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UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: May 2026

Module Number: EE6350 **Module Name: Artificial Intelligence (C-18)**

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.

3. A biomedical engineering team is developing a deep learning model for real time ECG abnormality detection. During training, the engineers observe the following issues:
   - Some neurons stop updating permanently during training.
   - The output layer must generate probability values between 0 and 1.
   - The hidden layers require fast convergence with reduced vanishing gradient effects.

   Which statement/(s) describe/(s) the most suitable activation function choices for this scenario?

   (a) ReLU helps reduce vanishing gradient problems and improves computational efficiency in hidden layers.

   (b) Sigmoid activation is preferred in deep hidden layers because it completely eliminates gradient saturation.

   (c) Leaky ReLU can reduce the "dying ReLU" problem by allowing small negative gradients.

   (d) Tanh produces output values only between 0 and 1, making it ideal for probability estimation in output layers.

   (e) Softmax and Sigmoid are unsuitable for classification outputs because they cannot represent probabilities.

4. In Federated Learning, two major approaches known as **Horizontal Federated Learning (HFL)** and **Vertical Federated Learning (VFL)** are used to enable collaborative machine learning while preserving data privacy.

   Which statement/(s) correctly describe/(s) the differences between Horizontal Federated Learning and Vertical Federated Learning?

   (a) Horizontal Federated Learning is applied when participating parties have the same feature space but different sample spaces.

   (b) Vertical Federated Learning is used when organizations contain different feature spaces but share overlapping user samples.

   (c) Horizontal Federated Learning requires identical user identities across all participating organizations before model training.

   (d) Vertical Federated Learning is mainly designed for situations where all organizations possess identical attributes and identical records.

   (e) Horizontal Federated Learning exchanges complete raw datasets between participants to improve global model accuracy.

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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.

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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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Faculty of Engineering

End-Semester 6 Examination in Engineering: May 2026

Module Number: EE6350 **Module Name: Artificial Intelligence (C-18)**

Part – B

[Two Hours and Thirty Minutes]

[Answer **all questions, 40 Marks** in total]

Q1 a) A rule-based expert system is developed for a **Smart Hospital Emergency Management System** to support decision-making during critical patient situations.

Rules

1. IF patient_temperature > 39°C AND oxygen_level < 90%
   → THEN patient_condition = critical
2. IF patient_condition = critical AND ICU_beds_available = false
   → THEN recommend = transfer_to_nearest_hospital
3. IF heart_rate > 120 AND blood_pressure = low
   → THEN recommend = immediate_cardiac_monitoring
4. IF contagious_disease = true AND isolation_rooms_available = false
   → THEN recommend = emergency_quarantine_protocol
5. IF ambulance_delay > 20 minutes AND traffic_condition = heavy
   → THEN recommend = air_medical_support
6. IF recommend = immediate_cardiac_monitoring AND
   recommend = emergency_quarantine_protocol
   → THEN final_action = activate_emergency_response_team

Facts

- Patient temperature is 40°C
- Oxygen level is 85%
- ICU beds are unavailable
- Heart rate is 130 bpm
- Blood pressure is low
- Contagious disease detected
- Isolation rooms are unavailable
- Ambulance delay is 25 minutes
- Traffic conditions are heavy

i) **Using forward chaining determine all recommendations generated by the system.** List the rules fired and the new facts derived at each step.

ii) **Using backward chaining, explain how the system concludes that final_action = activate_emergency_response_team.**
Show the chain of rules and conditions used.

iii) Identify one pair of rules that may create a conflict during inference and describe a suitable conflict resolution strategy that should be used to determine which rule fires first.

[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) 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]

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.

