Test-5

Total marks: 100 | Date: 28.09.2022 | Time: 2 hours

Part-I: *(20 X 2 = 40)*

1. Which of the following logic cannot be modelled with a single neuron?
   a) 3-AND
   b) 3-XOR
   c) NOT
   d) All can be easily modelled

Correct Answer: b

2. Which of the following is true for neural networks?
   i. The error calculation which is followed in "Back-propagation algorithm" is the steepest descent method.
   ii. Simulated annealing approach is followed in unsupervised learning.
   iii. A problem whose output is linearly separable can also be solved with MLFFNN.
   iv. The output of the perceptron with hard limit transfer function is more accurate than it is defined with any sigmoid transfer function.

   a) i and iii are true
   b) i and ii are true
   c) ii and iv are true
   d) all are true

Correct Answer: a

3. In ANN to generate the final output, the sum is passed to a filter called _____, which releases the output.
   a) Fitness function
   b) Transfer function
   c) Objective function
   d) Elicit Function

Correct Answer: b

4. The behaviour of a biological neural network can be captured by a simple model called
   a) Perceptron
   b) Neural Connection
   c) Positron
   d) CON

Correct Answer: a

5. Which of the following statements is wrong about the learning techniques in Artificial Neural Networks (ANN)?
   a) Learning is performed by modifying the weights, bias terms or other related parameters.
   b) Learning is performed through multiple iterations/steps
   c) Many of the learning techniques utilize the gradient decent method to optimize the trainable parameters
   d) Learning is done by changing the number of hidden layers of the ANN architecture.

Correct Answer: d

6. Hebbian learning is a form of
   a) Z-scores
   b) T-scores
   c) F ratios
   d) Chi square

Correct Answer: b

7. The log-sigmoid transfer function for an input variable I is represented by following equation (consider is the constant of the transfer function) –
   a) $\varphi(I) = \frac{1}{1-e^{-\alpha I}}$
   b) $\varphi(I) = \frac{e^{\alpha I}+e^{-\alpha I}}{e^{\alpha I}-e^{-\alpha I}}$

c) $\varphi(I) = \frac{e^{-\alpha I}}{e^{\alpha I} - e^{-\alpha I}}$

d) $\varphi(I) = \frac{1}{1+e^{-\alpha I}}$

Correct Answer: d

8. For a given function $f(z) = \frac{1}{1+e^{-z}}$ the derivative of $f(z)$ with respect to z can be represented as -

a) $f'(z) = f(z) \times (1 - f(z))$

b) $f'(z) = f(z) \times (1 + f(z))$

c) $f'(z) = (1 - 2f(z))$

d) $f'(z) = (1 + 2f(z))$

Correct Answer: a

9. As per neural network terminology, the terms 'feed-forward' and 'back propagation' usually indicate,

a) Forward propagation of input information from input layer to output layer and back propagation of input information from output layer to input layer.

b) Forward propagation of error from input layer to output layer and back propagation of error from output layer to input layer

c) Forward propagation of error from input layer to output layer and back propagation of input information from output layer to input layer.

d) Forward propagation of input information from input layer to output layer and back propagation of error from output layer to input layer.

Correct Answer: d

10. A batch mode of training is generally implemented through the _____ in error calculation

a) Minimization of individual errors.

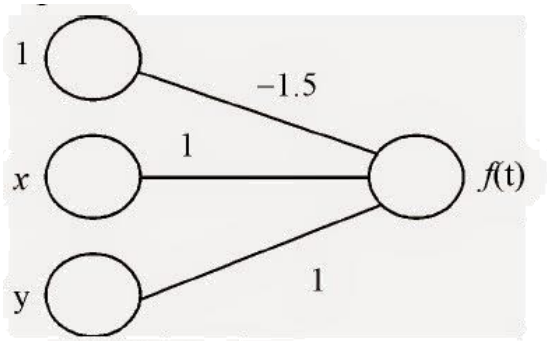
b) Maximization of individual errors.

c) Maximization of mean square error.

d) Minimization of mean square error.

Correct Answer: d

11. Consider a single perception with weights as given in the following figure. The perception can solve



and $f(t)$ defined as

$$f(t) = \begin{cases} 1, & t > 0 \\ 0, & t \le 0 \end{cases}$$

Choose the correction option form the following list of options.

a) OR problem

b) AND problem

c) XOR problem

d) NAND problem

Correct Answer: b

Explanation: according to given definition of f(t), f(t)=1 if t>0 else f(t)=0

x	y	net	output
0	0	(-1.5 +0.1+0.1)	0.
0	1	(-1.5 +0.1+1.1)	0
1	0	(-1.5+1.1+0.1)	0
1	1	(-1.5+1.1+1.1)	1.

