B.E. / B.Tech. Computer Science & Engineering (Model Curriculum) Semester-VI

# TEE2043CS / NEURAL NETWORK1 - Elective-III

# Neural Network and Deep Learning

P. Pages : 3 **GUG/S/25/13829**

Time : Three Hours * 2 2 8 2 * Max. Marks : 80

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Notes : 1. All questions are compulsory.
2. All questions carry equal marks.
3. Due credit will be given to neatness and adequate dimensions.
4. Illustrate your answers wherever necessary with the help of neat sketches.

**1.** a) In what real-world scenarios are artificial neural networks applied, and how do they revolutionize fields like computer vision, natural language processing, and predictive analytics? **8**

b) Draw and explain the mathematical model of a McCulloch-Pitts Neuron for the logical OR operation and give the expressions for the output (Y) considering the 3 input neurons. **8**

**OR**

**2.** a) Explain the concept of linearly separable and non-linearly separable problems. State whether a single-layer perceptron can solve both types of problems. Illustrate this with the AND and XOR two-input logical functions, giving the equation of the separator and inequalities where applicable. Identify which of these functions is linearly non-separable and explain why. **8**

b) What is the Perceptron Model in Artificial Neural Networks (ANNs)? Describe the structure and functionality of its architecture. **8**

**3.** a) Outline the steps of the Perceptron Learning Algorithm. What are the key limitations of a single-layer Perceptron? **8**

b) State true or false- "Single Perceptron solve only linearly separable problem". Justify your answer by giving equation of separator and inequalities for the following 2 input logical function. 1) AND 2) XOR. Among these two logical functions which one is linearly non separable? And why? **8**

**OR**

**4.** a) Explain how a network of perceptron (a multilayer perceptron) can overcome the limitations of a single perceptron in solving non-linearly separable problems such as the XOR function. Briefly describe the role of a hidden layer in this context. **8**

b) Consider 4 data points with 3 dimensions that are divided into two classes, Class-1 and Class-2. **8**

| Sample | Data Point(x) | Class |
|---|---|---|
| S1 | [1, 0, 1] | 1 |
| S2 | [0, 1, 1] | 0 |
| S3 | [1, 1, 0] | 1 |
| S4 | [0, 0, 1] | 0 |

Let the initial weight vector be [-0.5, 1, 0.2]. Apply the perceptron learning algorithm to the sample data in the same order, Find the value of weight vector at the end of sample S4. (Hint: If $x \in 1$, perform w = w + x, else perform w = w - x).

**5.** a) Give the following confusion matrix for a binary classification problem: **8**

| | Predicted Class-0 | Predicted Class-1 |
|---|---|---|
| Actual Class – 0 | 40 | 10 |
| Actual Class – 1 | 5 | 45 |

1. Calculate the Accuracy, Precision, Recall, and F1-Score

2. Compute the Specificity and Sensitivity.

b) What are the widely used activation functions in neural networks, and what are their distinct roles? Explain the properties and significance of any four. **8**

**OR**

**6.** a) Explain the Associative Memory of Real Coded Pattern Pairs model. How is it useful in pattern recognition tasks. **8**

b) What is Adaptive Resonance Theory (ART)? Explain the difference between ART1 and ART2. **8**

**7.** a) How do Batch Gradient Descent, Stochastic Gradient Descent, and Mini-Batch Gradient Descent differ in their computational requirements and convergence rates? **8**

b) What are the disadvantages of using ReLU, and how do they lead to the Dying ReLU Problem? **8**

**OR**

**8.** a) There is a set of certain optimizers which helps in improving the parameter optimization process. Explain any two optimizers among the followings: (a) Adagrad (b) RMSProp (c) Adam. **8**

b) What is the primary goal of gradient descent when training a neural network? Explain the key concept of minimizing a cost function using this optimization algorithm and describe the significance of learning rate in guiding the process. **8**

**9.** a) List and explain the followings in the context of convolutional neural networks: **8**

a. Parameter sharing

b. 1x1 convolution

b) What are the basic building blocks of CNN architecture? Explain the process of convolution with an input image of size 6 X 6 and a filter 3 X 3 valid padding with stride of 1. **8**

**OR**

**10.** a) Given the input matrix and the kernel, perform convolution with stripe being 2, padding being 1. Find the output feature map. **8**

| | | | | |
|---|---|---|---|---|
| 1 | 0 | 1 | 1 | 0 |
| 0 | 0 | 0 | 1 | 1 |
| 1 | 0 | 0 | 0 | 1 |
| 0 | 1 | 1 | 1 | 0 |
| 1 | 1 | 0 | 1 | 0 |

Input matrix

| | | |
|---|---|---|
| 1 | 0 | 0 |
| 0 | 0 | 1 |
| 1 | 1 | 0 |

Kernel

b) Performa a 2x2 Average Pooling and Max Pooling operation on the given matrix. Calculate and compare the resulting pooled output both techniques. **8**

| | | | |
|---|---|---|---|
| 2 | 4 | 6 | 8 |
| 1 | 3 | 5 | 7 |
| 0 | 2 | 4 | 6 |
| 9 | 7 | 5 | 3 |

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