[1.5 Marks]

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

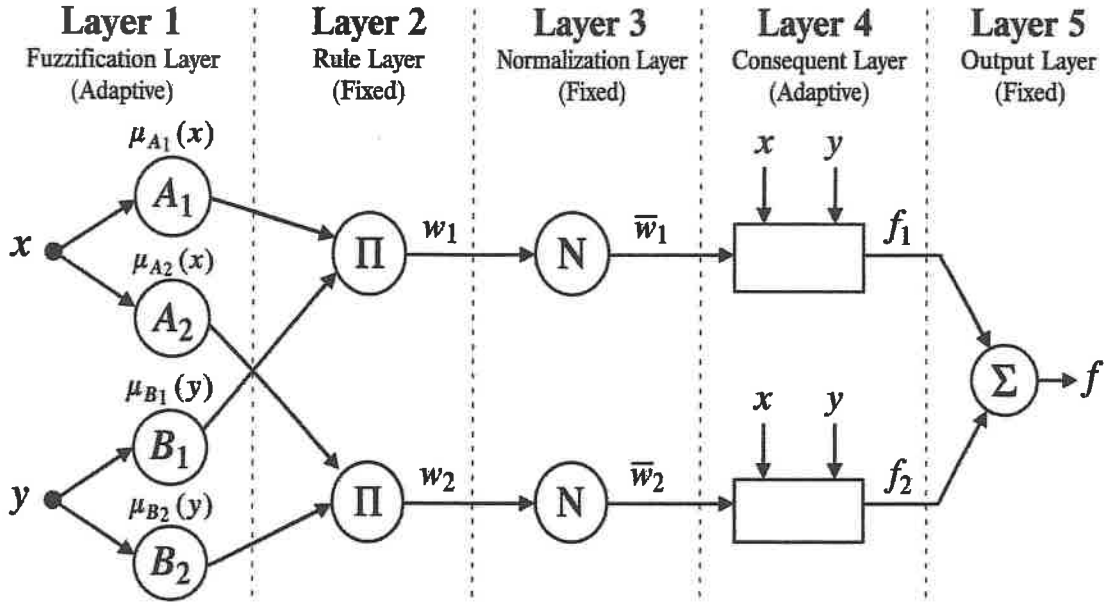


Figure Q2 c)

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 are 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]

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

ii) List two algorithms used in Federated Learning.

[1.5 Marks]

e) Compare **Rule-Based Expert Systems (RBES)** and **Artificial Neural Networks (ANN)** in terms of knowledge representation, learning ability, handling complex data and transparency.

[2.0 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.

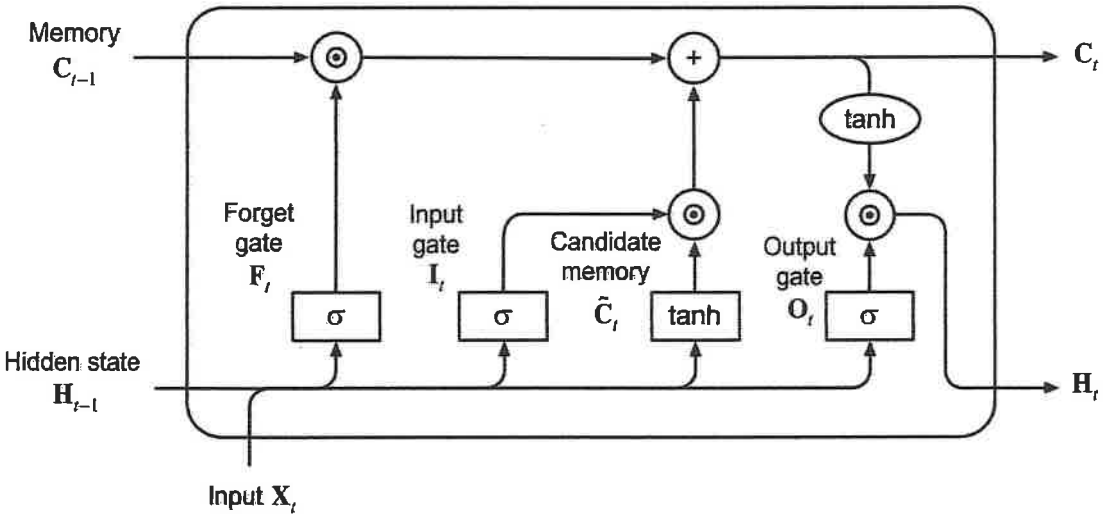


Figure Q4 f)

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]