PES University, Bengaluru

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END SEMESTER ASSESSMENT (ESA) - JULY - 2023

UE20CS342 - Topics in Deep Learning

Total Marks : 100.0

1.a. **Find the derivative of the following Activation Functions.**

1. **Tanh(x)**
2. **Sigmoid**

(4.0 Marks)

1.b. **Explain any 4 methods to overcome overfitting.** (8.0 Marks)

1.c.

You are solving the binary classification task of classifying images as cat vs. non-cat.

You design a CNN with a single output neuron. Let the output of this neuron be z.

The final output of your network, $\hat{y}$ is given by: $\hat{y} = \text{Tanh}(\sigma(z))$

You classify all inputs with a final value $\hat{y} \geq 0.5$ as cat images.

What problem are you going to encounter?

(2.0 Marks)

1.d.

a. After visually inspecting the dataset, you realize that the training set only contains pictures taken during the day, whereas the test dataset only has pictures taken at night. Explain what is the issue and how you would correct it.

b. What are the programming elements in Tensorflow?

(6.0 Marks)

2.a. You come up with a CNN classifier. For each layer, calculate the number of weights, number of biases and the size of the associated feature maps. The notation follows the convention:

• CONV-K-N denotes a convolutional layer with N filters, each them of size K×K, Padding and stride parameters are always 0 and 1 respectively.

• POOL-K indicates a K × K pooling layer with stride K and padding 0.

• FC-N stands for a fully-connected layer with N neurons.

Layer	Activation map dimensions	Number of weights	Number of biases
INPUT	128 × 128 × 3	0	0
CONV 9-32			
POOL2			
CONV 5-64			
POOL 2			
CONV 5-64			
POOL 2			
FC-3			

(6.0 Marks)

2.b.

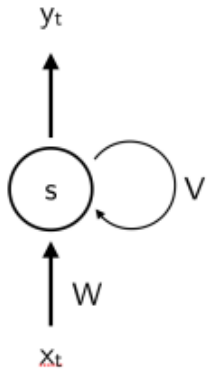
1. **Consider the following scenario. You find online that the exact same network has already been trained on 1,000,000 historical objects from a slightly different time period. What is the name of the method that could reuse these pretrained weights for the task at hand?**
2. **Following the last FC-3 layer of your network, what activation must be applied? Given a vector a = [0.3, 0.3, 0.3], what is the result of using your activation on this vector?**
3. **Why is it important to place non-linearities between the layers of neural networks?**

(3.0 Marks)

2.c. **You have a dataset D1 with 1 million labeled training examples for classification, and dataset D2 with 100 labeled training examples. Your friend trains a model from scratch on dataset D2. You decide to train on D1, and then apply transfer learning to train on D2. State one problem your friend is likely to find with his approach. How does your approach address this problem?** (3.0 Marks)

2.d. **Explain different deep learning techniques that you have come across for Object Detection.** (8.0 Marks)

3.a. **In feedforward neural networks, we saw that it does not contain any cycles and for which the nodes do not maintain a persistent state over several runs. This exercise considers artificial neural networks with nodes that maintain a persistent state that can be updated. This kind of neural network is called a recurrent neural networks (RNN).**
As an example, consider the following RNN with
$y_t = W x_t + V s_t$
$s_{t+1} = y_t$
from some initial state S_0, where t denotes the t^{th} call of the RNN, i.e., X_t is the t^{th} input.



