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UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: May 2026

Module Number: EC6301 **Module Name: Artificial Intelligence (C-23)**

Part – A

[Thirty Minutes]

[Answer **all questions, 10 Marks** in total]

- Part A contains 10 multiple-choice questions (MCQs), each having either one correct answer or multiple correct answers, carrying a total of 10 marks.
- You should first attempt Part A of the paper, which will be collected 30 minutes after the exam commencement.

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1. Select correct statement/(s) related to convergence behavior, population diversity, and evolutionary operators in advanced Genetic Algorithm optimization systems.
   (a) Excessive selection pressure may reduce population diversity and increase the risk of premature convergence.
   (b) Mutation operators are unnecessary when elitism is applied because the best chromosomes are always preserved.
   (c) Increasing crossover probability always guarantees convergence to the global optimum solution.
   (d) Maintaining population diversity improves the exploration capability of search space.
   (e) Roulette wheel selection completely prevents local optimum convergence in multimodal optimization problems.

2. A research team develops a hybrid intelligent system integrating Neural Networks (NN), Genetic Algorithms (GA), and Rule-Based Expert Systems (RBES) for medical diagnosis. Select the correct statement/(s) related to this architecture.
   (a) Genetic Algorithms can optimize Neural Network weights and architecture parameters automatically.
   (b) Rule-Based Expert Systems improve explainability by providing human-readable decision rules.
   (c) Combining multiple intelligent techniques always guarantees lower computational complexity.
   (d) Neural Networks are mainly used to provide symbolic reasoning and logical rule tracing.
   (e) Hybrid intelligent systems can improve robustness by combining learning, optimization, and reasoning capabilities.

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3. Figure Q3 shows a simple feedforward Artificial Neural Network (ANN) consisting of input layer with two input neurons, hidden layer with two neurons and output layer with one neuron.

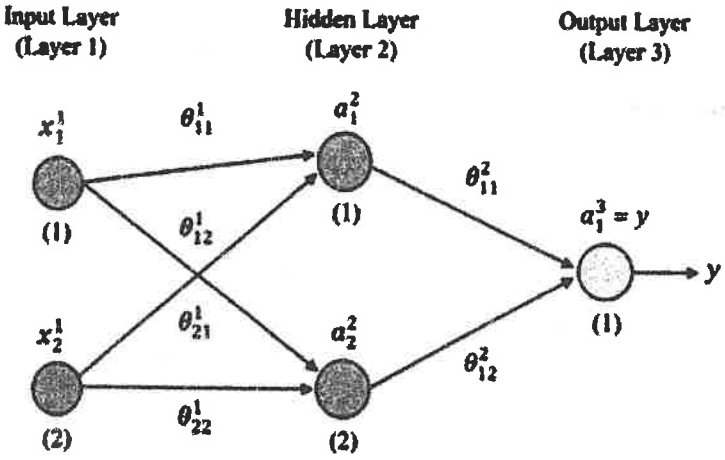


Figure Q3

Assume the following values are given,

$$X = \begin{bmatrix} 1.0 \\ 0.5 \end{bmatrix}$$

$$\Theta^1 = \begin{bmatrix} 0.2 & 0.4 \\ 0.3 & 0.5 \end{bmatrix}$$

$$\Theta^2 = [0.6 \quad 0.8]$$

The sigmoid activation function ($\sigma(z) = \frac{1}{1+e^{-z}}$) is used for both hidden and output layers. Perform one iteration of forward propagation and calculate the final output value y. Use standard rounding rules and round all intermediate calculations and the final output value y to 4 decimal places.

(a) y = 0.7063
(b) y = 0.7064
(c) y = 0.7062
(d) y = 0.7065
(e) y = 0.7061

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4. Figure Q4 shows a rule-based expert system consisting of conjunction and disjunction layers.