12. What is the canonical form of the matrix $A = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$?

a) $x + xy + y^2$
b) $x^2 + xy$
c) $x^2 + y^2$
d) $x^2 + xy + y^2$

Correct answer: d

13. Which of the following is true for matrices?

a) $(AB)^{-1} = B^{-1}A^{-1}$
b) $A^T = A$
c) $AB = BA$
d) $A * I = I$

Correct answer: a
Explanation: The correct forms of the other options are:
$(A^T)^T = A$
$AB \neq BA$
$A*I = A$

14. The sum of two symmetric matrices is also a symmetric matrix.

a) True
b) False

Correct Answer: a

15. The solution of the system of equations
$x + y + z = 4,\ \ x - y + z = 0,\ \ and\ \ 2x + y + z = 5$ is

a) $x = 2, y = 2, z = 0$
b) $x = 1, y = 4, z = 1$
c) $x = 2, y = 4, z = 3$
d) $x = 1, y = 2, z = 1$

Correct Answer: d
Explanation:
From equation (2) we get, $x + z = y$ and adding (1) + (2) we get $x + z = 2$, hence $y = 2$
Performing, (3) – (1) we get $x = 1$. Hence $z = 1$

16. Consider the systems, each consisting of m linear equations in n variables.

i. If $m < n$, then all such systems have a solution.
ii. If $m > n$, then none of these systems has a solution.
iii. If $m = n$, then there exists a system which has a solution.

Which one of the following is correct?

a) i, ii, and iii are true
b) only ii and iii are true
c) only iii is true
d) All are false

Correct Answer: c

17. Which of the following is true for $\boldsymbol{A} \times \boldsymbol{B} = \boldsymbol{C}$ where $\boldsymbol{A} \in \mathbb{R}^{a \times b}, \boldsymbol{B} \in \mathbb{Z}^{b \times c}$

a) $\boldsymbol{C} \in \mathbb{Z}^{a \times c}$
b) $\boldsymbol{C} \in \mathbb{R}^{a \times c}$
c) $\boldsymbol{C} \in \mathbb{Z}^{c \times a}$
d) $\boldsymbol{C} \in \mathbb{Z}^{b \times b}$

Correct Answer: b

18. The set of numbers $\{-1.09, 0, 0.05, -2.73, 3.765\}$ is best represented as

a) $\mathbb{R}^5$
b) $\mathbb{C}^5$
c) $\mathbb{N}^5$
d) $\mathbb{R}^{+5}$

Correct Answer: a

19. A basket has 52 balls with 13 balls of each of the colors Red, Green, Blue, Black. Each ball is inscribed with a number, such that there is one ball of Red with number 1, one ball of Green with number 1, one ball of Blue with number 1 and one ball of Black with number 1. Similarly, it is repeated for all the other numbers. In experiment A of sampling with substitution, the probability of obtaining a number n be $p_A(n)$, and in another experiment B of sampling without substitution, the probability of obtaining a number n be $p_B(n)$, then which one is always TRUE.

a) $p_A(n) = p_B(n)$
b) $p_A(n) = {}^1/_{13}$
c) $p_B(n) = {}^1/_{13}$
d) $p_A(n) = {}^1/_4$

Correct Answer: c

20. An RGB image of size 640x480 px can be best represented by which of the following tensors

a) $\mathbb{R}^{640\times480\times3}$
b) $\mathbb{Z}^{640\times480\times3}$
c) $\mathbb{C}^{640\times480\times3}$
d) $\mathbb{Z}^{640\times480}$

Correct Answer: b

Part-II: Subjective type questions **6 X 10 = 60**

1. Show the implementation of perceptron algorithm for XOR logic gate with 2-bit binary input. (10)

Answer:

Truth table for 2-bit binary XOR gate is-

x_1	x_2	y
0	0	0
0	1	1
1	0	1
1	1	0

We can observe that, $XOR(x_1, x_2) = AND(NOT(AND(x_1, x_2)), OR(x_1, x_2))$

Now steps to design the Perceptron Network:

Step-1: Now for the corresponding weight vector w: (w_1, w_2) of the input vector x: (x_1, x_2) to the AND and OR node, the associated Perceptron function can be defined as:

