UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2022/2023 Academic Session

July/August 2023

EEM348 – Principle of Intelligent Systems

Duration : 2 hours

Please check that this examination paper consists of **Eight (8)** pages of printed material including appendix before you begin the examination.

Instructions : This paper consists of **TWO (2)** questions. Answer **Two (2)** questions.

1. a) A rule-based expert system is developed to predict the buy or sell signal of a stock. The expert system uses four types of technical indicators which are the 50-day moving average (50-MA), Relative Strength Index (RSI), Bollinger Band (BB) and Moving Average Convergence Divergence (MACD) Histogram as the inputs to predict whether to buy or sell a stock. This system uses five rules based on the values of the indicators to make a decision as follows:

Rule 1:
IF the stock's price is above the 50-MA
AND the RSI is above 70 {LS = 2.5, LN = 0.6}
THEN sell the stock {Prior 0.5}

Rule 2:
IF the stock's price is below the 50-MA
AND the RSI is below 30 {LS = 1.6, LN = 0.4}
THEN buy the stock {Prior 0.5}

Rule 3:
IF the stock's price is above the upper BB
AND the RSI is above 70 {LS = 10, LN = 0.8}
THEN sell the stock {Prior 0.5}

Rule 4:
IF the stock's price is below the lower BB
AND the RSI is above 30 {LS = 8, LN = 1}
THEN buy the stock {Prior 0.5}

Rule 5:
IF the stock's price is above the 50-MA
AND the MACD is negative {LS = 3, LN = 0.3}
THEN sell the stock {Prior 0.5}

**Note: LS = likelihood of sufficiency, LN = Likelihood of necessity*

Given the values of technical indicators for company "XYZ" are as in Table 1.1. Using Bayesian accumulation of evidence method, perform the inference of all the rules and predict whether someone should buy or sell the "XYZ" stock.

Table 1.1: Technical Indicator values for Stock "XYZ"

Technical Indicator	**Value**
50-day moving average	Stock Price above the 50-MA
Relative Strength Index	RSI is 60
Bollinger Band	Stock Price is below the lower BB
MACD	MACD is negative value

(30 marks)

b) K-Nearest Neighbors (K-NN) is a popular machine learning algorithm used for classification task. It works by finding the K closest labeled examples in the training data to a new, unlabeled data point. The algorithm then predicts the label of the new point based on the majority class of its nearest neighbors. Consider an arbitrary new product with a weight of 12 gram and a perimeter of 28 mm. Using the K-NN algorithm with K=3 and the Euclidean distance measure (refer the appendix), predict whether this product belongs to class A or B based on the following 10 training data points in Table 1.2.

Table 1.2: Training data points with weight and perimeter as the input features and Class label as the output.

Training data	Weight (gram)	Perimeter (mm)	Class Label
1	10	25	A
2	9	26	A
3	11	23	A
4	13	27	B
5	14	29	B
6	12	30	B
7	15	31	A
8	16	32	A
9	18	33	A
10	20	35	B

(30 marks)

c) A Fuzzy expert system is developed to control fuel injection timing in an engine based on input variables of engine speed and engine temperature. The fuzzy expert system is designed to make decisions about the appropriate fuel injection timing based on the input values of engine speed and engine temperature, which are represented as linguistic variables with three linguistic values each. The system uses three fuzzy rules to make these decisions, which are based on the combination of the input variables. These rules specify the appropriate fuel injection timing (short, moderate, or long) based on the input values of engine speed and engine temperature. The linguistic variable and linguistic value are given as follows:

Input >> Engine speed: Low, Medium, High
Input >> Engine temperature: Cold, Warm, Hot
Output >> Fuel injection time: Short, Moderate, Long

The range of the Fuzzy sets are given in Table 1.3.

Table 1.3: Fuzzy Set and range of the variables.

$\mu_{Speed}^{Low}(x) = 0, \quad \forall x \leq 0 \ \& \ \forall x \geq 2500$	$\mu_{Speed}^{Low}(x) = 1, \quad 1000 \leq x \leq 1500$
$\mu_{Speed}^{Medium}(x) = 0, \quad \forall x \leq 1500 \ \& \ \forall x \geq 4000$	$\mu_{Speed}^{Medium}(x) = 1, \quad 2500 \leq x \leq 3000$
$\mu_{Speed}^{High}(x) = 0, \quad \forall x \leq 3000 \ \& \ \forall x \geq 5000$	$\mu_{Speed}^{High}(x) = 1, \quad 4000 \leq x \leq 4500$
$\mu_{Temperature}^{Cold}(x) = 0, \quad \forall x \leq 0 \ \& \ \forall x \geq 100$	$\mu_{Temperature}^{Cold}(x) = 1, \quad 40 \leq x \leq 60$
$\mu_{Temperature}^{Warm}(x) = 0, \quad \forall x \leq 60 \ \& \ \forall x \geq 140$	$\mu_{Temperature}^{Warm}(x) = 1, \quad 80 \leq x \leq 120$
$\mu_{Temperature}^{Hot}(x) = 0, \quad \forall x \leq 120 \ \& \ \forall x \geq 200$	$\mu_{Temperature}^{Hot}(x) = 1, \quad 160 \leq x \leq 180$
$\mu_{InjectionTime}^{Short}(x) = 0, \quad \forall x \leq 0 \ \& \ \forall x \geq 50$	$\mu_{InjectionTime}^{Short}(x) = 1, \quad \forall x = 30$
$\mu_{InjectionTime}^{Moderate}(x) = 0, \quad \forall x \leq 30 \ \& \ \forall x \geq 80$	$\mu_{InjectionTime}^{Moderate}(x) = 1, \quad \forall x = 60$
$\mu_{InjectionTime}^{Long}(x) = 0, \quad \forall x \leq 60 \ \& \ \forall x \geq 100$	$\mu_{InjectionTime}^{Long}(x) = 1, \quad \forall x = 85$
Where, $\forall$ means for all variable values. Measurement Unit for Engine Speed is in rpm, Temperature is in °C, and Injection timing is in milisecond.	

