

QUESTION ONE (20 MARKS)

- a) McCulloch-Pitts is one of the earliest artificial neural networks. i. List any four requirements of the McCulloch-Pitts neuron. (4 marks) ii. Explain how a McCulloch-Pitts neural network would perform the logical XOR function. (4 marks)
- b) Demonstrate your understanding of neural network applications in the fields of medicine, automotive, and banking. (3 marks)
- c) Distinguish between each of the following terms as used in Neural Networks: i. Supervised and unsupervised learning (2 marks) ii. Pattern classification and pattern association (2 marks) iii. Feed forward network and recurrent network (2 marks) iv. Artificial neural networks and Biological neural networks (2 marks)
- d) The basic operation of an artificial neuron involves summing its weighted input signal and applying an activation function to determine whether it will 'fire' or not: a. Explain the term 'activation function'. (1 mark) b. Explain the following activation functions using appropriate illustrations: i. Binary Step Function (2 marks) ii. Bipolar Sigmoid Function (2 marks)
- e) Artificial neural networks (ANNs) are modeled from biological neurons. Outline the biological properties that are borrowed into ANNs. (6 marks)

QUESTION TWO (20 MARKS)

- a) Interpret the following code using a graph as used in the sigmoid function. (2 marks)
- $$\phi(z) = \frac{1}{1 + e^{-z}}$$
- b) Explain each of the following distance methods and provide appropriate examples: i. Euclidean distance (2 marks) ii. Jaccard index (2 marks) iii. Hamming distance (2 marks)
- c) Self-organizing maps (SOMs) are widely used in clustering problems of neural networks. Explain how the Kohonen self-organizing map works. (4 marks)

d) You have been hired in a Big Data company involved in predicting traffic patterns. Explain the techniques you would apply for this task and justify why. (5 marks)

e) Compare and contrast an artificial neural network and the biological neuron. (3 marks)

QUESTION THREE (20 MARKS)

a) Implement the following perceptron, showing how it can be applied in the education sector for grading students for graduation: $output = \begin{cases} 1 & \text{if } wx + b > 0 \\ 0 & \text{otherwise} \end{cases}$ (3 marks)

b) Explain how the Hamming Net algorithm works in Neural networks. (5 marks)

c) Within a given hidden layer of an artificial neural network, we can choose any activation function. Describe why you would recommend a particular activation function over another.

d) Compare and contrast forward and backpropagation concepts using suitable examples. (4 marks)

e) Discuss the steps of building a bird classifier using Transfer Learning approach. (5 marks)

QUESTION FOUR (20 MARKS)

a) Explain three characteristics that define neural networks and differentiate them from biological neural networks. (3 marks)

b) Interpret the result of the provided model, developed using Weka machine language software. (6 marks)

c) With a clear structure, interpret the following function as used in artificial neural networks: $z = \sum_{i=1}^n x_i \cdot w_i$ (2 marks)

d) Explain the function of the following components of biological neural networks: a. Dendrites b. Axon c. Soma (2 marks)

e) Explain three branches of artificial intelligence. (3 marks)

QUESTION FIVE (20 MARKS)

- a) Describe a multi-layer feedforward network in a hospital setting, emphasizing the importance of hidden and output layers. (7 marks)
- b) Using a diagram, explain fully the concepts of a recurrent network and a Jordan network. (6 marks)
- c) Suppose a credit card company plans to deploy a new system for assessing creditworthiness using a feedforward neural network. Discuss what the bank should have before implementing the system and potential problems associated with these requirements. (5 marks)
- d) Explain the following terms: a. Neurons b. Perception (2 marks)

-----**ANSWERS**-----

A) McCulloch-Pitts is one of the earliest artificial neural networks. i. List any four requirements of the McCulloch-Pitts neuron. (4 marks)

Answer: i. Four requirements of the McCulloch-Pitts neuron:

- Binary inputs: Inputs to the neuron are binary, typically represented as 0 or 1.
- Weighted connections: Each input is associated with a weight that determines its importance in the neuron's computation.
- Threshold: The neuron has a threshold value, and it fires (produces an output of 1) only if the weighted sum of its inputs exceeds this threshold.
- Activation function: It applies an activation function to the weighted sum of inputs to determine the neuron's output.

ii. Explain how a McCulloch-Pitts neural network would perform the logical XOR function. (4 marks)

Answer: The XOR function is not linearly separable, meaning a single McCulloch-Pitts neuron cannot solve it. However, by combining multiple neurons in a layered architecture, such as a multilayer perceptron, the XOR function can be effectively represented and solved.

