CS6123 : Advanced Pattern Recognition

End Semester Exam (29/11/2024 : 2:30 PM – 5:30 PM)

Maximum time: 3 Hours Total Marks: 75

Answer all of the questions.

Make reasonable assumptions as and whenever necessary. However, state them clearly. You can answer the questions in any sequence. However, the answers to all the parts of any particular question should appear together. No doubts will be cleared during the exam. No partial marks will be given.

No marks will be given without proper explanation/ justification.

1. You are given the following background and objective. $[5 \times 5 = 25]$

Background: You are provided with 100K (1 lakh) human ophthalmoscopic images of size $224 \times 224 \times 3$ from two groups of individuals. One group is suffering from Glaucoma (denoted as GL), and the other group is not suffering from Glaucoma (denoted as non-GL). The GL group contains 40K images, while the non-GL group contains 60K images. These images are properly labeled as either GL or non-GL.

Objective: As an expert, your task is to design the best-performing Neural Network (NN)-based real-time architecture to detect whether a given (unknown) ophthalmoscopic image corresponds to a Glaucoma patient.

Considering the above background and objective, answer the following with justifications.

(i) Which *activation functions* will you use in each layer of your NN? Briefly explain the advantages and limitations of each activation function you consider.

(ii) Which *loss function* will you use? Briefly explain the advantages and limitations of each loss function you consider.

(iii) Which *optimization function* will you use and why? What exactly are you optimizing in this context?

(iv) Suppose your training set accuracy is 97.95%, while the validation set accuracy is 71.45% (considering human accuracy $\approx 100\%$). Does your system exhibit any serious issues?

- If *Yes*, identify the issue and propose how to fix it.
- If *No*, provide a justification for your answer.

(v) Assume your architecture (NN-A) and another architecture (NN-B) achieve the same *accuracy*. How should the client judge which system is better?
Should the client consider any other performance measure??

- If *Yes*, which performance measure and why, considering the given background?
- If *No*, justify your response.

2. Suppose, at our institute's social media platforms (e.g., LinkedIn), users frequently comment on posts. We aim to develop a system that can automatically classify these comments as *"good"*, *"neutral"*, or *"poor"*. As an expert, your task is to design and propose such a system.

Based on this scenario, answer the followings: [3 × 5

(i) Which type of architecture would you propose for this task and why? Clearly specify the *input* and *output* of your architecture. Explain briefly.

(ii) Properly define the inside view/ internal layers of your architecture. Provide justifications for your choices.

(iii) How will you update the learning parameters of your architecture? Write down the mathematical expression for the *cost function* of your system and define all the symbols used in the expression.

3. Suppose, our institute library plans to install a smart door that automatically opens only for registered users (students/ staff). A 360° camera is mounted above the door to capture facial images of the user. The door's operation is based on *face verification*. As an expert, your task is to design and develop the face verification algorithm.

Based on this scenario, answer the followings: [3 × 5 =

(i) Which type of architecture would you propose for this task and why? Clearly specify the *input* and *output* of your architecture. (You may assume a preprocessing stage before feeding the data into the architecture.)

(ii) Provide an overview of your architecture. (Include the architectural details, such as the learning algorithm, activation functions, cost function, and the set of operations involved.)

(iii) How will you create the training dataset from scratch? Can you propose a strategy that ensures the system does not require re-training when a new staff member joins the institute?

---

4. **Write the correct option(s) only.** [10×2 = 20]

(i) Suppose you have 5 convolutional kernels of size 7 × 7 with zero padding and stride 1 in the first layer of a convolutional neural network. You pass an input of dimension 224 × 224 × 3 through this layer. What are the dimensions of the data that the next layer will receive?

(a) 218 × 218 × 5 (c) 217 × 217 × 8
(b) 217 × 217 × 3 (d) 220 × 220 × 7

(ii) A neuron with 3 inputs has the weight vector [0.2; −0.1; 0.1] and bias $b = 0$. The input vector is $X = [0.2;\ 0.4;\ 0.2]$. ReLU activation function is used. The total input to the neuron is:

(a) 0.02 (c) 1
(b) 0.2 (d) -1

(iii) What effect will generally have on the bias and variance of your model after regularizing the weights?

(a) Bias increases, variance decreases
(b) Bias increases, variance increases
(c) Bias decreases, variance increases
(d) Bias decreases, variance decreases

0.04 + 0.04 + 0.2

(iv) You are training an LSTM. You have a 10000-word vocabulary, and are using an LSTM with 100-dimensional activations $a^{<t>}$. What is the dimension of the update gate ($Gamma_u$) at each time step?

(a) 100
(b) 1
(c) 1000
(d) 10000

(v) What happens when you increase the regularization hyperparameter *lambda*?

(a) Weights are pushed toward becoming smaller (closer to 0)
(b) Weights are pushed toward becoming bigger (further from 0)
(c) Doubling λ should roughly result in doubling the weights
(d) Gradient descent taking bigger steps with each iteration (proportional to λ)

(vi) Below are the 8 actual values of the target variable in the training dataset: [0, 0, 0, 1, 1, 1, 1, 1]. What is the entropy of the target variable?

(a) $\frac{5}{8}\log\frac{5}{8} + \frac{3}{8}\log\frac{3}{8}$
(b) $\frac{3}{8}\log\frac{5}{8} + \frac{5}{8}\log\frac{3}{8}$
(c) $-\frac{5}{8}\log\frac{3}{8} - \frac{3}{8}\log\frac{5}{8}$
(d) $-\frac{5}{8}\log\frac{5}{8} - \frac{3}{8}\log\frac{3}{8}$

(vii) The *exploding gradient* problem is an issue in training deep networks where the gradient gets so large that the loss goes to an infinitely high value and then explodes. What is the probable approach when dealing with "Exploding Gradient" problem in RNNs?

(a) Use modified architectures like LSTM and GRUs
(b) Dropout
(c) Regularization
(d) Gradient clipping

(viii) What effect will using *dropout* to train a deep neural network generally have on the bias and variance of your model?

(a) Bias increases, variance increases
(b) Bias decreases, variance increases
(c) Bias decreases, variance decreases
(d) Bias increases, variance decreases

(ix) A neuron with 3 inputs has the weight vector $[0.2;\ -0.1;\ 0.1]$ and bias $b = 0$. The input vector is $X = [0.2;\ 0.4;\ 0.2]$. Sigmoid activation function is used. The total input to the neuron is:

(a) 0.2
(b) 1
(c) -1
(d) 0.51

(x) Which of the following statements is true about the K-means clustering algorithm?

(a) K-means is a supervised learning algorithm that requires labeled data to form clusters.
(b) K-means works by iteratively adjusting the cluster centroids based on the nearest data points, without requiring initialization.
(c) The number of clusters, K, in K-means is automatically determined by the algorithm.
(d) K-means clustering minimizes the sum of squared distances between the data points and the centroids of the clusters.