

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering



Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: DMX7306 Intelligent Control Systems
Academic Year	: 2023/2024
Date	: 14 th March 2025
Time	: 14.00h -17.00h
Duration	: 3 hours

General Instructions

1. Read all instructions carefully before answering the questions.
 2. This question paper consists of **five (5)** questions in **four (4)** pages.
 3. Answer for each question should commence from a new page.
 4. This is a Closed Book Test (CBT).
 5. Answers should be in clear handwriting.
 6. Answer to all questions.
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Question 01

- a) Briefly explain the three levels in intelligent control architecture and sketch the intelligent control hierarchy. [5]
- b) Briefly following hybrid control systems [5]
 - i. Sequential Hybrids
 - ii. Auxiliary Hybrids
 - iii. Embedded Hybrids
- c) Explain the difference between classical control and intelligent control with examples. [5]
- d) What are the fundamental principles of Model Predictive Control (MPC), and how does it differ from traditional control strategies like PID control? [5]

Question 02

- a) Briefly explain Parametric Model Identification and Non-Parametric Model Identification. [4]
- b) Obtain the normal equations to find a least-squares of the following polynomial regression equation. [6]

$$E_{(a,b)} = \sum_{i=1}^n (y_n - ax_n - b)^2$$

- c) Find the least-squares parabola that fits to the following data set by using derived normal equations from Question 02 (b). [6]

x	0	1	2	3	4	5
y	2.1	7.7	13.6	27.2	40.9	61.1

- d) Hence calculate the correlation coefficient (r) and comment on the correlation coefficient [4]

Question 03

- a) Explain the architecture of the PID-Like Fuzzy logic controller. [5]
- b) A fuzzy inference system (FIS) produces the following fuzzy output membership values for the "Speed" variable, Compute the defuzzified output using the Centroid (Center of Gravity) Method.

Speed (m/s)	2	4	6	8	10
Membership value	0.2	0.6	0.8	0.4	0.1

[5]

- c) A fuzzy system is designed to control a water pump speed based on temperature and humidity. The rule base is:

Temperature (°C)	Humidity (%)	Pump Speed (rpm)
Low	High	Slow
Medium	Medium	Medium
High	Low	Fast

Membership functions:

Temperature (Triangular): Low: (0,0,30) Medium: (20,50,80) High: (60,100,100)

Humidity (Triangular): Low: (0,0,50) Medium: (30,50,70) High: (50,100,100)

Pump Speed (Triangular): Slow: (0,0,50) Medium: (30,50,70) Fast: (50,100,100)

- i. Compute the membership values for Temperature = 40°C and Humidity = 60%.
- ii. Apply Mamdani inference using the Min-Max method.
- iii. Compute the final pump speed using the Centroid Defuzzification Method.

[10]

Question 04

- a) Describe how neural networks are used to achieve the function of a fuzzy logic controller. [4]
- b) Use the Gradient Descent method and Delta Learning rule to find out the best weight Δw_i . Consider the error function E , input y and output u .

$$E = \frac{1}{2} \sum (y - u)^2$$

[6]

- c) Figure Q4 shows a two-input single-output neural network with a single hidden layer, deriving equations for updated weights w_5 and w_1 using backpropagation, use the sigmoid transfer function for the hidden layer and output layer.

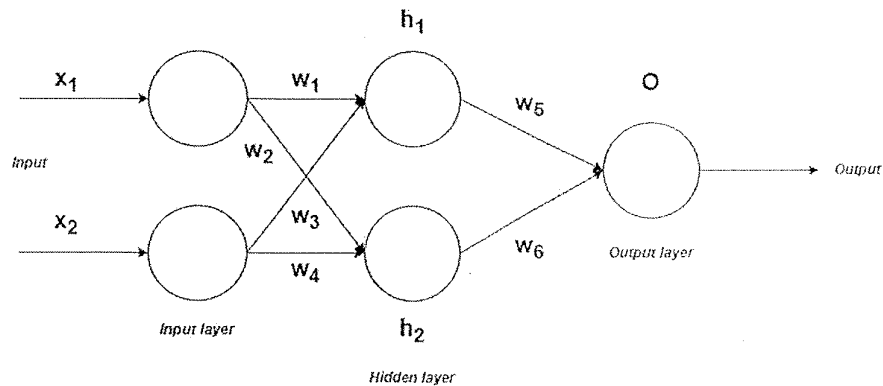


Figure Q4

[10]

Question 05

Lithium ion (Li-ion) batteries have been widely used in various kinds of applications, including consumer electronics, green energy systems, and electrical vehicles. Since the charging method has a significant influence on the performance and lifetime of Li-ion batteries, an intelligent charging algorithm which can properly determine the charging current is essential. A schematic diagram of a fuzzy-logic-control-based (FLC-based) five-stage Li-ion battery charger is shown in Figure Q5. The proposed charger takes the temperature rise of the battery into account, and adjusts the charging current accordingly.

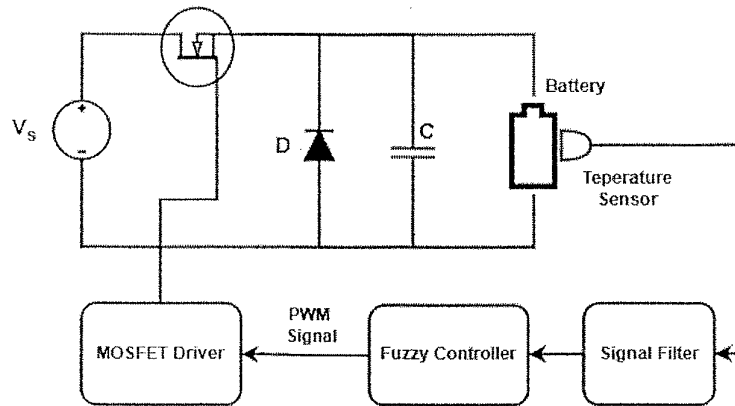


Figure Q5

- a) Develop a suitable PD-Like Fuzzy Logic control architecture for the battery charging system depicted in figure Q5, considering two inputs and a single output. Discuss the rule base, membership functions, and inference mechanism.

[10]

Note:

- You can select appropriate ranges for input and output fuzzy sets.
- Indicate any assumptions

- b) Sketch and indicate the components of the closed-loop control system architecture.

[2]

- c) Develop Neuro-Fuzzy architecture based on the above PD-like fuzzy controller. [8]

END