B) Demonstrate your understanding of neural network applications in the fields of medicine, automotive, and banking. (3 marks)

Answer: Neural networks are applied in medicine for diagnosing diseases based on patient data, in automotive for autonomous driving and vehicle diagnostics, and in banking for fraud detection and credit scoring.

C) Distinguish between each of the following terms as used in Neural Networks: i. Supervised and unsupervised learning (2 marks)

Answer: Supervised learning involves learning from labeled data, where each input is associated with a corresponding output. Unsupervised learning involves finding hidden patterns or structures in input data without explicit supervision.

ii. Pattern classification and pattern association (2 marks)

Answer: Pattern classification involves categorizing inputs into predefined classes or categories. Pattern association involves learning associations between inputs and outputs without explicit categories.

iii. Feed forward network and recurrent network
(2 marks)

Answer: Feed forward network: Information flows in one direction, from input to output layer, without feedback loops. Recurrent network: Contains feedback loops where output from one time step is fed back as input to the network.

iv. Artificial neural networks and Biological neural networks (2 marks)

Answer: Artificial neural networks are simplified mathematical models designed to mimic the structure and function of biological neurons. Biological neural networks are complex networks of interconnected neurons found in the brain, responsible for processing and transmitting information.

D) The basic operation of an artificial neuron involves summing its weighted input signal and applying an activation function to determine whether it will 'fire' or not: a.
Explain the term 'activation function'. (1 mark)

Answer: Activation function determines the output of a neuron given its input. It maps the weighted sum of inputs to a desired output, typically introducing non-linearity to the network.

b. Explain the following activation functions using appropriate illustrations: i. Binary Step Function (2 marks)

Answer: The binary step function outputs 1 if the input is greater than or equal to 0 and 0 otherwise. It's commonly used in perceptrons for binary classification tasks.

ii. Bipolar Sigmoid Function (2 marks)

Answer: The bipolar sigmoid function smoothly transitions from -1 to 1 as the input varies. It's commonly used in neural networks for its smooth, differentiable properties.

E) Artificial neural networks (ANNs) are modeled from biological neurons. Outline the biological properties that are borrowed into ANNs. (6 marks)

Answer: Biological properties borrowed into artificial neural networks include parallel processing, fault tolerance, and adaptability to changing environments. Artificial neural networks are inspired by the architecture and learning mechanisms of biological neurons, influencing their design and functionality.

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Apologies for the oversight. Let me continue with the remaining questions:

QUESTION TWO (20 MARKS)

A) Interpret the following code using a graph as used in the sigmoid function. (2 marks)

$$\phi(z) = \frac{1}{1 + e^{-z}}$$

Answer: A well-structured graph of the sigmoid function would illustrate a smooth S-shaped curve. The curve approaches 0 as x approaches negative infinity and approaches 1 as x approaches positive infinity.

B) Explain each of the following distance methods and provide appropriate examples:

i. Euclidean distance (2 marks) ii. Jaccard index (2 marks) iii. Hamming distance (2 marks)

Answer: i. Euclidean distance measures the straight-line distance between two points in a multidimensional space, commonly used in clustering and classification algorithms. ii. Jaccard index measures the similarity between two sets by comparing their intersection to their union, often used in text mining and recommendation systems. iii. Hamming distance measures the number of positions at which corresponding symbols differ between two strings of equal length, frequently used in error detection and correction.

C) Self-organizing maps (SOMs) are widely used in clustering problems of neural networks. Explain how the Kohonen self-organizing map works. (4 marks)

Answer: Kohonen self-organizing maps (SOMs) use unsupervised learning to organize input data into clusters or groups based on similarity. During training, each input is compared to the neurons in the map, and the neuron with weights most similar to the input is selected as the winner. The weights of the winning neuron and its neighbors are adjusted

to become more similar to the input, facilitating map organization.

D) You have been hired in a Big Data company involved in predicting traffic patterns. Explain the techniques you would apply for this task and justify why. (5 marks)

Answer: For predicting traffic patterns, techniques like time series analysis, regression modeling, and machine learning algorithms such as recurrent neural networks (RNNs) or Long Short-Term Memory (LSTM) networks would be suitable. These techniques can capture temporal dependencies and patterns in traffic data, enabling accurate prediction of future traffic conditions.

E) Compare and contrast an artificial neural network and the biological neuron. (3 marks)

Answer: Artificial neural networks are simplified mathematical models inspired by biological neurons but differ in complexity and functionality. While both use weighted inputs and activation functions, biological neurons have complex structures with dendrites, soma, and axons, allowing for parallel processing and adaptation to changing environments. Artificial neurons lack these biological properties but are efficient in performing specific computational tasks.

