UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2012/2013

June 2013

EEE 551 – INTELLIGENT SYSTEMS

Time: 3 Hours

INSTRUCTION TO CANDIDATE:

Please ensure that this examination paper contains **NINE** printed pages and **SIX** questions before answering.

Answer **FIVE** questions.

Answer to any question must start on a new page.

Distribution of marks for each question is stated accordingly.

All questions must be answered in English.

1. (a) Define knowledge and intelligence. What is the goal of artificial intelligence (AI)?

(15 marks)

(b) Instead of asking, 'Can machine think?', Turing said we should ask, 'Can machines pass a behaviour test for intelligence?' How does Turing explain this for intelligent behaviour of a computer?

(20 marks)

(c) In his section, you need to design a rule-based expert system for Malaysian University Advisor which can guide international student to choose universities in Malaysia.

(i) Your design must incorporate knowledge base (number of rules at least 6), linguistic objects (at least 2), linguistic values (at least 6), options/final goal of your rule-based expert system (at least 1) and dialogue between expert system interface and user (at least 3). Please state the inference techniques of your expert system.

(ii) Summarize your developed Malaysian University Advisor expert system in (c)(i) using the tree diagram.

(50 marks)

(d) List three main shortcomings of the rule-based expert system.

(15 marks)

2. (a) Define fuzzy logic, fuzzy set and fuzzy rules. Provide one example for the following:

(i) A fuzzy rule with multiple antecedents.

(ii) A fuzzy rule with multiple consequents.

(20 marks)

(b) Describe the four steps in the Mamdani-syle inference.
As we know, the Mamdani-style inference is not computationally efficient. How can we shorten the time of fuzzy inference and how is the crisp output obtained by using this approach?

(30 marks)

(c) An automotive engineer is investigating two types of metering device for an electronic fuel injection system to determine whether they differ in their fuel mileage performance. The experiment used three ranges of metering device_1 and two ranges of metering device_2. The response variable is fuel mileage performance (%).

All related linguistic variables, linguistic values and rules are given as follows:

$\mu^{long}_{metering\ device1}(x)=0,\forall x\leq 35;$	$\mu^{long}_{metering\ device1}(x)=1, x\geq 60;$
$\mu^{medium}_{metering\ device1}(x)=0,\forall x\leq 25\ \&\ \forall x\geq 55;$	$\mu^{medium}_{metering\ device1}(x)=1, x=45;$
$\mu^{shortl}_{metering\ device1}(x)=0,\forall x\geq 20;$	$\mu^{short}_{metering\ device1}(x)=1, x\leq 5;$
$\mu^{low}_{metering\ device2}(x)=0,\forall x\geq 25;$	$\mu^{low}_{metering\ device2}(x)=1, x\leq 15;$
$\mu^{high}_{metering\ device2}(x)=0,\forall x\leq 10;$	$\mu^{high}_{metering\ device2}(x)=1, x\geq 40;$
$\mu^{poor}_{performance}(x)=0,\forall x\geq 35\%;$	$\mu^{poor}_{performance}(x)=1, x\leq 15\%;$
$\mu^{good}_{performance}(x)=0,\forall x\leq 20\%\ \&\ \forall x\geq 80\%$	$\mu^{good}_{performance}(x)=1, 40\%\leq x\leq 60\%$
$\mu^{excellent}_{performance}(x)=0,\forall x\leq 65\%$	$\mu^{excellent}_{performance}(x)=1, x\geq 80\%$

Rule 1: **IF** metering device_1 is short
AND metering device_2 is low
THEN performance is poor

Rule 2: **IF** metering device_1 is medium
OR metering device_2 is high
THEN performance is good

Rule 3: **IF** metering device_1 is long
AND metering device_2 is high
THEN performance is excellent

Assuming that metering device_1 is 55 and metering device_2 is 25. By using the Mamdani method, min and max methods for AND and OR operations, maximum method for aggregation and centroid for defuzzification, calculate the fuel mileage performance.

(50 marks)

3. (a) Define the definition of the following:

   (i) Frame
   (ii) Slot
   (iii) Demon
   (iv) Facet

   Consequently, design one example of class frame for your preferred object.

(30 marks)

(b) Describe how an inference engine works in a frame-based expert system. What is the main difference in comparison to the rule-based expert system.

(10 marks)

(c) Describe uncertainty in expert system and what the sources of uncertain knowledge in expert systems are.

(20 marks)

(d) Suppose the rule in knowledge base is represented as

IF *E* is true
THEN *H* is true (with probability *p*)

which implies that if event *E* occurs, then the probability that event *H* will occurs is *p* where E is evidence and H is hypothesis.

   (i) By using basic probability theory i.e. Bayesian rule equation, derive a formula in order to manage uncertainty in expert systems.

   (ii) Consequently, explain how this formula can be used by the user of your expert system.

(40 marks)

4. (a) Give three differences between genetic algorithms and evolution strategies.

(30 marks)

(b) Briefly describe the main processes involved in simulating evolution as often conducted in evolutionary computation.

(20 marks)

(c) Answer these questions in relation to Holland's simple genetic algorithm.

(i) How does a crossover operator work? (10 marks)

(ii) How does the mutation operator work? (10 marks)

(iii) What is the common termination criterion used in genetic algorithm? Please explain.

(15 marks)

(iv) What is roulette wheel selection technique? Please explain.

(15 marks)

5. (a) A neural network can be defined as a model of reasoning based on the human brain.

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

(20 marks)

(ii) Given an *m*-dimensional input vector, $\mathrm{x} = (\mathrm{x}_1, \ldots, \mathrm{x}_\mathrm{m})$, describe the operations involved in processing the input signal until an output signal is obtained from the McCulloch-Pitts neuron.

(20 marks)

(b) The Rosenblatt's Perceptron is based on the McCulloch and Pitts neuron model.

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

(10 marks)

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

(10 marks)

(iii) Table Q5(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.

Table Q5(1)

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

The initial weights are $w_0 = -0.5, w_1 = 0.3, w_2 = -0.2$.

By stating any assumptions made, 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 Q5(2).

Table Q5(2)

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

(40 marks)

6. (a) The delta rule and Hebb's rule represent two different methods of learning in neural networks. Explain the differences between these two rules.

(10 marks)

(b) (i) In general, what are the main problems with the back-propagation learning algorithms? Discuss an example.

(10 marks)

(ii) Learning can be accelerated in multilayer neural networks. Discuss 2 methods that can be applied in terms of its architectural structure.

(10 marks)

(c) What is a hybrid intelligent system? Describe an example.

(15 marks)

(d) An adaptive neurol-fuzzy inference system (ANFIS) refers to the first order Sugeno fuzzy model.

(i) Describe the function of each layer of ANFIS.

(40 marks)

(ii) In general, how does an ANFIS learn?

(15 marks)

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