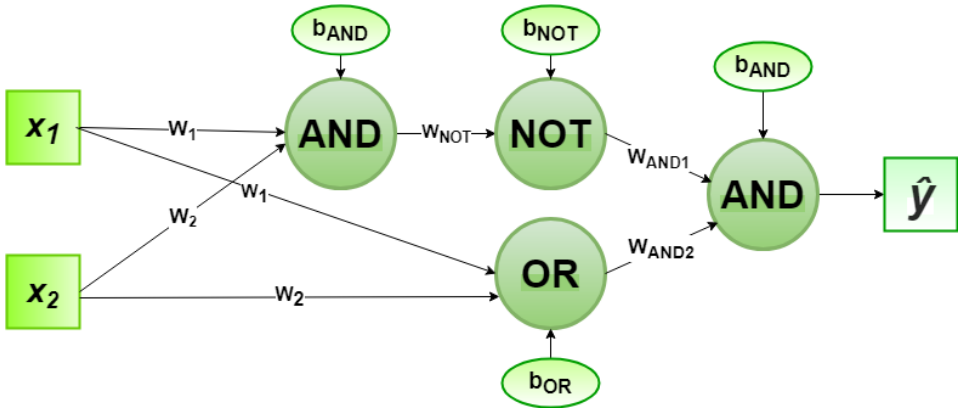
$$\hat{y}_1 = \Theta(w_1x_1 + w_2x_2 + b_{AND}$$
$$\hat{y}_2 = \Theta(w_1x_1 + w_2x_2 + b_{OR}$$

Step-2: The output $(\hat{y}_1)$ from the AND node will be inputted to the NOT node with weight w_{NOT} and associated Perceptron Function can be defined as:

$$\hat{y}_3 = \Theta(w_{NOT}\hat{y}_1 + b_{NOT})$$

Step-3: The output $(\hat{y}_2)$ from the OR node and the output $(\hat{y}_3)$ from NOT node as mentioned in Step-2 will be inputted to the AND node with weight (w_{AND1}, w_{AND2}). Then the corresponding output $\hat{y}$ is the final output of the XOR logic function. The associated Perceptron Function can be defined as:

$$\hat{y} = \Theta(w_{AND1}\hat{y}_3 + w_{AND2}\hat{y}_2 + b_{AND})$$



For the implementation, the weight parameters are considered to be $w_1 = 1, w_2 = 1, w_{NOT} = -1, w_{AND1} = 1, w_{AND2} = 1$ and the bais parameters are $b_{AND} = -1.5, b_{OR} = -0.5, b_{NOT} = 0.5$

2. What is Backpropagation? How Backpropagation algorithm works, explain through an NN diagram. (3+7)

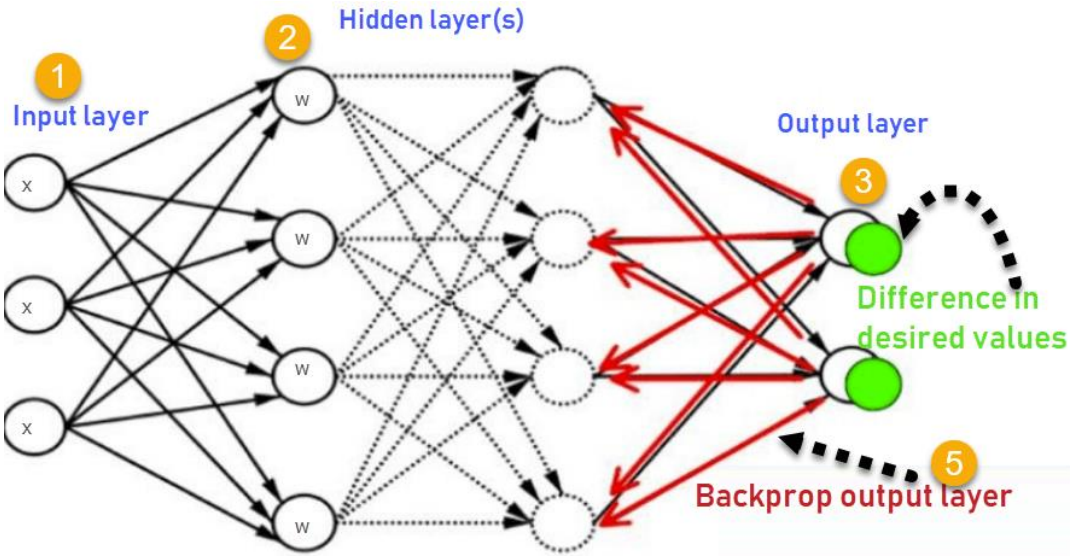
Answer:

Backpropagation: Backpropagation is the essence of neural network training. It is the method of fine-tuning the weights of a neural network based on the error rate obtained in the previous epoch (i.e., iteration). Proper tuning of the weights allows you to reduce error rates and make the model reliable by increasing its generalization.