QUESTION THREE (20 MARKS)

A) Implement the following perceptron, showing how it can be applied in the education sector for grading students for

graduation: (3 marks) $output = \begin{cases} 1 & \text{if } wx + b > 0 \\ 0 & \text{otherwise} \end{cases}$

Answer: To apply the perceptron in the education sector, weights (w) could represent the importance of different academic criteria (e.g., exam scores, coursework grades), and b could represent a threshold for passing. The output would indicate whether a student meets the criteria for graduation based on their weighted inputs.

I will continue with the remaining questions in the subsequent response.

B) Explain how the Hamming Net algorithm works in Neural networks. (5 marks)

Answer: The Hamming Net algorithm is used for pattern recognition and classification tasks in neural networks. It calculates the Hamming distance between an input pattern and a set of stored patterns. The input pattern is classified as belonging to the category represented by the stored pattern with the minimum Hamming distance. This algorithm is effective for tasks where patterns are represented as binary vectors and similarity is measured by the number of differing bits.

C) Within a given hidden layer of an artificial neural network, we can choose any activation function. Describe why you would recommend a particular activation function over another.

Answer: The choice of activation function depends on the specific task and the

characteristics of the data. For example, the ReLU (Rectified Linear Unit) activation function is often recommended due to its simplicity, computational efficiency, and ability to mitigate the vanishing gradient problem. However, for tasks where the output needs to be bounded between certain values, the sigmoid or tanh activation functions may be more appropriate.

D) Compare and contrast forward and backpropagation concepts using suitable examples. (4 marks)

Answer: Forward propagation involves passing inputs through the network to compute the predicted outputs. Each layer applies its activation function to the weighted sum of inputs from the previous layer. Backpropagation is the process of adjusting the weights of the network to minimize the difference between predicted and actual outputs. This is done by calculating the gradient of the loss function with respect to each weight using the chain rule and updating the weights accordingly. For example, in a neural network trained to classify images, forward propagation computes the predicted class probabilities for an image, while backpropagation adjusts the weights based on the difference between predicted and true labels to improve classification accuracy.

E) Discuss the steps of building a bird classifier using Transfer Learning approach. (5 Marks)

Answer:

- **Data Collection:** Gather a dataset of bird images with corresponding labels.
- **Preprocessing:** Resize images, normalize pixel values, and augment data if necessary.
- **Transfer Learning:** Choose a pre-trained neural network model (e.g., VGG, ResNet) and fine-tune it on the bird dataset. Freeze the early layers to retain learned features and train only the top layers.
- **Training:** Train the model on the bird dataset, monitoring performance using validation data.
- **Evaluation:** Evaluate the trained model on a separate test set to assess its accuracy and performance.
- **Deployment:** Deploy the bird classifier for real-world applications, such as bird species identification in wildlife conservation efforts.

QUESTION FOUR (20 MARKS)

A) Explain three characteristics that define neural networks and differentiate them from biological neural networks. (3 marks)

Answer: Three characteristics defining neural networks:

- **Weighted Connections:** Neural networks use weighted connections between neurons to modulate the flow of information, whereas biological neurons transmit signals through chemical and electrical synapses.
- **Activation Functions:** Neural networks employ activation functions to introduce non-linearity and determine neuron output, while biological neurons integrate inputs through complex dendritic structures.

- **Learning Algorithms:** Neural networks learn from data using mathematical optimization algorithms like gradient descent, whereas biological neural networks learn through synaptic plasticity and neuronal adaptation mechanisms.

I'll continue with the answers for the remaining questions in the next response.

B) Interpret the result of the provided model, developed using Weka machine language software. (6 marks)

Answer: The provided model appears to be a decision tree classifier trained on a full training set. It indicates the classification decisions made by the model for different instances based on their attributes. Each branch represents a decision node, and the leaf nodes contain the predicted class labels. For example, the model predicts the class label "Y" for instances meeting certain attribute conditions and "N" for others.

C) With a clear structure, interpret the following function as used in artificial neural networks: $Y = \sum_{i=1}^n x_i \cdot w_i$ (2 marks)

Answer: The function represents the weighted sum of inputs in an artificial neural network. x_i represents the input value for the i th neuron, and w_i represents the weight associated with that input. The weighted inputs are summed together to produce the output Y , which may then pass through an activation function to produce the final output of the neuron.

