
UNIVERSITI SAINS MALAYSIA

Semester II Examination
Academic Session 2004/2005

March 2005

EEE 551 – INTELLIGENT SYSTEM

Time : 3 hours

INSTRUCTION TO CANDIDATE:

Please ensure that this examination paper contains **THIRTEEN (13)** printed pages and **SIX (6)** questions before answering.

Answer **FIVE (5)** questions.

Distribution of marks for each question is given accordingly.

All questions must be answered in English.

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1. (a) List five potential sources of knowledge for a knowledge engineer and state where in the knowledge acquisition process (early, middle, late) each source might be applicable and why.
(20%)
- (b) Describe the responsibilities of each and every member making up the team in the development of a knowledge based system with reference to the exploratory development cycle of an expert system.
(20%)
- (c) Dr. Abd. Halim, a medical expert, was interviewed as part of a project to produce rules for a system to diagnose meningitis. The following is a transcript of part of an interview between a Knowledge Engineer (KE) and Dr. Abd. Halim (EX) conducted in the knowledge acquisition phase of system development.

KE: Doctor, can you please tell me what the symptoms of meningitis are?

EX: Okay!..In most cases, acute meningitis is preceded by a minor, influenza-like infection or by a sore throat. After one or two days, there is a sudden onset of a severe headache, vomiting, fever, stiff neck and then mental confusion. In the worst of cases, the patient lapses into a coma. He or she may also show symptoms of photophobia which is abnormal sensitivity to light. Some infections that cause meningitis for example, Meningococcal Meningitis, may produce skin rashes. Meningococcal Meningitis and Septicaemia are rare illnesses. The onset can be sudden and the consequences can be rapidly fatal. So, it is very important to be aware of the symptoms. In small children, meningitis may cause irritability, lethargy and a loss of appetite. If the onset of meningitis is gradual, the symptoms are similar to those of the acute form but these develop over a period of one or two weeks.

KE: May I know, what actually causes meningitis?

EX: Sure!...Meningitis can be caused by a wide variety of viral, fungal, protozoan or bacterial infections.

KE: How then...I mean...Can you brief me on the first approach that you will take in order to diagnosis meningitis?

EX: Absolutely! There are three steps that I would take – first I would look at the symptoms that the patient is suffering from. Secondly, I would employ a systematic questions approach regarding for example, the medical state of the patient. Finally, I would examine the patient in order to diagnose if it is meningitis he/she has contracted and from this, I would identify the form that he or she has.

KE: If it is so...how then do you differentiate between viral, fungal, protozoan, or bacterial infections?

EX: Well!..All forms of meningitis exhibit symptoms of headache, nausea and vomiting. However with viral infections, the patient may also be drifting in and out of consciousness. Fungal meningitis present similar symptoms but here, the patient remains conscious and will most probably have earaches and so, difficulty in hearing. We call this altered sensorium. Unlike the previous examples, patients suffering with tuberculous meningitis do not show symptoms of photophobia. Instead, they do drift in and out of consciousness and are subject to seizures. However, normally, there is no fever evident.

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KE: One last question, doctor...Are there any other forms of meningitis? If there are, how do you diagnose them then?

EX: Hmm...Let me see. There are two other main forms: meningococcal and bacterial. Both show the three main symptoms of meningitis. Meningococcal infections are characterized by a rash of spots which do not disappear when pressed with a glass, there is rapid breathing, muscle pain and drifting in and out of consciousness. We never see photophobia, fever or seizures with meningococcal infections. Bacterial meningitis has similar symptoms to the meningococcal variety but there is no rash, rapid breathing or muscle pain. Ohh!...Patients with bacterial meningitis usually have a fever and complain of a stiff neck."

(i) If you were the knowledge engineer above, what were the things that you would have done before the interview was conducted?
(10%)

(ii) List the diseases mentioned by the expert.
(10%)

(iii) Provide the basis of differentiating the diseases in the form of 8 rules with certainty values associated with each.
(40%)

2. (a) Search strategies generally consist of two types. Name them and give two examples of each of the type of searching strategies. Explain in detail one out of each of the two examples that you have just named.
(30%)

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(b) In the context of production rules, briefly explain the following terms:

- (i) working memory
- (ii) premises
- (iii) conflict resolution
- (iv) 'fired' rules
- (v) condition and action (20%)

(c) Suppose you are given the following knowledge base.

