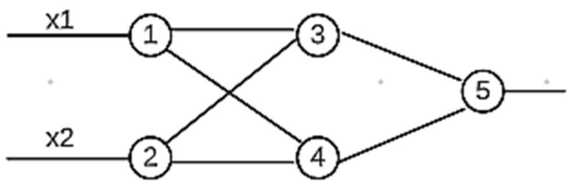
Q	No.	Question	Marks	BL	PO	CO	PSO
OR	iii.	Assume that the neurons have a sigmoid activation function. Perform a forward pass and a backward pass on the network. Assume that the actual output of y is 0.5 and learning rate is 1. Perform another forward pass.	**8**	2	1 2 4 5	3	2



Take

x1=0.35 x2= 0.9

w13= 0.1 w14= 0.4

w23= 0.8 w24= 0.6w35 = 0.3 w45 = 0.9

Q	No.	Question	Marks	BL	PO	CO	PSO
Q.5	i.	Differentiate between single-channel and multi-channel data in ConvNet.	**3**	1	1 2 4 5	4	2
	ii.	Explain how convolutional layers and pooling layers act as strong priors in image recognition tasks.	**7**	2	1 2 4 5	4	2
OR	iii.	Describe the effect of increasing the stride in a convolutional layer. How does this impact the size of the output feature map?	**7**	2	1 2 4 5	4	2
Q.6	i.	What is the attention mechanism in neural networks?	**3**	1	1 2 4 5	5	2
	ii.	Explain the architecture of Generative Adversarial Networks (GANs).	**7**	2	1 2 4 5	5	2
OR	iii.	What are the key ethical considerations in the development and deployment of AI and neural networks?	**7**	2	1 2 4 5	5	2

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Total No. of Questions: 6 *Total No. of Printed Pages:4*

Enrollment No......................................

Faculty of Engineering
End Sem Examination Dec 2024
RA3EL26 Neural Network

Programme: B.Tech. Branch/Specialisation: RA

Duration: 3 Hrs. **Maximum Marks: 60**

Note: All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d. Assume suitable data if necessary. Notations and symbols have their usual meaning.

Q	No.	Question	Marks	BL	PO	CO	PSO
Q.1	i.	The three primary layers in a neural network system are: (a) Input, hidden, and output layers (b) Axon, dendrite, and soma (c) Training, validation, and testing layers (d) Activation, feedforward, and feedback layers	**1**	1	1 2 4,5	1	2
	ii.	Which of the following accurately describes a Single-Layer Perceptron (SLP)? (a) It consists of one hidden layer between the input and output (b) It can solve both linearly and non-linearly separable problems (c) It can only classify linearly separable problems (d) It uses the sigmoid activation function exclusively	**1**	1	1 2 4	1	2
	iii.	Which of the following is true about Recurrent Neural Networks (RNNs)? (a) They do not have loops (b) They are suitable for processing sequential data (c) They work only with feedforward connections (d) They require no memory of previous states	**1**	1	1 2 4	2	2
	iv.	In a feedforward neural network, information flows: (a) In cycles (b) Back and forth (c) In one direction (d) Randomly between neurons	**1**	1	5	2	2

v. What is the main purpose of dropout as a regularization technique? **1** 1 5 3 2
(a) To increase the number of neurons in a layer
(b) To randomly deactivate neurons during training to prevent overfitting
(c) To scale up the model's complexity
(d) To reduce the learning rate during training

vi. In the context of transfer learning, what does fine-tuning involve? **1** 1 1 2 4 3 2
(a) Modifying a pre-trained model by adjusting its parameters to a new task
(b) Training a model from scratch on a new dataset
(c) Replacing the loss function of the model
(d) Adding new neurons to the model

vii. What is the purpose of the kernel in a convolutional layer? **1** 1 5 4 2
(a) To reduce dimensionality
(b) To perform element-wise multiplication with the input data
(c) To store learned weights
(d) To perform pooling operations

viii. In a ConvNet, how are multi-channel inputs handled during convolution? **1** 1 1 2 4 4 2
(a) Each channel is convolved separately with the same kernel
(b) A separate kernel is used for each channel
(c) Channels are concatenated before convolution
(d) The input is down sampled before convolution

ix. Which of the following is a key goal of Explainable AI (XAI)? **1** 1 5 5 2
(a) To make neural networks larger
(b) To reduce the training time of models
(c) To make AI decisions interpretable and understandable
(d) To increase data privacy

x. Which ethical issue is most commonly associated with AI models that are trained on biased datasets? **1** 1 1 2 4,5 5 2
(a) Increased accuracy
(b) Unfair or discriminatory decision-making
(c) Higher computational costs
(d) Lack of interpretability