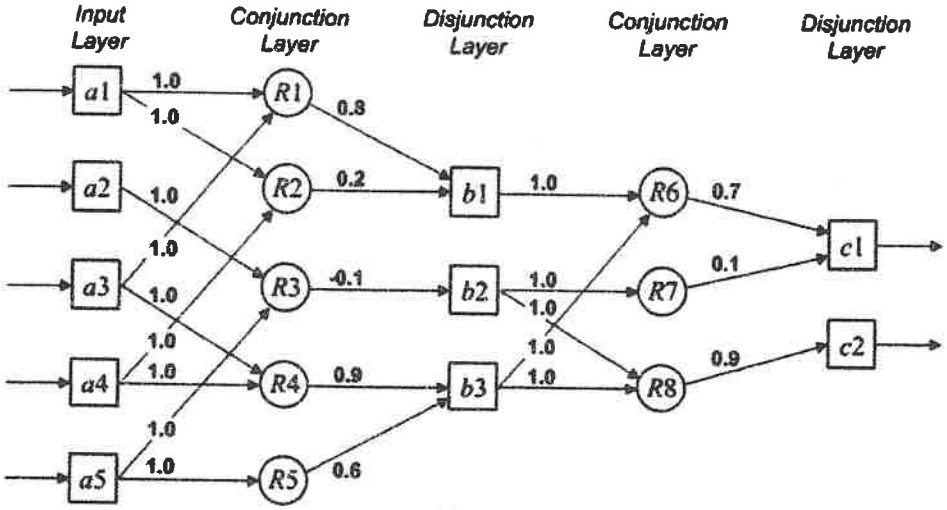


Figure Q4

Assume the following input values are applied to the system

$$a_1 = 0, a_2 = 0.7, a_3 = 0, a_4 = 0.8, and\ a_5 = 0.5.$$

Calculate the final output values of c_1 and c_2.

(a) $c_1 = 0.5,\ c_2 = -0.45$

(b) $c_1 = 0,\ c_2 = -0.045$

(c) $c_1 = 0.5,\ c_2 = -0.045$

(d) $c_1 = -0.045,\ c_2 = 0$

(e) $c_1 = 0.5,\ c_2 = 0$

5. A biomedical decision-support system integrates an Artificial Neural Network (ANN) with a Rule-Based Expert System (RBES) to improve disease diagnosis and clinical reasoning. The ANN is mainly responsible for feature learning from medical images, while the RBES performs symbolic reasoning using expert-defined clinical rules.

Select correct statement/(s) related to this hybrid intelligent system.

(a) The Rule-Based Expert System improves explainability by providing interpretable decision rules for the ANN predictions.

(b) The ANN eliminates the need for expert knowledge representation in hybrid architecture.

(c) Integrating ANN with RBES can improve robustness by combining data-driven learning and symbolic reasoning capabilities.

(d) Rule-Based Expert Systems automatically optimize ANN weights using gradient descent algorithms.

(e) The hybrid system must increase computational complexity due to the integration of learning and inference mechanisms.

6. Which of the following best describes the main contribution of the **DENDRAL** project?
   (a) It introduced general-purpose algorithms for all AI problems.
   (b) It demonstrated that computers could replace all human decision-making.
   (c) It showed that domain-specific knowledge and rules can make computers perform like human experts.
   (d) It focused only on hardware development for computer systems.
   (e) All of the above.

7. Which of the following correctly identifies the main approaches in Reinforcement Learning?
   (a) Value-based, Policy-based, Model-based
   (b) Supervised, Unsupervised, Reinforced
   (c) Classification, Regression, Clustering
   (d) Deterministic, Probabilistic, Statistical
   (e) Value-based, logic-based Rule-based

8. Consider a feature map of size 6 × 6. You apply a 2 × 2 pooling window with a stride of 2 and no padding. What will be the spatial dimensions of the output feature map after pooling?
   (a) 3x3
   (b) 2x2
   (c) 4x4
   (d) 5x5
   (e) None of the above.

9. What is the main advantage of Long Short-Term Memory (LSTM) over a standard Recurrent Neural Networks (RNN)?
   (a) Faster training speed.
   (b) Ability to handle long-term dependencies.
   (c) Requires less data.
   (d) It completely removes the need for hidden states in sequence processing.
   (e) All of the above.

10. The cell state in LSTM is mainly used to:
   (a) Store long-term memory
   (b) Store only short-term memory
   (c) Perform classification
   (d) Compute loss function
   (e) Transfer data directly to the output layer without processing.

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Part – B

[Two Hours and Thirty Minutes]

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

Q1 a) A smart traffic management team is developing a fuzzy logic-based traffic signal controller for a busy city intersection. The system automatically adjusts the green light duration based on the traffic density and vehicle waiting time at the junction.

The input variables are,

- **Traffic Density (TD)** (0 – 100 vehicles)
- **Vehicle Waiting Time (VWT)** (0 – 120 seconds)

The output variable is,

- **Green Light Duration** (0 – 80 seconds)

The linguistic terms are defined in Table 1: Q1 a).

Table 1: Q1 a)

Traffic Density	Vehicle Waiting Time	Green Light Duration
Low (L)	Low (L)	Small negative (SN)
Medium (M)	Medium (M)	Zero (Z)
High (H)	High (H)	Small positive (SP)

The output actions are,

- **SN** – The controller slightly reduces the green light duration.
- **Z** – The controller maintains the current green light duration without any change.
- **SP** – The controller slightly increases the green light duration.

The fuzzy rules are defined in Table 2: Q1 a).