Facts of the form $\text{parent}(A,B) : P$ denote that person A is a parent of person B with probability P.

While predicate $\text{grandparent}(X, Y)$ denotes that X is a grandparent of Y.

$\text{parent}(\text{majid}, \text{salih}): 0.5$

$\text{parent}(\text{sofiah}, \text{salih}): 1$

$\text{parent}(\text{zahrah}, \text{sofiah}): 0.8$

$\text{parent}(\text{salmah}, \text{majid}): 0.6$

$\text{grandparent}(X, Y) \leftarrow \text{parent}(X, Y) \wedge \text{parent}(Z, Y):1$

$A \leftarrow B$ means A imply B

$A \wedge B$ means A and B are both true

\forall means for all

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Backward deduction can be applied to this rule base to answer the following question:

"What is the probability that salmah and zahrah are grandparents of salih"?

(i) Show precisely how you would write the question as a goal for backward deduction.

(10%)

(ii) Show in detail how that goal is satisfied from the knowledge base and the resultant probability answer that you arrived at.

(20%)

(iii) Assuming that the question has been changed to

"What is the certainty that salmah and zahrah are grandparents of salih"?

and assuming that the numbers that are alongside the rule base are certainty factors (CF) then show in detail how you arrived at the resultant certainty.

(20%)

3. (a) Describe in detail the stages involved in the process of developing a Fuzzy Inference System (FIS).

(20%)

(b) Which process is the most laborious in the process of developing an FIS? Explain why it is so.

(10%)

- (c) Describe the principle difference between the Mamdani style inference method and the Sugeno style inference method.

(10%)

- (d) Mr. Mazian has applied for a loan from Syarikat BudiEmas Finance. His salary is RM 12.5 K and his debts amounting to RM 7K. The loan company employs certain rules to assess credit capabilities which are as follows:

Rule 1:

IF creditor_salary is adequate

OR Creditor debts are small

THEN creditor risk is low

Rule 2:

IF creditor_salary is marginal

AND creditor_debts are large

THEN creditor risk is normal

Rule 3:

IF creditor_salary is poor

THEN creditor_risk is high

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- (i) Using the rule base as given, compute the risk associated with Mr. Mazian using the Mamdani style of inference and the Centroid of Area (COA) method in the defuzzification stage.
(20%)
- (ii) Repeat the calculations for Mr. Mazian, only this time by using the Mean-Max method for defuzzification.
(20%)
- (iii) Use the Sugeno method of inferencing and compare and comment on the results obtained with (i) and (ii).
(20%)

The membership functions for the linguistic variables are to be derived from the following statements:

Creditor Salary in RM K:

People with salaries of RM 50K or more are definitely adequately paid and possibly those earning salaries as low as RM 25K; those earning between RM 15K and RM 30K are regarded as marginally paid people; poor salary earners typically earn less than RM 15K, but if they earn less than RM 10K they are definitely poor.

The Creditor Debts in RM K:

People with debts of less than RM 5K definitely have small debts and those owing between RM 5K and RM7.5K may be regarded as having small debts. Those with debts of RM 10K or more are definitely people with large debts, but those owing between RM 5K and RM 10K may be considered as large debtors.

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Risks

The membership functions of risk from 0% to 100% are as follows:

$$\mu_{\text{Risk}}^{\text{Low}}(x) \begin{cases} = 1 & \text{if } x \leq 0.2 \\ = \frac{x - 0.2}{0.2} & 0.2 \leq x \leq 0.4 \\ = 0 & \text{if } x \geq 0.4 \end{cases}$$

and

$$\mu_{\text{Risk}}^{\text{Norm}}(x) \begin{cases} = \frac{x - 0.2}{0.2} & 0.2 \leq x \leq 0.4 \\ = 1 & 0.4 \leq x \leq 0.6 \\ = \frac{x - 0.6}{0.2} & 0.6 \leq x \leq 0.8 \\ = 0 & \end{cases}$$

and

$$\mu_{\text{Risk}}^{\text{High}}(x) \begin{cases} = 0 & \text{if } x \leq 0.4 \\ = \frac{x - 0.4}{0.2} & 0.4 \leq x \leq 0.6 \\ = 1 & \text{if } x \geq 0.6 \end{cases}$$

4. (a) There are two broad types of learning methods in artificial neural networks. What are they? For each learning method, discuss an application example that is suitable for the corresponding method.

