UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: December 2025

Module Number: EE8210 **Module Name: Intelligent Systems Design (C-18)**

Part - B

[2 Hours and 30 Minutes]

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

Q1 a) State two (2) major limitations of rule-based expert systems that led researchers to look toward neural networks in the mid-1980s.

[1.0 Mark]

b) In his 1950 paper, Alan Turing proposed an "Imitation Game" to address the question, "Can machines think?",

i) According to Alan Turing, under what condition can it be said that a computer has passed the intelligent behavior test?

[0.5 Marks]

ii) State one reason why the Turing Test is considered an **objective standard** for viewing intelligence.

[1.0 Mark]

c) Consider the following rule-based expert system for a Loan Approval Process:

Rules:

1. IF credit_score > 700 AND steady_income = true → THEN risk_level = low
2. IF risk_level = low AND (collateral_available = true OR down_payment ≥ 20%) → THEN recommend = approve_loan
3. IF debt_to_income_ratio > 40% → THEN risk_level = high
4. IF risk_level = high AND co_signer = false → THEN recommend = reject_loan
5. IF recommend = approve_loan AND employment_verified = true → THEN final_action = issue_contract

Facts:

- Credit score is 750
- Steady income is confirmed
- Debt-to-income ratio is 25%
- Down payment is 25%
- Employment is verified

i) If the goal is to determine if the system should **issue_contract**, explain how **Backward Chaining** would approach this goal, including the "stacking" of subgoals. Indicate the rules fired and the new facts stored in the database.

[2.0 Marks]

ii) List and explain a **conflict resolution method** that could be used if multiple rules in the Loan Approval system were triggered simultaneously.

[1.0 Mark]

iii) Explain a scenario where **Forward Chaining** is more suitable to be used with respect to an example.

[1.0 Mark]

d) List two (2) **ethical challenges** that arise when Artificial Intelligence (AI) systems are used in high-stakes domains such as healthcare, recruitment, or criminal justice.

[1.0 Mark]

e) Using relevant real-world examples, describe how AI models are trained using user data by technology companies or government organizations, sometimes without explicit user consent. Discuss suitable measures that can be implemented to protect user data privacy and prevent misuse. (Maximum 200 words)

[2.5 Marks]

Q2 A university wants to develop an intelligent system to automatically classify student handwriting digits (0-9) using scanned images. Each image is represented by pixel intensity values. The system should learn patterns from data and improve accuracy over time.

a) Explain why ANN classifier is suitable for this problem than a traditional linear classifier.

[2.5 Marks]

b) Propose a suitable ANN architecture for this problem and justify your selection.

[3.0 Marks]

c) Explain how **backpropagation** is used to train the network in this scenario.

[2.5 Marks]

d) Discuss the role of **bias units and hidden layers** in improving classification accuracy.

[2.0 Marks]

Q3 a) Describe the main components involved in an Evolutionary Neural Network.

[2.0 Marks]

b) Briefly explain the main four (4) stages of a typical Hybrid Intelligent System.

[4.0 Marks]

c) Explain the role of the following genetic operators in the optimization process of a **Genetic Algorithm**.

i) Crossover

ii) Mutation

[2.0 Marks]

d) Discuss why Genetic Algorithms are effective for solving **NP-Hard problems**, with reference to an example.

[2.0 Marks]

Q4 a) Explain the role of the following components in a **Convolutional Neural Network (CNN)**.

i) Convolutional layer
ii) Pooling layer
iii) Fully connected layer

[1.5 Marks]

b) A convolutional layer receives an input feature map of size 128 × 128 × 3 and uses 32 filters of size 3 × 3, with 2 strides and no padding.

i) Calculate the spatial dimensions of the **output feature map**.
ii) State the **depth** of the output feature map and justify your answer.

[2.0 Marks]

c) Explain how you decide whether to use **Data Augmentation and Regularization techniques** when training a CNN.

[1.0 Mark]

d) A feature map obtained from a convolutional layer is given below:

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

Apply **min pooling** with a pool size of 2 × 2 and a stride of 2. Calculate the resulting output feature map.

[0.5 Marks]

e) In terms of memory representation, distinguish between what the **Cell State** and the **Hidden State** represent in a Long Short-Term Memory (LSTM) cell.

[1.0 Mark]

f) You are given the following values for an LSTM cell at time step t.

- Previous hidden state (h_{t-1}) = 0.5
- Previous cell state (C_{t-1}) = 2.0
- Current input (x_t) = 1.0

Use the following **weights (same for x_t and h_{t-1})** and biases for each gate:

- Forget gate: $W_f = 0.6,\ b_f = -0.2$
- Input gate: $W_i = 0.5,\ b_i = 0.1$
- Candidate cell: $W_c = 0.4,\ b_c = 0.0$
- Output gate: $W_o = 0.7,\ b_o = -0.1$

Note that the general gate equation takes the form:

$$z_t = \text{activation}(Wx_t + Wh_{t-1} + b)$$

The internal structure of an LSTM cell is shown in Figure Q4 (f) as a reference.

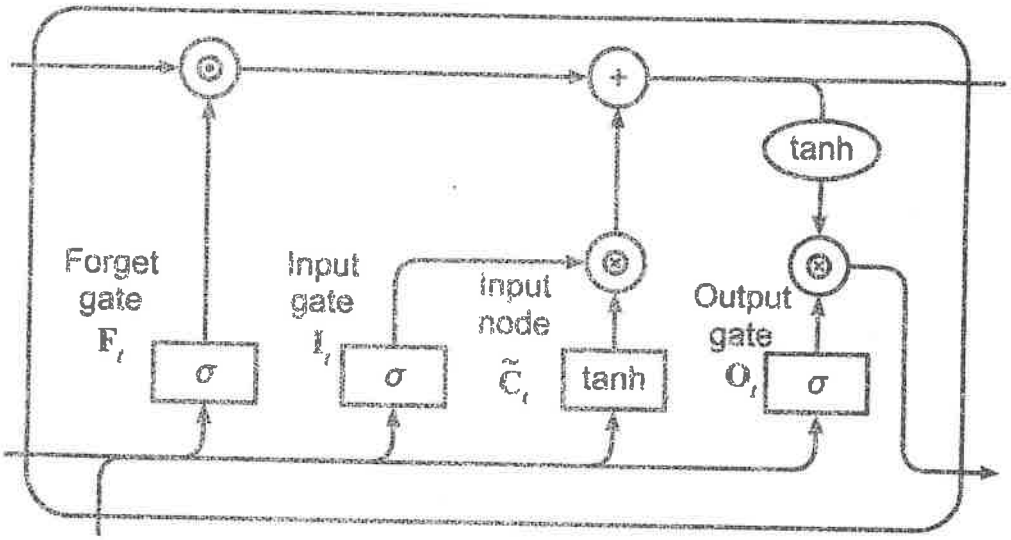

Figure Q4 (f): Internal block diagram of an LSTM cell

Compute the **new cell state** (C_t) and **new hidden state** (h_t) values. Show your working.

Hint:

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$

$$tanh(x) = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}}$$

[3.0 Marks]

g) The **Gated Recurrent Unit (GRU)** is often considered a simplified version of the LSTM. State two (2) primary architectural simplifications made in the GRU compared to the LSTM.

[1.0 Mark]