Q.2 i. Draw a simple neural network having one input layer, 2 hidden layer and one output layer. Also write the names of various terminologies related to Neural network. **3** 1 1 2 4,5 1 2

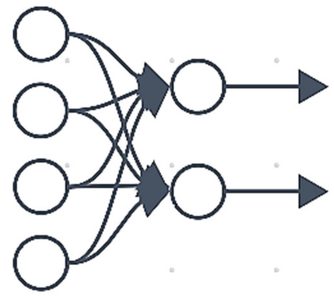
ii. Explain biological neuron with the help of a diagram. Also, write any three differences between biological neuron and artificial neuron **7** 2 1 2 4,5 1 2

OR iii. Implement XOR logic function using McCulloch-Pitts Model. Find the values of threshold and weights. **7** 2 1 2 4,5 1 2

Q.3 i. Explain Radial Basis Function (RBF) networks. **2** 2 1 2 4 2 2

ii. What are activation Functions? Explain various types of activation functions used in the neural network. **8** 2 1 2 4 2 2

OR iii. Consider the network shown in fig which considers four training samples each of length 4 and two output units **8** 2 1 2 4 5 2 2



Train the SOM network by determining the class membership of the input data-

X1= [1,0,1,0] X2= [1,0,0,0]
X3= [1,1,1,1] X4= [0,1,1,0]

Output units:
[Unit 1] = [0.3,0.5,0.7,0.2]
[Unit 2] = [0.6,0.5,0.4,0.2]
Take learning rate= 0.6

Q.4 i. What is transfer learning in neural networks? **2** 1 1 2 4,5 3 2

ii. Discuss the role of regularization techniques like dropout and weight decay in neural networks. **8** 2 1 2 4 5 3 2

Marking Scheme
RA3EL26 (T) Neural Network (T)

Q.1 i) a) Input, hidden, and output layers **1**

ii) c) It can only classify linearly separable problems **1**

iii) b) They are suitable for processing sequential data **1**

iv) c) Only in one direction **1**

v) b) To randomly deactivate neurons during training to prevent overfitting **1**

vi) a) Modifying a pre-trained model by adjusting its parameters to a new task **1**

vii) b) To perform element-wise multiplication with the input data **1**

viii) b) A separate kernel is used for each channel **1**

ix) c) To make AI decisions interpretable and understandable **1**

x) b) Unfair or discriminatory decision-making **1**

Q.2 i. Draw a simple neural network having one input layer, 2 hidden layer and one output layer**……………………1.5 marks** **3**
Also write the names of various terminologies related to Neural network. **……………………1.5 marks**

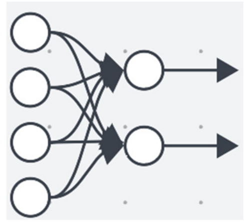
ii. Explain biological neuron with the help of a diagram. **……………………4 marks** **7**
Also, write any 3 differences between biological neuron and artificial neuron**……………………3 marks**

OR iii. Implement XOR logic function using McCulloch-Pitts Model. **……………………5 marks** **7**
Find the values of threshold and weights. **…………….2 marks**

Q.3 i. Explain Radial Basis Function (RBF) networks**…………2 marks** **2**

ii. What are activation Functions. **…………4 marks** **8**
Explain various types of activation functions used in the neural network. **…………4 marks**

OR iii. Consider the network shown in fig which considers four training samples each of length 4 and two output units **8**



Train the SOM network by determining the class membership of the input data

X1= [1,0,1,0] X2= [1,0,0,0]

X3= [1,1,1,1] X4= [0,1,1,0]

Output units:

[Unit 1] = [0.3,0.5,0.7,0.2]

[Unit 2] = [0.6,0.5,0.4,0.2]