(20%)

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- (b) Artificial neural networks have been employed successfully to solve a variety of practical problems. By using *one* specific example, describe the advantages and disadvantages of using artificial neural networks in that application area.

(20%)

- (c) (i) Sketch the structure of a Correlation Matrix Memory (CMM) network with three input neurons and three output neurons.

(10%)

- (ii) List the step-by-step algorithm of the Correlation Matrix Memory.

(20%)

- (iii) Consider the pattern pairs given by

$$x_1 = \begin{bmatrix} 2 \\ 5 \\ 8 \end{bmatrix}, \quad y_1 = \begin{bmatrix} 2 \\ 4 \\ 6 \end{bmatrix} \quad x_2 = \begin{bmatrix} 3 \\ 1 \\ 5 \end{bmatrix}, \quad y_2 = \begin{bmatrix} 7 \\ 1 \\ 8 \end{bmatrix} \quad x_3 = \begin{bmatrix} 7 \\ 6 \\ 1 \end{bmatrix}, \quad y_3 = \begin{bmatrix} 9 \\ 3 \\ 5 \end{bmatrix}$$

where x 's are the input vectors, and y 's are the desired output vector.

Find the final weight matrix according to the CMM algorithm stated in part (c)(ii).

(30%)

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5. (a) What is the Perceptron Convergence Theorem? Explain. (15%)
- (b) In the context of pattern classification, explain the terminology of
- (i) decision boundary
 - (ii) linear separability
- Give an illustration for each answer. (20%)
- (c) With a suitable illustration, explain the difference in decision boundary established by Perceptron and Adaline. (15%)
- (d) Table 5(a) shows four patterns that belong to two classes. Illustrate how the Perceptron can be used to categorise the four patterns into two separate classes.

Input Pattern	Class
(0.3, 0.7)	1
(0.1, 0.9)	1
(0.8, 0.3)	0
(0.7, 0.2)	0

Table 5(a)

The initial weight vector is

$$w(0) = \begin{bmatrix} 0.6 \\ 0.3 \\ -0.5 \end{bmatrix}$$

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Assume that the learning rate is 1.0, and threshold is 0.0. 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 5(b).

Pattern	Time, t	Net Input	Error Signal	Weight, w_0	Weight, w_1	Weight, w_2
-	$t=0$	-	-	0.6	0.3	-0.5
1	$t=1$					
2	$t=2$					
3	$t=3$					
4	$t=4$					

Table 5(b)

(50%)

6. (a) Draw a diagram to illustrate the *working memory model* as postulated by Cohen and colleagues in 1993.

(10%)

- (b) Discuss the main components of the working memory model, as given in (a).

(20%)

- (c) Draw and label the structure of the Adaline. Explain the operation of information processing in the Adaline using the Widrow-Hoff learning rule.

(20%)

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- (d) (i) By using a suitable diagram, list and label the main components of the attentional subsystem and orienting subsystem in a generic architecture of an unsupervised Adaptive Resonance Theory (ART) network.

(10%)

- (ii) Given an input pattern, explain in detail the pattern matching cycle involved in an unsupervised ART network. Use suitable diagrams to help clarify the explanation.

(20%)

- (iii) A trained Fuzzy ART network has one committed node with complement-coded weight vector $w_1 = [0.2, 0.4, 0.8, 0.6]$. Given an input pattern $a = [0.1, 0.2]$

- (i) Calculate the complement-coded input vector, A ;
- (ii) Assume the choice parameter $\alpha = 0.0001$, determine the choice function, T , for input vector A and weight vector w_1 ;
- (iii) Perform the vigilance test for input vector A and weight vector w_1 ;
- (iv) Suggest a value of the vigilance parameter that will satisfy the vigilance test and will lead to resonance in the Fuzzy ART network;
- (v) Perform learning by updating the weight vector w_1 using the *fast learning rule*

(20%)

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