UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2006/2007

April 2007

EEE 551 – INTELLIGENT SYSTEMS

Duration: 3 hours

Please check that this examination paper consists of SIX pages of printed material before you begin the examination.

This paper contains SIX questions.

Instructions: Answer **FIVE (5)** questions.

Answer to any question must start on a new page.

Distribution of marks for each question is given accordingly

All questions must be answered in English.

1. (a) Define defuzzification and explain its use. [3 marks]

(b) State and explain TWO defuzzification methods. Write their equations, and illustrate the use of the equations using an example.

[12 marks]

(c) A system for detecting a disease from blood test is to be developed. A blood test is 90% effective in detecting a disease. It also falsely diagnoses that a healthy person has the disease 3% of the time.

(i) What type of intelligent system is most suitable for developing the system?

(ii) If 10% of those tested have the disease, what is the probability that a person who tests positive will actually have the disease?

[5 marks]

2. (a) State and explain FOUR main sources of uncertain knowledge in a rule-based expert system.

[10 marks]

(b) Determine the net certainty for each of the following expert system rules:

(i) RULE : IF today rain {*cf 0.9*}
AND sky is cloudy {*cf 0.8*}
AND today windy {*cf 0.7*}
THEN tomorrow will rain {*cf 0.8*}

(ii) RULE : IF today rain {*cf 0.9*}
OR sky is cloudy {*cf 0.8*}
OR today windy {*cf 0.7*}
THEN tomorrow will rain {*cf 0.8*}

[2 marks]

(c) Generate EIGHT rule based that permits you to distinguish between various types of computers. Use the data provided in Table Q2(c). The types of computer are listed in increasing priority.

Type of computer	*Cost (USD)*	*Speed (Millions Instructions Per Second)*
Microcomputer	100 – 5000	=< 1
Minicomputer	5000 – 75000	0.1 to 3
Mainframe	30,000 – 5,000,000	0.2 – 0.5 to 30
Supercomputer	> 3,000,000	> 20

Table Q2(c)

[8 marks]

3. Consider the rules below:

Rule 1 : IF A = X
AND B = Y
THEN D = V

Rule 2 : IF F = W
THEN *goal* = no

Rule 3 : IF D = V
THEN B = Z

Suppose a user prompts for attribute A only, and that variable *goal* is the goal, explain (using ordering of fired rules) how an expert system inference engine fires the set of rules above:

(a) using forward chaining. [7 marks]

(b) using backward chaining. [8 marks]

(c) compare the number of fired rules for methods 3(a) and 3(b). Identify and explain TWO factors that contribute to the equal or different numbers of firings.

[5 marks]

4. (a) (i) Draw a diagram to illustrate the structure of an artificial neuron as proposed by McCulloch and Pitts. Discuss the comparison between a McCulloch-Pitts neuron and the biological neuron.

[4 marks]

(ii) Given an m-dimensional input vector, $\mathbf{x} = (x_1, \cdots, x_m)$, describe the operations involved in processing the input signal until an output signal is obtained from the McCulloch-Pitts neuron.

[4 marks]

(b) (i) Draw and label the structure of a simple Perceptron unit.

[2 marks]

(ii) What is the Perceptron Convergence Theorem? Explain.

[2 marks]

(iii) Table Q4(1) shows four patterns that belong to two classes. Illustrate how the Perceptron can be used to categorize the four patterns into two separate classes.

Input Pattern	Class
(0.2, 0.9)	1
(0.2, 0.8)	1
(0.9, 0.2)	-1
(0.7, 0.3)	-1

Table Q4(1)

The initial weights are $w_0(t=0) = -0.5$, $w_1(t=0) = 0.3$, $w_2(t=0) = -0.2$.

Assume that the learning rate is 1.0. Calculate the net inputs, error signals, and weight vectors of the four patterns for the first cycle.

Show the detail calculations for each parameter and tabulate the results in Table Q4(2).

Pattern	Time, t	Net Input	Error Signal	Weight, w_0	Weight, w_1	Weight, w_2
-	t=0	-	-	-0.5	0.3	-0.2
1	t=1					
2	t=2					
3	t=3					
4	t=4					

Table Q4(2)

[8 marks]

5. (a) (i) What are cortical or topological maps in the context of the human brain? Explain the three main topological maps in the brain cortex.

[5 marks]

(b) (i) Memory is content addressable in that incomplete or noisy representations of objects in the environment will invoke the corresponding recollections of previously stored impressions.

List and explain ***two*** types of Content Addressable Memory (CAM).

[5 marks]

(ii) Explain the hypothesis selection, hypothesis test, and hypothesis search procedures involved in an unsupervised Adaptive Resonance Theory (ART) network. Use an illustration to clarify the explanation.

[4 marks]

(c) A new Fuzzy ART network is presented with an input vector, $\boldsymbol{a}$ = [0.2, 0.4]. The network has one new node with weight vector, $\boldsymbol{w}_1$ = [1.0, 1.0, 1.0, 1.0].

(i) Calculate the complement-coded input vector, $\boldsymbol{A}$.

(ii) Assume the choice parameter α = 0.0001, determine the choice function, T, for the complement-coded vector $\boldsymbol{A}$ and weight vector $\boldsymbol{w}_1$;

(iii) Assume that the vigilance parameter, ρ = 0.0, perform the vigilance test for the complement-coded vector $\boldsymbol{A}$ and weight vector $\boldsymbol{w}_1$;

(iv) Perform learning by updating the weight vector $\boldsymbol{w}_1$ using the *fast learning* rule.

[6 marks]

6. (a) What are the main properties of a genetic algorithm for solving optimization problems?

[4 marks]

(b) Explain the following terminologies with regard to a genetic algorithm.

(i) fitness function
(ii) crossover
(iii) mutation
(iv) elitism

[6 marks]

(c) Consider the problem of maximizing the function $f(x) = x^2 - 2x$ using a genetic algorithm, where x is between 0 and 15 and is coded as a 4-bit binary string.

(i) Suggest a fitness function for the problem [2 marks]

(ii) Suppose an initial population of 4 chromosomes is generated randomly, as shown in Table Q6(1). Compute the fitness value for each chromosome, and the probability of selecting each chromosome based on the roulette-wheel selection method.

No.	Initial Population	Fitness (*i*)	Probability of Selection (*i*)
1	1011		
2	1100		
3	0001		
4	0111		

Table Q6(1)

[4 marks]

(iii) Given the information as shown in Table Q6(2), determine the new population.

No.	Mating Pool	Mate	Crossover Site	New Population
1	0111	3	1	
2	1100	4	2	
3	1011	2	2	
4	1011	1	3	

Table 5

[4 marks]

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