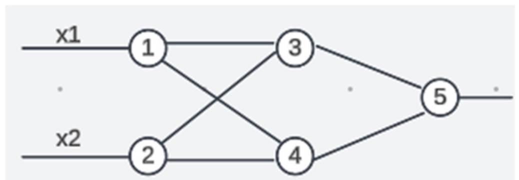
Take learning rate= 0.6

Finding answer…………8 marks

Q.4 i. What is transfer learning in neural networks**…………2 marks** **2**

ii. Discuss the role of regularization techniques like dropout and weight decay in neural networks. **8**
Dropout**…………4 marks**
Weight decay**…………4 marks**

OR iii. Assume that the neurons have a sigmoid activation function. Perform a forward pass and a backward pass on the network. Assume that the actual output of y is 0.5 and learning rate is 1. Perform another forward pass. **8**



Take x1=0.35 x2= 0.9

w13= 0.1 w14= 0.4

w23= 0.8   w24= 0.6
w35 = 0.3   w45 = 0.9
Finding answer…………8 marks

Q.5	i.	Differentiate between single-channel and multi-channel data in ConvNet. **…………3marks**	**3**
	ii.	Explain how convolutional layers and pooling layers act as strong priors in image recognition tasks. convolutional layers **…………3 marks** pooling layers **…………4 marks**	**7**
OR	iii.	Describe the effect of increasing the stride in a convolutional layer. **Finding answer…………4 marks** How does this impact the size of the output feature map? **…………3 marks**	**7**
Q.6	i.	What is the attention mechanism in neural networks? **…………3 marks**	**3**
	ii.	Explain the architecture of Generative Adversarial Networks (GANs). **…………7 marks**	**7**
OR	iii.	What are the key ethical considerations in the development and deployment of AI and neural networks? **…………7 marks**	**7**

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Q. 3 (iii)

Given Data:

1. **Input vectors:**
   - $X_1 = [1, 0, 1, 0]$
   - $X_2 = [1, 0, 0, 0]$
   - $X_3 = [1, 1, 1, 1]$
   - $X_4 = [0, 1, 1, 0]$

2. **Output unit weights:**
   - **Unit 1:** $W_1 = [0.3, 0.5, 0.7, 0.2]$
   - **Unit 2:** $W_2 = [0.6, 0.5, 0.4, 0.2]$
3. **Learning rate:** $\eta = 0.6$

Step 1: Process Input $X_1 = [1, 0, 1, 0]$

1.1 Compute Euclidean Distance

- For **Unit 1** ($W_1 = [0.3, 0.5, 0.7, 0.2]$):

$$D_1 = \sqrt{(1-0.3)^2 + (0-0.5)^2 + (1-0.7)^2 + (0-0.2)^2}$$

$$D_1 = \sqrt{(0.7)^2 + (-0.5)^2 + (0.3)^2 + (-0.2)^2} = \sqrt{0.49 + 0.25 + 0.09 + 0.04} = \sqrt{0.87} \approx 0.933$$

- For **Unit 2** ($W_2 = [0.6, 0.5, 0.4, 0.2]$):

$$D_2 = \sqrt{(1-0.6)^2 + (0-0.5)^2 + (1-0.4)^2 + (0-0.2)^2}$$

$$D_2 = \sqrt{(0.4)^2 + (-0.5)^2 + (0.6)^2 + \downarrow 0.2)^2} = \sqrt{0.16 + 0.25 + 0.36 + 0.04} = \sqrt{0.81} = 0.9$$

1.2 Determine the Winning Unit

- $D_1 \approx 0.933$, $D_2 = 0.9$
- **Unit 2** wins because it has the smaller distance.

