National University
of Computer & Emerging Sciences-Islamabad
Chiniot-Faisalabad Campus

Dr. Hashim Yasin
Department of AI & DS.

AI3002 –Machine Learning
Assignment No. 5

Assignment Submission Guidelines:

1. Submit your assignment in **soft form (Code + Report)** within the due date and time. Soft form does not mean submitting photos of the hardcopy. Late submissions will result in a deduction of marks.
2. The **report** must include a discussion, comments, and a conclusion about your solution. Submitting without a report will result in a loss of full marks.
3. Name the zip or other folder/file that you submit using the following format: **ML_A5_RollNo_FirstName**.
4. Ensure that you solve each task of the assignment on your own.
5. You are allowed to do your assignment in **groups of a maximum of two members**.
6. There is no restriction on the programming language used for the tasks.
7. For programming tasks, you are NOT allowed to use any built-in functions or libraries for specific tasks.
8. This assignment may hold more weightage comparatively.

Question No. 1: Support Vector Machine (SVM)

(a) What is a support vector? Derive the objective function of support vector machines (SVM) for linearly separable data. Differentiate between soft margin and hard margin classifier.

(b) MNIST dataset, which is a set of 70,000 small images of digits handwritten digits, can be downloaded from the following website,
(https://www.kaggle.com/datasets/hojjatk/mnist-dataset).
Each image, in this dataset, is labelled with the digit it represents. There are 70,000 images, and each image has 784 features. This is because each image is 28 × 28 pixels, and each feature simply represents one pixel's intensity, from 0 (white) to 255 (black). Figure below shows some digits from the MNIST dataset:

Perform the following tasks:

(a) Download MNIST dataset.

(b) Train a linear SVM classifier on the MNIST. SVM classifiers are binary classifiers (you will need to use one-versus-all to classify all 10 digits), and also report its training accuracy.

(c) Scale (standardize) the data first, retrain a linear SVM classifier and also report its training accuracy.

(d) Now retrain the classifier with a non-linear SVM using Radial Basis Function (RBF) Kernel (aka Gaussian Kernel), and also report its training accuracy.

(e) Now make predictions on the above models for each class on test data and report your results.

Question No. 2: ANN & CNN

Consider the above dataset and perform the followings,

(a) Design ANN architecture and implement it. Justify every step of your architecture, including number of neurons, number of layers and the activation function(s).

(b) Design CNN architecture and apply it directly to images without doing any pre-processing. Justify every step of your architecture, including number of layers and the activation function(s).

Question No. 3: ANN

Consider the Boolean function given below where $\mathbf{X_1}$, $\mathbf{X_2}$, $\mathbf{X_3}$, $\mathbf{X_4}$, and $\mathbf{X_5}$ are the attributes and **Y** is the class variable.

X_1	X_2	X_3	X_4	X_5	Y
0	0	0	1	0	1
1	0	0	0	1	1
0	1	0	1	1	0
0	0	1	1	1	0
1	1	0	0	0	0
1	0	1	0	1	1
0	1	1	0	1	0
1	1	1	0	0	1
0	0	0	0	1	0
0	0	1	0	0	1
0	1	1	1	0	1
1	1	1	1	0	1
0	0	0	0	0	0
0	1	1	1	1	1
1	1	1	1	1	1

(a) Your task is to construct the architecture of the neural network and implement it for that Boolean function.

(b) Justify your architecture of the neural network in task (a), e.g., number of hidden layers, the number of neurons within hidden layers, etc.

(c) In the above-mentioned task (a), apply different activation functions like (sigmoid, tanh, ReLU and its variant, Softmax) in the hidden layers and the output layer. At which combinations of activation functions, the accuracy is the highest. Justify your answer.