Table 2: Q1 a)

VWT \ TD	L	M	H
L	**SN**	**Z**	**Z**
M	**SN**	**Z**	**SP**
H	**Z**	**SP**	**SP**

For the following traffic conditions,

- Traffic Density = **80 vehicles**
- Vehicle Waiting Time = **20 seconds**

Perform the following tasks.

i) Define and draw suitable triangular membership functions for all linguistic terms. Derive only the membership required for the given input values.

ii) Perform fuzzification of the input values.

iii) Determine the crisp output value of the green light duration using centroid defuzzification.
(Hint: $x^* = \frac{\sum \mu(x_i) x_i}{\sum \mu(x_i)}$)

[5.0 Marks]

b) A student group is developing an Artificial Neural Network (ANN) model to classify whether a patient has a cardiovascular disease using biomedical data such as ECG measurements, cholesterol level, blood pressure, glucose level, and age. The students collected only 500 patient records from a hospital database and designed the system to achieve high accuracy for their final year project demonstration.
During the implementation process, the students configured the ANN using a fixed and very high learning rate to speed up training. They also used the same dataset for both testing and validation purposes. To improve the intelligence of the system, the group designed a highly complex ANN architecture with many hidden neurons and layers compared to the size of the dataset. In addition, the ANN was trained for nearly 600 epochs even after the validation accuracy started decreasing during the training process.

i) Identify four inappropriate practices performed in the ANN model development process described above.

ii) Explain why each identified inappropriate practice is considered as poor practice in ANN model development.

iii) Discuss two ethical issues that may arise if the developed ANN model is directly used in a hospital without proper model validation.

[5 Marks]

Q2 a) Explain how crossover and mutation operators in Genetic Algorithm help improve the search process and reduce premature convergence to local optimum solutions.

[1 Mark]

b) Explain the impact of elitism selection on the convergence dynamics of Genetic Algorithm systems. Discuss how excessive elitism may lead to premature convergence, reduced genetic diversity, and poor global search capability.

[1 Mark]

c) Discuss the suitability of the tanh and ReLU activation functions in Artificial Neural Network architectures for binary classification, hidden layer operations, and output layer operations. Your discussion should include the limitations of each activation function.

[1.5 Marks]

d) Explain how the integration of Artificial Neural Networks and Genetic Algorithms can improve optimization and learning performance. Your discussion should include optimization capability, convergence behavior, and computational challenges associated with hybrid intelligent systems.

[1.5 Marks]

e) Figure Q2 e) illustrates a five layer Adaptive Fuzzy Inference System (ANFIS) architecture used for intelligent decision-making applications.

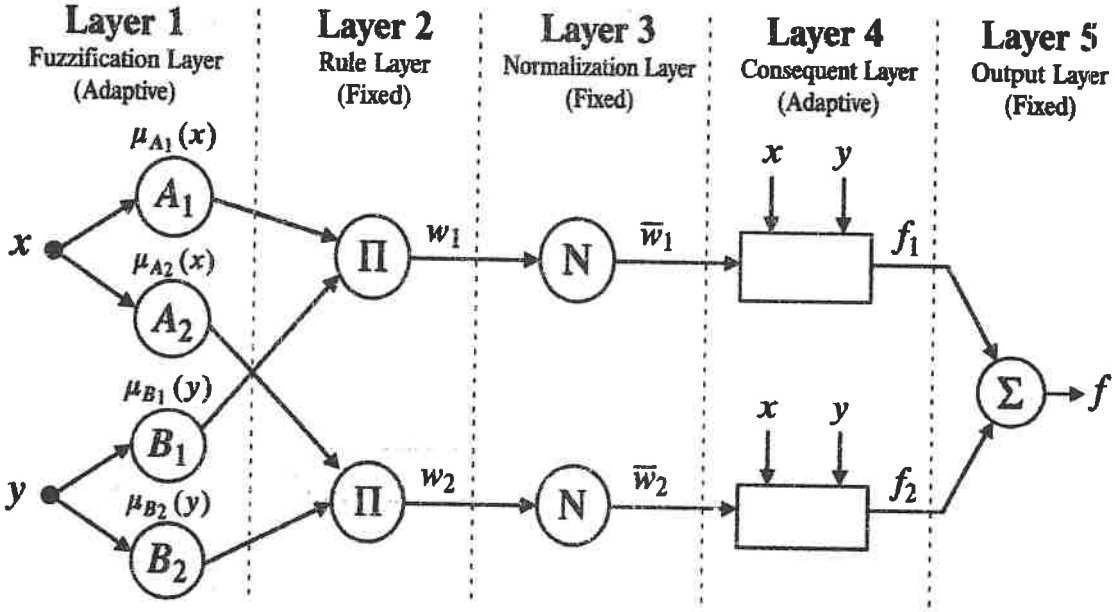


Figure Q2 e)

Answer the following questions based on the given architecture.

i) Define the equations of all layers using standard ANFIS notations and derive the final output equation f. Clearly state all assumptions and define suitable notations for the premise and consequent parameters.

ii) Explain what the premise parameters and consequent parameters represent in the ANFIS architecture.

iii) Explain how these parameters are treated during the forward pass and backward pass of the hybrid learning algorithm.

iv) Describe why normalization is used in Layer 3 of the ANFIS architecture.

v) State one real-world application that can be implemented using the ANFIS architecture.

