DEPARTMENT OF INFORMATION TECHNOLOGY
YEAR/SEM: III/VI
23CSX502 – DEEP LEARNING AND NEURAL NETWORKS FUNDAMENTALS

UNIT I
INTRODUCTION TO NEURAL NETWORK

Neural Networks Basics - Functions in Neural networks – Classification and Clustering problems - Deep networks basics - Shallow neural networks – Deep Neural Networks – Forward and Back Propagation. Deep Learning Frameworks – Data Augmentation - Underfitting- Overfitting.

INTRODUCTION

Neural Networks are computational models inspired by the structure and functioning of the human brain. They consist of interconnected processing units called neurons that work together to process information and learn patterns from data. In recent years, neural networks have become the foundation of modern artificial intelligence and deep learning applications such as image recognition, speech processing, natural language processing, medical diagnosis, and autonomous systems.

This unit introduces the basic concepts of neural networks, their mathematical functions, and their role in solving classification and clustering problems. It also explains shallow and deep neural networks, learning mechanisms such as forward and back propagation, deep learning frameworks, data augmentation techniques, and the problems of underfitting and overfitting in model training.

NEURAL NETWORK BASICS

A neural network is a collection of artificial neurons arranged in layers and connected through weighted links. Each neuron receives input signals, processes them, and produces an output signal. A basic neural network consists of three main components: input layer, hidden layer(s), and output layer.

1. Neuron
A neuron is the basic processing unit of a neural network. It receives input signals, multiplies them with weights, adds a bias, applies an activation function, and produces an output.

2. Input Layer
The input layer is the first layer of a neural network. It receives raw data from the external environment and passes it to the hidden layers without performing any computation.

3. Hidden Layer
A hidden layer is an intermediate layer between the input and output layers. It performs computations using weights and activation functions to extract important features from the input data.

4. Output Layer
The output layer is the final layer of a neural network. It produces the predicted result or classification based on the learned features.

5. Weights
Weights are numerical values assigned to connections between neurons. They determine the importance of each input in producing the output of a neuron.

6. Bias
Bias is an additional parameter added to the weighted sum of inputs. It allows the activation function to shift and helps the model learn patterns more effectively.

7. Activation Function
An activation function is a mathematical function applied to the output of a neuron. It introduces non-linearity into the network and decides whether a neuron should be activated.

8. Loss Function
A loss function measures the difference between the actual output and the predicted output of a neural network. It guides the learning process by indicating how much error is present.

FUNCTIONS IN NEURAL NETWORKS

Functions play a vital role in neural networks by controlling information flow and learning behavior. Activation functions introduce non-linearity into the network, enabling it to learn complex patterns. Loss functions measure the difference between predicted output and actual output and guide the learning process.

CLASSIFICATION AND CLUSTERING PROBLEMS

Classification is a supervised learning task where the model assigns input data to predefined classes. Clustering is an unsupervised learning task where data points are grouped based on similarity without prior labels.

DEEP NETWORKS BASICS

Deep networks contain multiple hidden layers that allow the model to learn hierarchical representations of data. Lower layers learn simple features, while deeper layers learn complex abstractions.

SHALLOW NEURAL NETWORKS

Shallow neural networks consist of one or two hidden layers and are suitable for simpler problems. They have limited representation power when handling complex datasets.

DEEP NEURAL NETWORKS

Deep neural networks consist of several hidden layers and large numbers of neurons. They are capable of modeling highly complex non-linear relationships in data.

FORWARD PROPAGATION

Forward propagation is the process of passing input data through the network to compute the output. Each neuron computes a weighted sum of inputs and applies an activation function.

BACK PROPAGATION

Back propagation is a learning algorithm that propagates error backward through the network. It updates weights using gradient descent to minimize the loss function.

DEEP LEARNING FRAMEWORKS

Deep learning frameworks provide tools and libraries to efficiently develop neural network models. Popular frameworks include TensorFlow, PyTorch, and Keras.

DATA AUGMENTATION

Data augmentation is a technique used to artificially increase the size of training datasets by applying transformations such as rotation, scaling, and flipping.

UNDERFITTING AND OVERFITTING

Underfitting occurs when a model is too simple to capture patterns in data. Overfitting occurs when a model learns noise and performs poorly on unseen data.