1.3 Update Weights for Winning Unit (Unit 2)

Using the weight update rule:

$$w_i(t+1) = w_i(t) + \eta \cdot (x_i - w_i(t))$$

- For $W_2 = [0.6, 0.5, 0.4, 0.2]$:

$$w_2(1) = 0.6 + 0.6 \cdot (\downarrow 0.6) = 0.6 + 0.6 \cdot 0.4 = 0.84$$

$$w_2(2) = 0.5 + 0.6 \cdot (0 - 0.5) = 0.5 + 0.6 \cdot (-0.5) = 0.2$$

$$w_2(3) = 0.4 + 0.6 \cdot (1 - 0.4) = 0.4 + 0.6 \cdot 0.6 = 0.76$$

$$w_2(4) = 0.2 + 0.6 \cdot (0 - 0.2) = 0.2 + 0.6 \cdot (-0.2) = 0.08$$

Updated weights for Unit 2:

$$W_2 = [0.84, 0.2, 0.76, 0.08]$$

Step 2: Process Input $X_2 = [1, 0, 0, 0]$

2.1 Compute Euclidean Distance

- For **Unit 1** ($W_1 = [0.3, 0.5, 0.7, 0.2]$):

$$D_1 = \sqrt{(1-0.3)^2 + (0-0.5)^2 + (0-0.7)^2 + (0-0.2)^2}$$

$$D_1 = \sqrt{(0.7)^2 + (-0.5)^2 + (-0.7)^2 + (-0.2)^2} = \sqrt{0.49 + 0.25 + 0.49 + 0.04} = \sqrt{1.27} \approx 1.127$$

- For **Unit 2** ($W_2 = [0.84, 0.2, 0.76, 0.08]$) (updated weights):

$$D_2 = \sqrt{(1-0.84)^2 + (0-0.2)^2 + (0-0.76)^2 + (0-0.08)^2}$$

$$D_2 = \sqrt{(0.16)^2 + (-0.2)^2 + (-0.76)^2 + (-0.08)^2} = \sqrt{0.0256 + 0.04 + 0.5776 + 0.0064} = \sqrt{0.6496} \approx 0.805$$

2.2 Determine the Winning Unit

- $D_1 \approx 1.127$, $D_2 \approx 0.805$
- **Unit 2** wins again because it has the smaller distance.

2.3 Update Weights for Winning Unit (Unit 2)

Using the update rule for $W_2 = [0.84, 0.2, 0.76, 0.08]$:

$$w_i(t+1) = w_i(t) + \eta \cdot (x_i - w_i(t))$$

- $w_2(1) = 0.84 + 0.6 \cdot (1 - 0.84) = 0.84 + 0.6 \cdot 0.16 = 0.936$
- $w_2(2) = 0.2 + 0.6 \cdot (0 - 0.2) = 0.2 + 0.6 \cdot (-0.2) = 0.08$
- $w_2(3) = 0.76 + 0.6 \cdot (0 - 0.76) = 0.76 + 0.6 \cdot (-0.76) = 0.304$
- $w_2(4) = 0.08 + 0.6 \cdot (0 - 0.08) = 0.08 + 0.6 \cdot (-0.08) = 0.032$

Updated weights for Unit 2:

$$W_2 = [0.936, 0.08, 0.304, 0.032]$$

Step 3: Process Input $X_3 = [1, 1, 1, 1]$

3.1 Compute Euclidean Distance

- For **Unit 1** ($W_1 = [0.3, 0.5, 0.7, 0.2]$):

$$D_1 = \sqrt{(1-0.3)^2 + (1-0.5)^2 + (1-0.7)^2 + (1-0.2)^2}$$

$$D_1 = \sqrt{(0.7)^2 + (0.5)^2 + (0.3)^2 + (0.8)^2} = \sqrt{0.49 + 0.25 + 0.09 + 0.64} = \sqrt{1.47} \approx 1.213$$

- For **Unit 2** ($W_2 = [0.936, 0.08, 0.304, 0.032]$):

$$D_2 = \sqrt{(1-0.936)^2 + (1-0.08)^2 + (1-0.304)^2 + (1-0.032)^2}$$

$$D_2 = \sqrt{(0.064)^2 + (0.92)^2 + (0.696)^2 + (0.968)^2}$$

$$D_2 = \sqrt{0.0041 + 0.8464 + 0.4844 + 0.9370} = \sqrt{2.2719} \approx 1.507$$

3.2 Determine the Winning Unit

- $D_1 \approx 1.213$, $D_2 \approx 1.507$
- **Unit 1** wins because it has the smaller distance.