[3.5 Marks]

f) i) List two advantages and two disadvantages of Federated Learning.

ii) List two algorithms used in Federated Learning.

[1.5 Marks]

Q3 a) State four important design criteria that should be considered, when designing a sequence modeling system for applications such as speech recognition or language translation.

[2.0 Marks]

b) Explain how Recurrent Neural Networks (RNNs) address sequence modeling problems.

[1.0 Mark]

c) i) List three different types of RNN architectures using illustrations.

[1.5 Marks]

ii) State practical use cases for each RNN architecture you mentioned under question Q3 c)(i).

[1.5 Marks]

d) Briefly explain why Back Propagation Through Time (BPTT) is required in RNN.

[1.0 Mark]

e) List two architectural differences between Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU) networks.

[1.0 Mark]

f) Figure Q4 f) shows the internal structure of the LSTM cell.

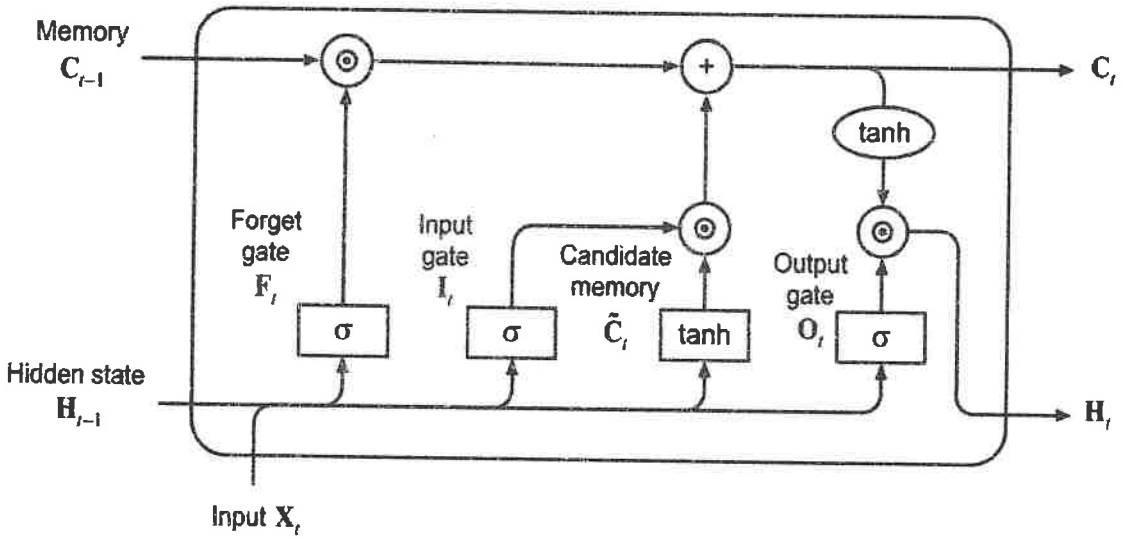


Figure Q4 f)

Using the given values, calculate the new cell state value C_t.

$F_t = 0.6$
$I_t = 0.7$
$\tilde{C}_t = 0.5$
$O_t = 0.8$
$C_{t-1} = 0.4$

[2.0 Marks]

Q4 a) Draw the architecture of a basic Convolutional Neural Network (CNN) and label all the components.

[1.0 Mark]

b) Explain why CNN performs better than Feedforward Neural Networks (FFNN) for image classification tasks.

[2.0 Marks]

c) Given the following input feature map and convolutional filter.

Input Feature Map (5 × 5):

$$\begin{bmatrix} 3 & 5 & 2 & 8 & 1 \\ 9 & 7 & 5 & 4 & 3 \\ 2 & 0 & 6 & 1 & 6 \\ 6 & 3 & 7 & 9 & 2 \\ 1 & 4 & 9 & 5 & 1 \end{bmatrix}$$

Convolutional Filter (3 × 3):

$$\begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Find the resulting feature map X after applying convolution (stride = 1, no padding).

[4.0 Marks]

d) What is the main objective of Turing Test as proposed by Alan Turing?

[1.0 Mark]

e) Define following terms in Reinforcement Learning.

- Agent
- Action
- State
- Reward

[2.0 Marks]