D) Explain the function of the following components of biological neural networks:

a. Dendrites b. Axon c. Soma (2 marks)

Answer: a. Dendrites: Dendrites are branching extensions of a neuron that receive signals from other neurons. They act as input terminals, collecting electrical signals (neurotransmitters) from neighboring neurons and transmitting them toward the cell body. b.

Axon: The axon is a long, slender projection of a neuron that conducts electrical impulses away from the cell body. It carries the neuron's output signals, known as action potentials or spikes, to other neurons, muscles, or glands. c.

Soma: Also known as the cell body, the soma is the main part of the neuron containing the nucleus and most of the cell's organelles. It integrates incoming signals from dendrites and, based on the input, generates outgoing signals that are transmitted along the axon.

E) Explain three branches of artificial intelligence. (3 marks)

Answer: Three branches of artificial intelligence are:

- **Machine Learning:** Machine learning focuses on developing algorithms that enable computers to learn from and make predictions or decisions based on data, without being explicitly programmed. It includes supervised learning, unsupervised learning, and reinforcement learning.
- **Natural Language Processing (NLP):** NLP involves enabling computers to understand, interpret, and generate human language. It

encompasses tasks such as language translation, sentiment analysis, and text generation.

- **Computer Vision:** Computer vision aims to give computers the ability to interpret and understand visual information from the real world. It involves tasks such as object detection, image classification, and image segmentation.

QUESTION FIVE (20 MARKS)

A) Using a case of a hospital describe a multi-layer feedforward network showing clearly the importance of hidden and output layers in it? (7 marks)

Answer: In a hospital setting, a multi-layer feedforward network can be used for medical diagnosis based on patient data. The input layer would receive features such as patient demographics, symptoms, and medical history. The hidden layers would perform complex transformations and feature extraction, capturing underlying patterns in the data. Finally, the output layer would produce the diagnosis or prediction, such as disease classification or treatment recommendation. The hidden layers are crucial for learning intricate patterns and relationships in the data, while the output layer provides actionable insights for medical decision-making.

I'll proceed with the answers for the remaining questions in the subsequent response.

B) Explain a recurrent neural network (RNN) and with the aid of a diagram, explain fully

recurrent network and Jordan network. (6 marks)

Answer: A recurrent neural network (RNN) is a type of artificial neural network designed to process sequential data or time-series data by maintaining internal state or memory. It has connections that form directed cycles, allowing it to exhibit temporal dynamics and capture dependencies across time steps. A fully recurrent network connects each neuron in a layer to every other neuron, forming a densely interconnected structure. In contrast, a Jordan network is a specific type of recurrent neural network where the output of the network at each time step is fed back as input to the network at the next time step. This feedback loop allows the network to consider its previous outputs when making predictions.

C) Suppose that a credit card company decided to deploy a new system for assessing creditworthiness of its customers using a feed-forward neural network with a supervised learning algorithm. Suggest what the bank should have before the system can be used? Discuss problems associated with this requirement. (5 marks)

Answer: Before deploying the system, the bank should have:

- **Sufficient Training Data:** A large and diverse dataset of credit applications with associated outcomes (approved or denied) for training the neural network.
- **Feature Selection and Engineering:** Relevant features or variables related to

creditworthiness, such as income, credit history, debt-to-income ratio, etc.

- **Validation Set:** A separate dataset for validating the performance of the trained model and tuning hyperparameters.
- **Model Evaluation Metrics:** Metrics to evaluate the model's performance, such as accuracy, precision, recall, and F1-score.

However, problems associated with these requirements may include:

- **Data Quality:** Poor data quality, missing values, or biases in the dataset can lead to inaccurate predictions.
- **Overfitting:** The model may memorize the training data instead of learning general patterns, leading to poor generalization on unseen data.
- **Interpretability:** Neural networks are often considered black-box models, making it challenging to interpret their decisions, which can be problematic in sensitive domains like finance.
- **Regulatory Compliance:** The use of machine learning models in credit assessment must comply with regulatory requirements regarding fairness, transparency, and accountability.

These challenges need to be addressed to ensure the reliability and fairness of the credit assessment system.

D) Explain the following terms: a. Neurons b. Perception (2 marks)

Answer: a. **Neurons:** Neurons are the fundamental units of a nervous system,

including the human brain. They are specialized cells responsible for transmitting electrical and chemical signals, enabling communication within the nervous system. In artificial neural networks, neurons are computational units that process and transmit information. b. **Perception:** Perception refers to the process of acquiring, interpreting, and organizing sensory information from the environment. In the context of neural networks, a perceptron is the simplest form of an artificial neuron that receives input signals, applies weights to them, sums them up, and passes the result through an activation function to produce an output.