3.3 Update Weights for Winning Unit (Unit 1)

Using the update rule for $W_1 = [0.3, 0.5, 0.7, 0.2]$:

$$w_i(t+1) = w_i(t) + \eta \cdot (x_i - w_i(t))$$

- $w_1(1) = 0.3 + 0.6 \cdot (1 - 0.3) = 0.3 + 0.6 \cdot 0.7 = 0.72$
- $w_1(2) = 0.5 + 0.6 \cdot (1 - 0.5) = 0.5 + 0.6 \cdot 0.5 = 0.8$
- $w_1(3) = 0.7 + 0.6 \cdot (1 - 0.7) = 0.7 + 0.6 \cdot 0.3 = 0.88$
- $w_1(4) = 0.2 + 0.6 \cdot (1 - 0.2) = 0.2 + 0.6 \cdot 0.8 = 0.68$

Updated weights for Unit 1:

$$W_1 = [0.72, 0.8, 0.88, 0.68]$$

Step 4: Process Input $X_4 = [0, 1, 1, 0]$

4.1 Compute Euclidean Distance

- For **Unit 1** ($W_1 = [0.72, 0.8, 0.88, 0.68]$):

$$D_1 = \sqrt{(0-0.72)^2 + (1-0.8)^2 + (1-0.88)^2 + (0-0.68)^2}$$

$$D_1 = \sqrt{(0.72)^2 + (0.2)^2 + (0.12)^2 + (0.68)^2}$$

$$D_1 = \sqrt{0.5184 + 0.04 + 0.0144 + 0.4624} = \sqrt{1.0352} \approx 1.017$$

P.T.O.

- For **Unit 2** ($W_2 = [0.936, 0.08, 0.304, 0.032]$):

$$D_2 = \sqrt{(0-0.936)^2 + (1-0.08)^2 + (1-0.304)^2 + (0-0.032)^2}$$

$$D_2 = \sqrt{(0.936)^2 + (0.92)^2 + (0.696)^2 + (0.032)^2}$$

$$D_2 = \sqrt{0.876 + 0.8464 + 0.4844 + 0.0010} = \sqrt{2.2078} \approx 1.486$$

4.2 Determine the Winning Unit

- $D_1 \approx 1.017$, $D_2 \approx 1.486$
- **Unit 1** wins because it has the smaller distance.

Final Results

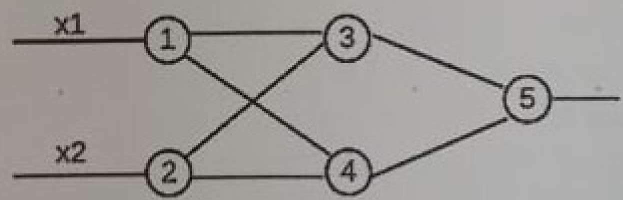
The updated weights are:

- **Unit 1:** $W_1 = [0.72, 0.8, 0.88, 0.68]$
- **Unit 2:** $W_2 = [0.936, 0.08, 0.304, 0.032]$

Q. 4 (iii)

[4]

iii. Assume that the neurons have a sigmoid activation function. Perform a forward pass and a backward pass on the network. Assume that the actual output of y is 0.5 and learning rate is 1. Perform another forward pass. **8**



Take

x1=0.35 x2= 0.9

w13= 0.1 w14= 0.4

w23= 0.8 w24= 0.6w35 = 0.3 w45 = 0.9

Given Data:

- **Inputs:** $x_1 = 0.35$, $x_2 = 0.9$
- **Weights:**
  - $w_{13} = 0.1$, $w_{14} = 0.4$, $w_{23} = 0.8$, $w_{24} = 0.6$, $w_{35} = 0.3$, $w_{45} = 0.9$
- **Actual output:** $y = 0.5$
- **Activation function:** Sigmoid $\sigma(z) = \frac{1}{1+e^{-z}}$
- **Learning rate:** $\eta = 1$

Step 1: Forward Pass (Initial Weights)

Hidden Layer Calculations:

The net input to hidden layer neurons h_3 and h_4 is:

$$h_j = \sigma\left(\text{Net}_j\right) \quad \text{where} \quad \text{Net}_j = x_1 \cdot w_{1j} + x_2 \cdot w_{2j}$$