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The Fuzzy Rules are given as:

Rule 1:
IF engine speed is Low
AND engine temperature is Cold
Then fuel injection time should be Short.

Rule 2:
IF engine speed is High
AND engine temperature is Hot,
THEN fuel injection time is Long.

Rule 3:
IF engine speed is Medium
AND engine temperature is Warm
THEN fuel injection time is Moderate.

Let say, the engine speed is 1900 rpm, and engine temperature is 130 °C, calculate the prediction for the fuel injection time. In your calculation, show the fuzzification and rules evaluation clearly. You have to use min and max method for AND and OR operations, maximum method for aggregation and centroid method for defuzzification.

(40 marks)

2. a) Multilayer Perceptron (MLP) is the basic architecture that builds up a Convolutional Neural Network (CNN).

i. Is this statement true? Explain.

(10 marks)

ii. Briefly explain one critical difference between VGG-16 and VGG-19.

(20 marks)

b) Hopfield Network (HN) and Bidirectional Associative Memory (BAM) are some of ANN variants. In what manner these two variants differ from MLP? Explain.

(30 marks)

c) Consider the network given in Figure 2.1. This network is initialized with the weights as indicated. We wish to train this network through two iterations using the backpropagation learning algorithm on the two patterns given in Table 2.1 below. Throughout, we assume a sigmoidal transfer function with $\lambda = 1$, a learning rate $\eta = 1.2$, a momentum $\alpha = 0.8$, k is the iteration/pattern index, m is the input layer, n is the output layer, x is the input, and y is the output. Provide updated weights and bias after the two iterations.

(40 marks)

Table 2.1: Patterns for backpropagation training neural network

Pattern index	x_1^k	x_2^k	y_1^k	y_2^k
1	0.5	-0.5	0.9	0.1
2	-0.5	0.5	0.1	0.9

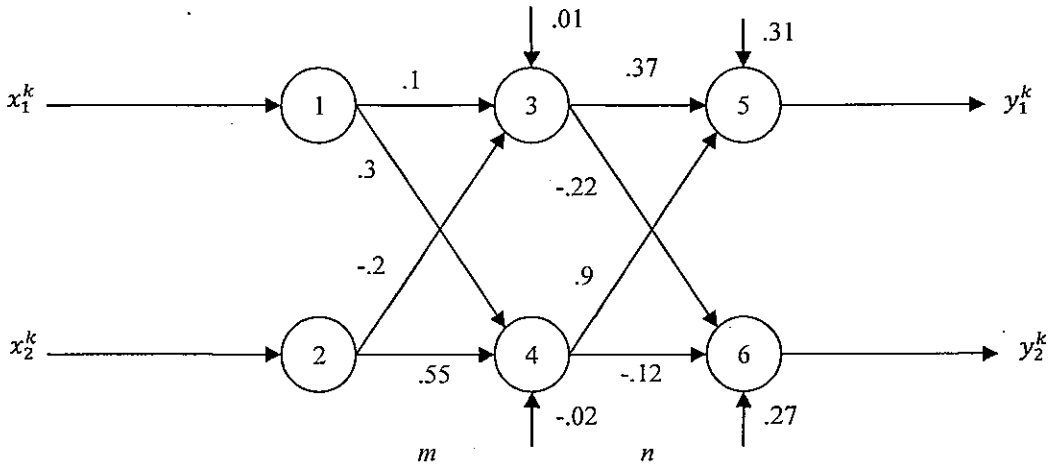

Figure 2.1: The initial architecture of the network

APPENDIX A

(i) Euclidean Distance

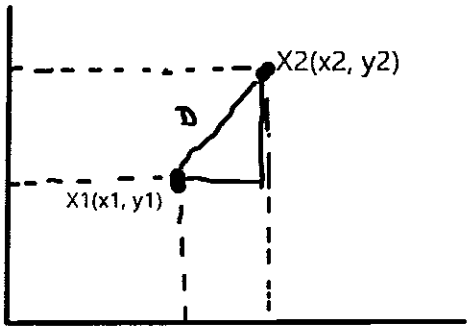

Figure A.1: Two arbitary data point in Euclidean space

Euclidean Distance, $D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$

(ii) Prior Odd, $O(H) = \frac{p(H)}{1-p(H)}$

(iii) Posterior Odd, $p(H|E) = \frac{O(H|E)}{1+O(H|E)}$

(iv) Defuzzification Centroid, $$\text{COG} = \frac{\sum_{x=a}^{b} \mu_A(x)x}{\sum_{x=a}^{b} \mu_A(x)}$$

APPENDIX B

Course Outcomes (Cos) – Program Outcomes (POs) Mapping

Question	Course Outcome (CO)	Programme Outcome (PO)
1(a)	1	PO1
1(b)	1	PO1
1(c)	1	PO1
2(a)	3	PO2
2(b)	3	PO2
2(c)	3	PO2