Indian Statistical Institute
Semester Examination: 2024 – 2025
Master of Science in Quality Management Science, Semester II
### Compulsory Optional: Neural Networks

Date: 02 May 2025   Maximum Marks: 100   Duration: 3 hours

Attempt all the questions. Credit will be given for precise and brief answers.

1. What is feature? Describe back propagation algorithm and learning rate. Observe the following neural network architecture for hand written digit recognition. Suggest a function for the output layer nodes (the same function will work for all the nodes). There is no single 'correct' answer to this question. Marks will be awarded for intelligent logical guess and explanation.

$$2 + 4 + 2 + 8 = 16$$
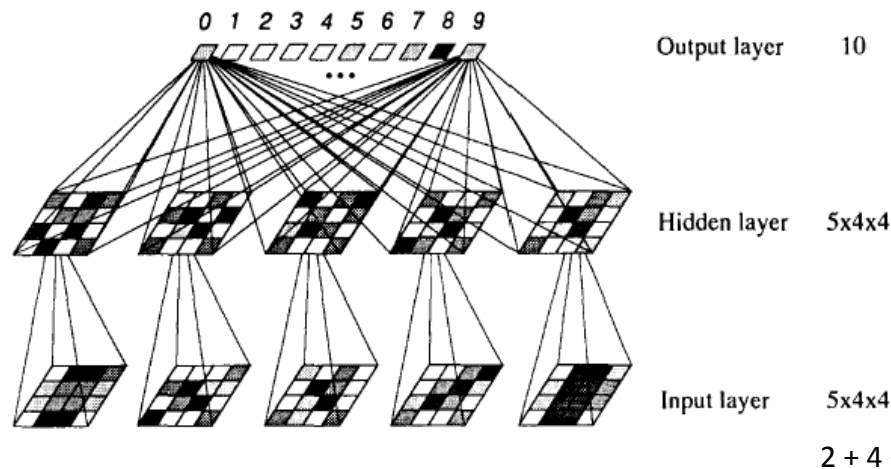
2. Why kernel technique is employed in machine learning? How many nodes should be there in the hidden layer of a Radial Basis Function (RBF) network? Describe a technique or algorithm to reduce that number. What function does an RBF network approximate and how? Drawing a diagram might be helpful for explanation. $2 + 2 + 4 + 2 + 6 = 16$

3. You are given n number of data points with variable dimension (different points have different dimensions). Suggest a method with appropriate reasoning by which you will be able to apply the principal component analysis (PCA) on this data set. Mention two drawbacks of PCA with justification. Why in PCA components are orthogonal? (Mathematical proof is needed, where you can assume variances of the different data given are all different). $4 + 4 + 4 + 4 = 16$

4. Consider four points in two dimensional Euclidean plane (1,1), (5,1), (5,5) and (1,5). (1,1) and (5,5) belong to one class, say T_1, and (5,1) and (1,5) belong to another class, say T_2. Are T_1 and T_2 linearly separable in the two dimensional Euclidean plane? Justify your answer with a suitable diagram. Construct a suitable projection to make them linearly separable in a higher dimensional space with justification. 4 + 12 = 16

5. What a single neuron with sigmoid or ReLU type of activation function does? You may briefly explain with a suitable diagram. With another diagram try to reason how a neural network with one single hidden layer made up of those neurons can approximate a continuous function on close and bounded interval. You can take continuous function as represented by a continuously drawn graph on a plain paper. 4 + 12 = 16

6. Write a short note on any two of the following: (1) Hopfield Network; (2) Probabilistic Network; (3) Convolutional Network; (4) Soft Computing with two examples (each is to be described within five sentences); (5) Deep Learning. 10 + 10 = 20