Course Code: 4871

Course Title: Neural Networks and Fuzzy Systems

Mid Term: 30 Marks

1. **Introductory Concept:**
   Neural network, human brain, biological inspiration of neural network, synapses and their weights, biasing input, characteristics of neural network, benefits of neural networks, limitation of neural network, application of neural network.
2. **Fundamental concept of ANN:** Basic models of artificial neuron, mathematical models of an artificial neuron, network architecture, neural network viewed as directed graph, activation functions, importance of nonlinearity in activation function, derivatives of activation functions.
3. **Perceptrons:** Overview of perceptrons, single layer of perceptrons, mathematical model of single layer perceptrons, mathematical model of multilayer perceptron (MLP), delta learning rule, supervised and unsupervised learning.

Final Term: 50 Marks

4. **Training Neural Network**: Quantifying different loss functions (Step, MSE, MAE, hinge loss, binary cross-entropy or log loss, categorical cross-entropy), loss optimization, weight initialization, gradient descent algorithms, computing gradients : back propagation learning algorithm, setting the learning rate, adaptive learning rate algorithms, gradient algorithm with mini-batch, stochastic gradient descent, vanishing and exploding gradients, Regularization: L1 and L2 regularization, dropout, early stopping.
5. **Recurrent Neural Network:** Why sequence models, Examples of sequence data, RNN architectures, training RNN, Vanishing gradients with RNNs, GRU, LSTM, language modeling with RNN, bidirectional RNN, Deep Belief Networks (DBNs).
6. **Convolutional Neural Network**: Concept of deep learning, Convolutional neural network (CNN) for computer vision, types of layer in a convolutional network (convolution , Pooling , Fully Connected layer), softmax classification, different convolution network examples, some classic CNNs, transfer learning, fine tuning, data augmentation.
7. **Fuzzy system:** Introduction to Fuzzy system, Fuzzy relations, fuzzy numbers, Linguistic description and their analytical form, fuzzy control.
8. **Defuzzification:** Defuzzification Methods, Centroid Method, Center of Sum Method, Mean of Maxima Defuzzification, Applications