UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: September 2023

Module Number: EE8210 **Module Name: Intelligent Systems Design**

[Three Hours]

[Answer **all questions,** each question carries **10 marks**]

Q1 a) Explain the role of Inference Engine in rule based expert systems.

[1.0 Mark]

b) State two advantages and disadvantages each of rule based expert systems.

[1.0 Mark]

c) Consider the following rule based expert system.

R1: A & R → P
R2: B | C → Q
R3: D → R
R4: E & Q → S
R5: Q | P → X
R6: R & S → Y

Notations: '&' denotes AND. '|' denotes OR.

i) Use forward chaining to determine all the rules fired given the database has the facts A, B, and D. Indicate the facts stored in the database after each step.

[2.0 Marks]

ii) Given the end goal is to prove X, use backward chaining to determine all the rules fired. Assume the database contains the facts A, B, and D.

[2.0 Marks]

iii) Compare the results of (i) and (ii) above, and comment on the use cases of forward chaining and backward chaining.

[1.0 Mark]

d) Explain two conflict resolution methods used in rule based expert systems.

[1.0 Mark]

e) Assume that you are given a task of developing an AI system for a language translation problem. What types of systems are currently in use for language translation in the world? Where do you see a rule-based expert system can help? Discuss the advantages of using a rule-based expert system in the areas you have identified.

[2.0 Marks]

Q2 a) Consider a simple feedforward Artificial Neural Network (ANN) with a single hidden layer. The network is trained using backpropagation. Briefly explain what the backpropagation algorithm does in the context of this network.

[2.0 Marks]

b) Briefly explain what the Exploding Gradient problem is and how to minimize it.

[1.0 Mark]

c) You have been provided with a dataset of handwritten digits (0-9). Each sample in the dataset is a 28 x 28 (height x width) grayscale image of a handwritten digit, along with the label of what digit the image represents. Your task is to design and train an ANN to classify these images.

i) Describe how you would preprocess this data for training an ANN. What steps would you take?

[1.0 Mark]

ii) Design a feedforward ANN with one hidden layer for this task. Provide a diagram of your network.

[2.0 Marks]

iii) What loss function would you use and why?

[1.0 Mark]

iv) How would you evaluate the performance of your trained network?

[1.0 Mark]

d) Consider a grayscale image of size 5 x 5 (height x width). You are applying a convolution operation on this image using a 3 x 3 filter with stride 1 and no padding.

i) Calculate the dimension of the output feature map after the convolution operation.

[1.0 Mark]

ii) Suppose you now apply a 2 x 2 max pooling operation with stride 2 on the output feature map from Q2) d) i). Calculate the dimension of the resulting output.

[1.0 Mark]

Q3 a) LSTMs have mechanisms called "gates" (input gate, forget gate, and output gate). Briefly explain the role of these gates in the functioning of an LSTM unit.

[1.5 Marks]

b) Name and describe the main features of Genetic Algorithms (GA).

[1.5 Marks]

c) Consider you are a personal trainer and you have a client who wants to maximize their workout efficiency. They have 60 minutes to spend in the gym and there are 10 different exercises they can do. Each exercise has a different calorie burn rate per minute and each exercise requires a different amount of time to complete. The client wants to burn as many calories as possible in the 60 minutes they have. The

problem is to find the best combination of exercises that the client can do in 60 minutes to maximize calorie burn.

i) Formulate this problem for a GA solution. Discuss how you would represent the individuals (solutions) and the population.

[3.0 Marks]

ii) Describe how you would define the fitness function for this problem.

[2.0 Marks]

d) Consider the problem of finding the shortest route through several cities, such that each city is visited only once and in the end returns to the starting city (the Travelling Salesman problem). Suppose that in order to solve this problem we use a GA, in which genes represent links between pairs of cities. For example, a link between London and Paris is represented by a single gene 'LP'. Also assume that the direction in which we travel is not important, so that LP = PL.

i) How many genes will be used in a chromosome of each individual if the number of cities is 10?

[1.0 Mark]

ii) How many genes will be in the alphabet of the GA?

[1.0 Mark]

Q4 a) In the context of a Neural Expert System, explain how the neural network component can enhance the capabilities of the traditional expert system.

[2.0 Marks]

b) Consider a scenario where you are designing a Neural Expert System for a healthcare provider to predict the likelihood of patients having a certain disease based on their symptoms.

i) Discuss how you would structure the neural network part of your system for this task. What kind of neural network architecture would you use and why?

[1.5 Marks]

ii) How would you represent the knowledge in your expert system? Discuss how you would acquire this knowledge and how it would be used in the system.

[1.5 Marks]

c) Comment on how the training of AI and machine learning models in the cloud infrastructure affects the environment.

[2.0 Marks]

d) Explain with examples how tech companies and governments are using our data to train AI models without our consent and comment on how to avoid such exploitations of data.

[3.0 Marks]

Q5 a) P and Q are two fuzzy sets written in the standard Zadeh notation; $\mu(x)/x$, where $\mu(x)$ is the membership that corresponds to the given value of x.

P = 0.0/1 + 0.3/2 + 0.6/3 + 0.9/4 + 0.8/5 + 0.5/6 + 0.3/7 + 0.2/8

Q = 0.4/1 + 0.8/2 + 0.5/3 + 0.3/4 + 0.6/5 + 0.9/6 + 1.0/7 + 0.5/8

By using the 'standard' (Zadeh) fuzzy operators for negation (NOT), intersection (AND), and union (OR), calculate the following fuzzy sets:

i) NOT P

ii) P AND Q

iii) P OR Q

iv) (NOT P) AND Q

[2.0 Marks]

b) Given the linguistic input variables, **Age** and **Height**, each with the given terms:

Age: *young* = 1/0 + 0.9/10 + 0.8/20 + 0.5/30 + 0.2/40 + 0.0/50

middle = 0.2/20 +0.5/30 + 0.7/40 + 1/50 + 0.7/50 + 0.5/60 + 0.2/70

old = 0.1/40 + 0.3/50 + 0.5/60 + 0.7/70 + 0.9/80 + 1/90 + 1/100

Height: *short* = 1/1.4 + 0.75/1.5 + 0.5/1.6 + 0.25/1.7

average = 0.5/1.6 + 1/0.7 + 0.5/1.8

tall = 0.2/1.6 + 0.5/1.7 + 0.75/1.8 + 1/1.9 + 1/2.0

and the single linguistic output variable **Employ**, with the three terms:

Employ: *bad* = 1/0 + 1/1 + 0.7/2 + 0.5/3 + 0.3/4

fair = 0.1/3 + 0.5/4 + 1/5 + 0.5/6 + 0.1/7

good = 0.3/6 + 0.5/7 + 0.7/8 + 1/9 + 1/10

Calculate the fuzzy set result of applying Mamdani inference on input values of **Age**=40 and **Height**=1.6 when firing the rules:

i) R1: IF **Age** is *young* OR **Height** is *tall* THEN **Employ** is *good*

ii) R2: IF **Age** is *middle* THEN **Employ** is *fair*

iii) R3: IF **Age** is *old* AND **Height** is *short* THEN **Employ** is *bad*

[6.0 Marks]

c) Calculate the defuzzified value of your output set from (b) above, using Centre-of-Gravity defuzzification.

[2.0 Marks]