ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

MID SEMESTER EXAMINATION **SUMMER SEMESTER, 2021-2022**

DURATION: 1 HOUR 30 MINUTES **FULL MARKS: 75**

CSE 4835: Pattern Recognition

Programmable calculators are not allowed. Do not write anything on the question paper.

Answer **all 3 (three)** questions. Figures in the right margin indicate full marks of questions whereas corresponding CO and PO are written within parentheses.

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1. a) Define Pattern Recognition (PR). Mention three applications of PR in any domain. Discuss some of the expected invariances of a good feature. 8 (CO1) (PO1)

   b) A common practice in training Deep Neural Networks is to divide the dataset into three splits as- the training, validation and test set. Once the training procedure is completed, it can produce three types of results (in terms of accuracy) as- the training accuracy, validation accuracy, and test accuracy. 4×3 (CO2) (PO2)

      i. Discuss the merit of drawing conclusion regarding the performance of a network solely based on one of these three types of accuracies.

      ii. According to the discussion in the previous question, do you recommend to solely depend on any of these three accuracies; or to depend on a pair of them; or to depend on all three of them? Justify your recommendation.

      iii. Justify the necessity of using three splits instead of using two splits or one split (using the entire dataset for training).

   c) i. Consider the multi-layer fully connected neural network given in Figure 1. All activations are sigmoid and the optimizer is stochastic gradient descent. All the weights and biases are initialized to zero and an input $x \in \boldsymbol{R}^{n\times 1}$ is forward propagated within the network. What is the value of output $\hat{y}$? 2.5×2 (CO2) (PO1)

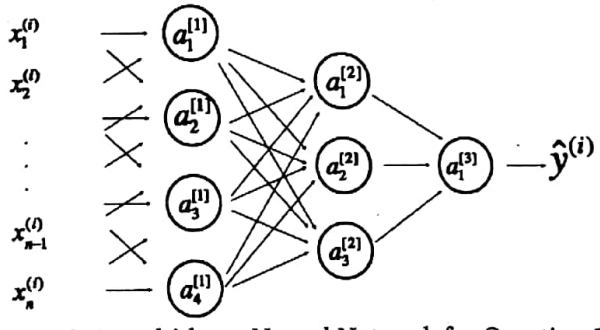
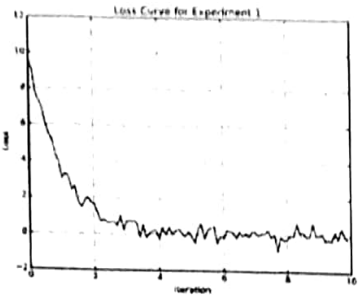


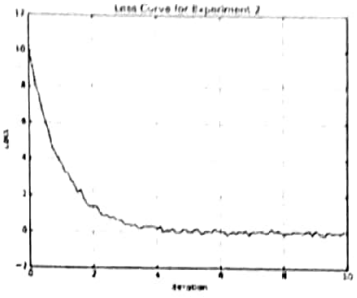
Figure 1: A multi-layer Neural Network for Question 1.c)

   ii. Suppose you are solving a classification task to determine whether a leaf image belongs to the 'healthy' or 'diseased' class. A Convolutional Neural Network (CNN) is designed with a single output neuron. Let the output of this neuron be z. The final output of the network $\hat{y}$ is given by: $\hat{y} = \sigma(ReLU(z))$. An Input with a final value $\hat{y} \geq 0.5$ is classified as 'diseased'. Comment on the possible output of this model.

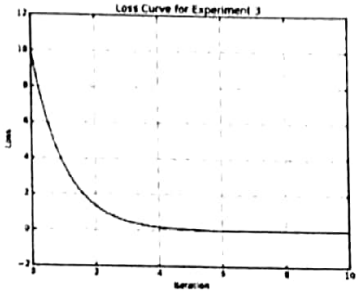
2. a)



(A)



(B)



(C)

Figure 2: Loss curves for Experiment A, Experiment B, and Experiment C

3×3
(CO2)
(PO2)

Figure 2(A) shows a loss curve produced by a 'black box optimizer'. Figures 2(B) and 2(C) show state of the loss curve after tuning a hyperparameter.

i. Which hyperparameter is likely to be modified here?

ii. Out of these experiments, which one corresponds to the largest magnitude of the hypermeter? Justify.

iii. The loss curve for Experiment C seems to be the most desirable. Despite this, is there any reason for which someone would choose the hyperparameter in Experiment B for training a model?

b) The Code Snippet 1 mentions the basic idea of Adam optimizer.

```
moment1 = 0
moment1 = 0
for t = 1 ... numSteps:
  dw = compute_gradient(w)
  moment1 = β1 × moment1 + (1 − β1) × dw
  moment2 = β2 × moment2 + (1 − β2) × dw
  w −= learningRate × moment1 / (√moment2 + 10^−7)
```

Code snippet 1: For question 2.b)

i. Explain the role of the *moment*1 and *moment*2 terms in ensuring better convergence. 5 (CO1) (PO1)

ii. Identify the limitation of the Code Snippet 1 and propose an improved solution. 5 (CO2) (PO2)

c) Discuss the concept of space warping in learning complex decision boundary. 6 (CO1) (PO1)

3. a) Draw a proper flow-chart by arranging the *keywords* mentioned below according to their roles in solving a classification problem. Discuss their roles and relation with each other properly. 5+5 (CO1) (PO1)

Keywords: {*Score, Weight vector, Gradient Descent, Loss Function, Input data, Backpropagation, Regularization*}

b) Consider a Convolutional Neural Network (CNN) defined by the layers in Table 1. The network takes a RGB image of size 128 × 128 as input and classifies it to one of the 10 available classes. Fill the size of the activation map, number of learnable parameters, and the number of floating-point operations (multiply-add) at each layer. 15 (CO2) (PO2)

The notation follows the convention:

- CONV-k-N denotes a convolutional layer with N filters, each having size $k \times k$. Padding and stride parameters are always 0 and 1 respectively.
- POOL-k indicates a $k \times k$ pooling layer with stride k and padding 0.
- FC-N stands for a fully-connected layer with N neurons.

Table 1: Network specification for Question 3.b)

Layer	**Activation map dimensions**	**Number of learnable parameters**	**Number of Multiple-add operation**
Input			
CONV-9-32			
POOL-2			
CONV-5-64			
POOL-2			
CONV-3-128			
POOL-2			
FC-256			
FC-64			
Output			