Backpropagation in neural network is a short form for "backward propagation of errors." It is a standard method of training artificial neural networks. This method helps calculate the gradient of a loss function with respect to all the weights in the network.

How Backpropagation algorithm works: The Backpropagation algorithm in neural network computes the gradient of the loss function for a single weight by the chain rule. It efficiently computes one layer at a time, unlike a native direct computation. It computes the gradient, but it does not define how the gradient is used. It generalizes the computation in the delta rule.

Consider the following Back propagation neural network example diagram to understand:



Algorithm:

Step-1: Inputs X, arrive through the preconnected path

Step-2: Input is modelled using real weights W. The weights are usually randomly selected.
Step-3: Calculate the output for every neuron from the input layer, to the hidden layers, to the output layer.
Step-4: Calculate the error in the outputs

$$ErrorB = Actual\ Output - Desired\ Output$$

Step-5: Travel back from the output layer to the hidden layer to adjust the weights such that the error is decreased.
Step-6: Keep repeating the process until the desired output is achieved.

3. A grayscale intensity image of size 4×2px represented using a 3-bit integer has a histogram such that each intensity value is represented once, then calculate the entropy of this image? (10)

Answer:

$Histogram = \{1,1,1,1,1,1,1,1\}$

$Probability = \{\frac{1}{8},\frac{1}{8},\frac{1}{8},\frac{1}{8},\frac{1}{8},\frac{1}{8},\frac{1}{8},\frac{1}{8}\}$

$Entropy = log_2 8 = \mathbf{3}$

4. Answer the following questions:
   a) The system of linear equations, $-y + z = 0,\ (4d-1)x + y + z = 0,\ and\ \ (4d-1)z = 0$, has a non-trivial solution. Find the value of d. (6)
   b) Find the slope of the curve, $y = x^3$ at $(1, 1)$. (4)

Answer:

a) $A = \begin{bmatrix} 0 & -1 & 1 \\ (4d-1) & 1 & 1 \\ 0 & 0 & (4d-1) \end{bmatrix}$

For non-trivial solution,

$|A| = 0$

$\Rightarrow 0 \times [(4d-1) - 0] - (-1) \times [(4d-1)^2 - 0] + 1 \times (0 - 0) = 0$

$\Rightarrow (4d-1)^2 = 0$

$\Rightarrow d = \mathbf{\frac{1}{4}, \frac{1}{4}}$

b) $y = x^3$

$m = \frac{dy}{dx} = 3x^2$

Hence slope of the curve $y = x^3$ at (1, 1) is

$m = 3 \times (1)^2 = \mathbf{3}$

5. Draw the diagram of a neural network with 100 input neurons and 10 output neurons. Demonstrate how the operation of the neural network with 100 input neurons and 10 output neurons can be represented with a matrix multiplication, indicating clearly the constitution of the matrices. (10)

Answer:

You can draw any neural network with 100 input, 10 output neurons. It should indicate the bias, the arrows, and also correctly label the weights.

6. Find the eigenvectors of the given matrix: (10)

$$A = \begin{bmatrix} 1 & 4 \\ -4 & -7 \end{bmatrix}$$

Answer:

Given, $A = \begin{bmatrix} 1 & 4 \\ -4 & -7 \end{bmatrix}$

$|A - \lambda I| = \begin{bmatrix} 1-\lambda & 4 \\ -4 & -7-\lambda \end{bmatrix}$

$(1-\lambda)(-7-\lambda) - 4(-4) = 0$

$(\lambda + 3)^2 = 0$

Therefore, $\lambda = -3, -3$

Use the eigenvector equation $AX = \lambda X$

Substitute λ value in the equation $AX = -3X$
We know that, $(A - \lambda I)X = 0$

$$\left(\begin{bmatrix} 1 & 4 \\ -4 & -7 \end{bmatrix} + \begin{bmatrix} 3 & 0 \\ 0 & 3 \end{bmatrix}\right)\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$4x + 4y = 0$
Or
$x + y = 0$

Assume that $x = k$
So, it becomes $k + y = 0$ or $y = -k$

Therefore, the eigenvector is $X = \begin{bmatrix} x \\ y \end{bmatrix} = k\begin{bmatrix} 1 \\ -1 \end{bmatrix}$

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