also, assume that Pc = 0.65 and Pm = 0.01.

[8 marks]

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(b) This part of the question deals with the simulation of the evolutionary computing process.

i) Assume that probability of crossover (Pc) is 1.0 and the probability of mutation (Pm) is 0.0. Here we use a binary tournament selection to populate the mating pool. The indexes of the randomly selected individuals for the mating slots are given in the following list.

Couple1: < (3,6) , (9,1)> ; Couple2: < (5,3) ; (8,10)> ; Couple3: < (2,3) ; (7,10)>;

Couple4: < (2,4) , (5,3)> ; Couple5: < (6,4) ; (7,4)>

The crossover sites are also given in the following list: <5,2,3,7,7>.

Compute the next generation. (An individual cannot live in more than one generation).

[10 marks]

ii) Discuss how the two schemata H1 and H2 performed in this one iteration evolutionary process.

[5 marks]

2. This questions concerns genetic programming.

In the following program, some logical operators have been indexed with subscript numbers ($NAND_1$, $NAND_2$, AND_3) for the sake of easy referencing. The numbers do not carry any semantic or syntactic meaning.

[((D1 $NAND_1$ D2) $NAND_2$ D0) NOR (D2 NOR (D4 NOR D3))] AND
[(D3 $NAND_1$ (D4 NAND D2)) $NAND_2$ (D1 AND_3 D3)]

(a) Create a program tree corresponding to the above expression.

[6 marks]

(b) Create two subroutines ADF1 and ADF2 such that:

i) ADF2 encompasses the nodes $NAND_1$ and $NAND_2$.

[2 marks]

ii) ADF1 encompasses the nodes $NAND_1$,$NAND_2$ and AND_3.
It should use ADF2.

[4 marks]

iii) Update the main program tree.

[4 marks]

iv) Duplicate the first parameter of ADF1 and update the whole tree accordingly.

[4 Marks]

(c) The three genetic operators used in altering the individual programs in genetic programming are given below. Briefly explain each of them and state their frequency of occurrences.

i) Crossover. [1 Mark]

ii) Mutation. [1 Mark]

iii) Architecture altering operators. [3 marks]

3. This question concerns the ant cycle algorithms.

(a) After *n*-2 transitions (*n* is the number of cities), how many cities are in the tabu list and what is the probability (probabilities) to transit to the remaining city (cities)?

[3 marks]

(b) What are the roles of the parameters α and β. If $\alpha = 0$, what kind of a search technique will the ant-cycle algorithm become?

[4 marks]

(c) Draw a figure in which you show the Ant-cycle behaviour for different combinations of α-β parameters in the probabilistic transitional formulae.
Explain the behaviour of the Ant cycle algorithm based on different setting of the aforementioned parameters.

[6 marks]

(d) Explain the difference between exploration and exploitation in population-based search techniques. With regards to Ant Systems, state and explain the two factors responsible of driving the *exploration* aspect and the *exploitation* aspect of the algorithm.

[4 marks]

(e) Contrast between Ant Systems and Genetic Algorithms in terms of: exploration, exploitation, stopping condition, and elitism.

[8 marks]

4. The first part of this question concerns fuzzy logic, while the reminder deals with knowledge representation.

(a) Table 4.1 given below summarises the information describing a set of houses on sale.

House	*Expensiveness (given in Price)*	*ClosenessToWork (Given in Distance)*	*Neighbourh ood Index*	*GoodInvestment (FuturePrice)*
H1	130K	45	4	136
H2	200K	60	6	220
H3	380K	50	7	400
H4	60K	10	2	62
H5	170K	45	4	175

Table4.1 data for cars alternatives

In order to decide which house to buy, one needs to consider a few criteria. Assume one wants to choose one house amongst the five alternatives (H1,…,H5) given in Table4.1. Below, are the specifications (formula) of how to compute the fuzzy data pertaining to each criterion.

The fuzzy data of each car alternative is computed according to the formula, specific to each criterion, given below.

- The fuzzy concept of *expensiveness* is computed as: (Price) / 400.
- The fuzzy concept of *ClosenessToWork* is computed by: (80 – *Distance) /10.*
- The fuzzy *Neighbourhood_Index* is computed by: *Neighbourhood_Index /10.*
- The fuzzy concept of *goodInvestment* is computed as:
  (*FutureEstimatePrice – Price) /Price*.

i) For each alternative, compute the corresponding fuzzy data based on the formula given above. Report your results in a table similar to Table4.1.
[6 marks]

ii) Give the formulae of the support of a fuzzy set A. Is the support of a fuzzy set fuzzy?
[2 marks]

iii) Is any of the fuzzy concepts in Table4.1 normal? Explain. Compute the support of each fuzzy concept in Table4.
[3 marks]

iv) Give the formulae of the ***strong*** α-cut of a fuzzy set A.
What is a support of a fuzzy set in terms of ***strong*** α-cut?
[3 marks]

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(b) This part of the question concerns the knowledge representation.

i) There are 4 primitive conceptualisations in Conceptual Dependency Theory, from which the world of meaning is built. State these 4 primitives.
[2 marks]

ii) Using the Conceptual dependency Theory, model the following phrase:
"I am getting better" [3 marks]

iii) With respect to the Semantic Networks, what is meant by a Case Frame? Use the case Frame technique to model the following phrases:

The dealer has sold the first house.
He will Choose the best house with the help of this AI model.
[6 marks]

5. This question deals with meta-heuristics search algorithms.

(a) i) Write down the hill-climbing algorithm as shown in the lecture (assume the evaluation function is being maximised). Explain each part and step of the algorithm.
[8 marks]

ii) How would you change the algorithm when the optimisation is a minimisation (hill-descending) problem?
[2 marks]

iii) Explain two major problems with hill-climbing algorithm and propose solutions to avoid them.
[5 marks]

(b) Write down the Simulated Annealing algorithm as shown in the lecture. Explain each part and step of the algorithm.
[10 marks]