

M.ETCE FIRST YEAR SECOND SEMESTER, 2025**Deep Learning and Model Predictive Control****Time: 3 hours****Full Marks: 100****Answer any 4 questions.**

1. a) Define and explain gradient decent learning.
 b) Develop the weight adaptation in a feed-forward NN using gradient decent learning.
 c) Use the above results to develop the Back-propagation algorithm.
 d) What is done when BP algorithm gets stuck at local minima?
[6+10+6+3]
2. Use KKT condition to maximize:

$$f(x, y) = 3x + 4y$$
 subject to

$$g_1(x, y) = x^2 + y^2 \leq 4$$

$$\text{and } g_2(x, y) = -x \leq -1.$$
[25]
3. a) Draw and explain the architecture of a CNN.
 b) Justify the importance of the ReLU and Maxpool operations.
 c) How the weights of convolutional layer are optimized?
 d) How the feature extraction from raw data is possible using CNN?
[10+4+6+5]
4. a) Define Control Lyapunov function and Control Barrier function.
 b) Derive the affine model of the quadrotor given by $\ddot{\vec{x}}_i = A\dot{\vec{x}}_i + B\vec{u}_i$
 where, $A = \begin{bmatrix} 0_3 & I_3 \\ 0_3 & 0_3 \end{bmatrix}$, $B = \begin{bmatrix} 0_3 \\ I_3 \end{bmatrix}$, $\vec{x}_i^T = [\vec{p}_i^T \quad \vec{v}_i^T]$ and $\vec{u}_i = \vec{v}_i$.
 c) Formulate the CLF constraints for the MPC.
 d) Assuming $\vec{e}_i = \vec{x}_i - \hat{x}_i$ and $V(\vec{e}_i) = \vec{e}_i^T \vec{e}_i$, show that $\dot{V}(\vec{e}_i, \vec{u}_i) = 2(\vec{x}_i - \hat{x}_i)^T (\ddot{\vec{x}}_i - \hat{\ddot{x}}_i)$.
 e) Construct the Lagrangian to satisfy MPC-CLF and hence formulate the KKT conditions for the same.
[6+6+6+4+3]
5. a) What is the importance of fuzzy logic in fuzzy MPC?
 b) Construct a fuzzy MPC formulation for multi-quadrotor formation control and explain.

[Turn over

- c) How will you determine the leader position from the individual quadrotor positions using fuzzy logic?
- d) Explain the architecture of MPC formulation of multi-quadrotor formation control?

[4+6+6+9]

6. a) Draw and explain the schematic architecture of GCNN.

- b) How GCNN can be interfaced with a PSO algorithm to use it as a graph classifier?
- c) Why brain-network classification is important?
- d) What feature of fuzzy relational connectivity between nodes of a graph are utilized for classification of brain network?

[8+6+6+5]

7. Write a long note on Autoencoder illustrating its significance, scope and applications.

[25]