(a) What is the recurrent state in the RNN from Figure? Mention some examples that can be
more naturally modeled with RNNs than with feedforward neural networks?
(b) As the state of an RNN changes over different runs of the RNN, the loss functions that we use for feedforward neural networks do not yield consistent results. For given dataset X, please propose a loss function (based on the mean square loss function) for RNNs and justify why you chose this loss function.
(c) For a dataset $X := (x_t, y_t)_1^k$ (for some $k \in N$), show how information is propagated by drawing a feedforward neural network that corresponds to the RNN from Figure 1 for k = 3.
Recall that a feedforward neural network does not contain nodes with a persistent state.
(Hint: unfold the RNN.) (5.0 Marks)

3.b. **Explain with a neat diagram the Transformer Model emphasizing on the each type of the layers in detail. Which layer helps to focus on the relevant parts of the input data?**
(Ex: In case of text input, relevant parts of sentence).
Why such a layer is needed? (5.0 Marks)

3.c. **Consider a problem of classifying a very popular database of IMDB reviews as 'positive' or 'negative',**
Explain the sequence of steps to be followed for a sequential model.
(5.0 Marks)

3.d. **Explain 3 gates in LSTM network with a neat diagram.** (5.0 Marks)

4.a. What is Meta Learning? Explain the importance of meta learning with the example of training a machine learning model to classify discrete breeds of dogs.
(5.0 Marks)

4.b. What are autoencoders? Explain important features of autoencoders with a neat diagram. (5.0 Marks)

4.c. **Compare Variational Auto Encoders with Autoencoders?** (5.0 Marks)

4.d.
Consider a Graph Neural network Model. Explain different steps that are performed on every node the graph.

(5.0 Marks)

5.a. **Consider the following applications of Text to Image Synthesis, Image-to-Image translation, Anomaly detection, Data augmentation, Synthesis of music and videos, etc., These applications normally have scarcity of images. You need to accumulate / populate the dataset.**

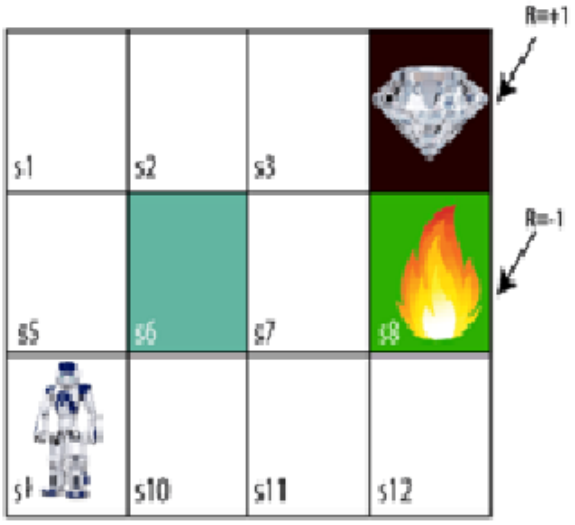
1. **Which generative model do you propose and why?**
2. **Explain different blocks of the proposed model in detail with an example.**
3. **Write the objective functions of blocks used in the model.**

(6.0 Marks)

5.b. **Write the algorithm for filling the Q Table in Reinforcement Learning Technique.** (5.0 Marks)

5.c. **Consider the following scenario of a maze environment that the agent needs to explore.**

- **Environment:** It can be anything such as a maze
- **Agent:** An intelligent agent such as AI robot.



In the above image, the agent is at the very first block of the maze block s9. The maze is consisting of an S_6 block, which is a **wall**, S_8 a **fire pit**, and S_4 a **diamond block.**

The agent cannot cross the S_6 block, as it is a solid wall. If the agent reaches the S_4 block, then gets the **+1 reward;** if it reaches the fire pit, then gets **-1 reward point**. It can take four actions**: move up, move down, move left, and move right. The agent gets 1 point towards destination and 0 reward point backwards or when there is no path to move.**

The agent can take any path to reach to the final point, but he needs to make it in possible fewer steps. For example, if the agent is at S9, the agent considers the path **S9-S5-S1-S2-S3**, so he will get the +1-reward point.

Using the **Bellman equation**, find value at each state of the given environment. Start from the block, which is next to the target block (block with diamond). Assume the value of gamma(Y)=0.9 and α or learning rate = 1.

Compute values of all the states in the environment. (6.0 Marks)

5.d. What is Deep Reinforcement Learning? Explain. (3.0 Marks)