1. **For h_3:**

$$\text{Net}_3 = (0.35)(0.1) + (0.9)(0.8) = 0.035 + 0.72 = 0.755$$

$$h_3 = \sigma(0.755) = \frac{1}{1 + e^{-0.755}} \approx 0.680$$

2. **For h_4:**

$$\text{Net}_4 = (0.35)(0.4) + (0.9)(0.6) = 0.14 + 0.54 = 0.68$$

$$h_4 = \sigma(0.68) = \frac{1}{1 + e^{-0.68}} \approx 0.663$$

Output Layer Calculation:

The net input to output neuron o_5 is:

$$\text{Net}_5 = h_3 \cdot w_{35} + h_4 \cdot w_{45}$$

$$\text{Net}_5 = (0.680)(0.3) + (0.663)(0.9) = 0.204 + 0.5967 = 0.8007$$

The output at o_5 is:

$$o_5 = \sigma(0.8007) = \frac{1}{1 + e^{-0.8007}} \approx 0.690$$

Step 2: Backward Pass (Error Calculation and Weight Updates)

Error at the Output Layer:

The error is given as the difference between actual output $y = 0.5$ and predicted output $o_5 = 0.690$:

$$\delta_5 = (y - o_5) \cdot \sigma'(0.8007)$$

The derivative of sigmoid:

$$\sigma'(z) = \sigma(z) \cdot (1 - \sigma(z))$$

$$\sigma'(0.8007) = 0.690 \cdot (1 - 0.690) = 0.690 \cdot 0.310 = 0.2139$$

Thus:

$$\delta_5 = (0.5 - 0.690) \cdot 0.2139 = -0.190 \cdot 0.2139 \approx -0.0406$$

Update Weights to Output Layer:

Using the weight update rule:

$$\Delta w_{j5} = \eta \cdot \delta_5 \cdot h_j$$

1. **For w_{35}:**

$$\Delta w_{35} = 1 \cdot (-0.0406) \cdot 0.680 \approx -0.0276$$

$$w_{35} = 0.3 + (-0.0276) = 0.2724$$

2. **For w_{45}:**

$$\Delta w_{45} = 1 \cdot (-0.0406) \cdot 0.663 \approx -0.0269$$

$$w_{45} = 0.9 + (-0.0269) = 0.8731$$

Error Propagation to Hidden Layer:

The error at hidden layer neurons h_3 and h_4 is:

$$\delta_j = \sigma'(h_j) \cdot (\delta_5 \cdot w_{j5})$$

1. **For h_3:**

$$\sigma'(h_3) = h_3 \cdot (1 - h_3) = 0.680 \cdot (1 - 0.680) = 0.680 \cdot 0.320 = 0.2176$$

$$\delta_3 = 0.2176 \cdot (-0.0406) \cdot 0.3 \approx -0.0026$$

2. **For h_4:**

$$\sigma'(h_4) = h_4 \cdot (1 - h_4) = 0.663 \cdot (1 - 0.663) = 0.663 \cdot 0.337 = 0.2235$$

$$\delta_4 = 0.2235 \cdot (-0.0406) \cdot 0.9 \approx -0.0082$$

Update Weights to Hidden Layer:

1. **For w_{13}:**

$$\Delta w_{13} = 1 \cdot (-0.0026) \cdot x_1 = -0.0026 \cdot 0.35 \approx -0.00091$$

$$w_{13} = 0.1 + (-0.00091) = 0.0991$$

2. **For w_{14}:**

$$\Delta w_{14} = 1 \cdot (-0.0082) \cdot x_1 = -0.0082 \cdot 0.35 \approx -0.00287$$

$$w_{14} = 0.4 + (-0.00287) = 0.3971$$

3. **For w_{23}:**

$$\Delta w_{23} = 1 \cdot (-0.0026) \cdot x_2 = -0.0026 \cdot 0.9 \approx -0.00234$$

$$w_{23} = 0.8 + (-0.00234) = 0.7977$$

4. **For w_{24}:**

$$\Delta w_{24} = 1 \cdot (-0.0082) \cdot x_2 = -0.0082 \cdot 0.9 \approx -0.00738$$

$$w_{24} = 0.6 + (-0.00738) = 0.5926$$

Updated Weights:

- $w_{13} = 0.0991$
- $w_{14} = 0.3971$
- $w_{23} = 0.7977$
- $w_{24} = 0.5926$
- $w_{35} = 0.2724$
- $w_{45} = 0.8731$