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**Semester End Examination**
**Master of Computer Applications**
**MCAE401: Deep Learning**
**Unique Paper Code: 223402401**
**Semester IV (May 2023)**
**Year of admission: 2021**

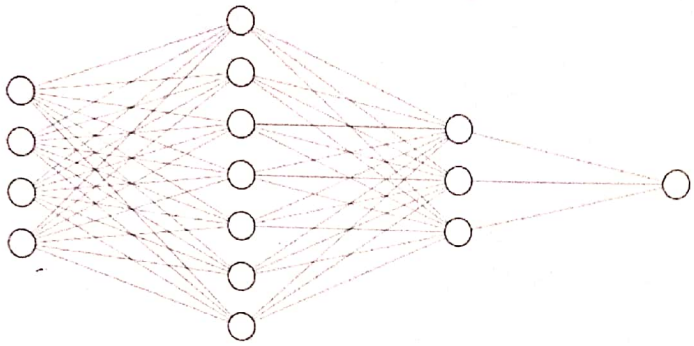
**Time: Three hours** **Max. Marks: 70**

**Note: ML denotes machine learning throughout the question paper.**

| | | |
|---|---|---|
| 1. | For each of the following questions, answer in 3-4 lines: | 7 × 2 |
| | a. You have 500 examples in a dataset, of which only 175 were examples of preterm births (positive examples, label = 1). To compensate for this class imbalance, an ML engineer duplicates all of the positive examples and splits the data into train, validation, and test sets. The domain experts tell you that the model should not miss preterm births, but false positives are okay. An ML model achieves 100% recall using the split as mentioned above. Will you recommend it for deployment? Or you see a problem with this approach. If so, how do you fix the issue? Justify your answer. | |
| | b. Weight sharing allows CNNs to deal with image data without using too many parameters. Does weight sharing increase the bias or the variance of a model? | |
| | c. Suppose you have built up a model for classifying different dog species, which is getting a high training set error. Which of the following are promising things to try to improve your classifier?<br>(i) Use a bigger neural network<br>(ii) Get more training data<br>(iii) Increase the regularization parameter `lambda`<br>(iv) Increase the parameter `keepprob` in the dropout layer (assume the classifier has dropout layers) | |
| | d. Why is the sigmoid activation function susceptible to the vanishing gradient problem? | |
| | e. Why is it necessary to include non-linearities in a neural network through activation functions? | |
| | f. Which initialization of weights and biases will result in all the neurons in the layer (under consideration) learning the same function even after several epochs of the gradient descent backpropagation algorithm? | |
| | g. How can you address the gender bias in word embeddings? | |
| | | |

2. **8 + 7**

a. Consider the following neural network, comprising four layers: layer 1, layer 2, layer 3, and layer 4. $W^{[i]}$ and $b^{[i]}$ denote the weights and biases of layer i.



Determine the dimensions of the following arrays:

$W[1], b[1], W[2], b[2], W[3], b[3], W[4], b[4]$

For the above neural network, determine which of the following pieces of code will correctly initialize the network parameters. The components of the vector **dim** denote the number of neurons in the respective layer.

I
```
import np.random.randn as npRand
N = len(dim)
for i in range(1,N):
    parameter['W' + str(i)] = npRand(dim [i], dim [i - 1])) * 0.01
    parameter['b' + str(i)] = npRand(dim [i-1], 1) * 0.01
```

II
```
import np.random.randn as npRand
N = len(dim)
for i in range(1,N):
    parameter['W' + str(i)] = npRand(dim[i-1], dim[i])) * 0.01
    parameter['b' + str(i)] = npRand(dim[i-1], 1) * 0.01
```

III
```
import np.random.randn as npRand
N = len(dim)
for i in range(1,N):
    parameter['W' + str(i)] = npRand(dim[i], dim[i - 1])) * 0.01
    parameter['b' + str(i)] = npRand(dim[i], 1) * 0.01
```

IV
```
import np.random.randn as npRand
N = len(dim)
for i in range(1,N):
    parameter['W' + str(i)] = npRand(dim[i-1], dim[i]))*0.01
    parameter['b' + str(i)] = npRand(dim[i], 1) * 0.01
```

b. The following Convolutional Neural Network (CNN) is applied to a database of images to predict the true class of the image out of 10 choices. Each image is of size 100 × 100 with three channels. Give the dimensions of the input layer of the CNN. If all convolution layers have stride 1 and all pooling functions have stride 2, determine the total number of parameters for each layer.

Input layer: As mentioned in the question above.
C1: Conv 33, padding same, 10 filters
C2: Conv 77, padding same, 20 filters
P1: 22 max pooling
C3: Conv 55, padding same, 10 filters
P2: 44 max pooling
FC1: fully connected Output layer: Softmax

| | | |
|---|---|---|
| | Note: C1, C2, and C3 denote convolution layers, P1 and P2 denote pooling layers, and FC1 denotes fully connected layers. | |
| 3. | a. What are the problems associated with the basic beam search algorithm? How do we address them?<br><br>b. Give the architecture of an LSTM network, clearly stating the semantics of each component.<br><br>c. Suppose you are training an LSTM unit for speech recognition application. You have a vocabulary of 100,000 words. Input(X) is 1000-dimensional, and all activations are 100-dimensional. Determine the dimension of the following at each time step:<br>• $c^{<t>}$<br>• $c^{\sim<t>}$<br>• $\Gamma_u$<br>• $\Gamma_f$<br>• $\Gamma_o$<br><br>d. What are the pros and cons of character-level language models compared to word-level language models? | 3+4+5+3 |
| 4. | a. Suppose you have a neural network that has difficulty handling variable-length input sequences. How could you modify the network to incorporate an attention mechanism to address this issue?<br><br>b. Why is a GAN discriminator trained using real and fake examples?<br><br>c. A Generative Adversarial Network (GAN) is trained to generate images of cats. During training, the generator produces 2000 fake images, and the discriminator correctly identifies 1000 as fake. What is the hit ratio of the discriminator? | 5+3+3 |
| 5. | Answer the questions based on the different explainable AI methods:<br>a. Consider the following explanation **(FIGURE A)** generated by LIME for classifying an image as a wolf. Interpret LIME's explanation.<br>b. Describe the SHAP method. Consider a dataset with F as the Feature set. Let S be a subset of the feature S, and $f_S$ be the output of the model using feature subset S. Consider the formula for determining the shapley value of feature i:<br>$$\phi_i = \sum_{S \subseteq F \setminus \{i\}} \frac{|S|!(|F| - |S| - 1)!}{|F|!} \left[ f_{S \cup \{i\}}(x_{S \cup \{i\}}) - f_S(x_S) \right].$$<br>Describe how the above formula captures the role of the $i^{th}$ feature.<br>c. Consider the **FIGURE B** depicting SHAP values of features determined by the SHAP method. Determine which feature is contributing most towards the prediction. Justify your answer. | 5+5+5 |

(a) Classified as Labrador (b) Explanation

**FIGURE A**

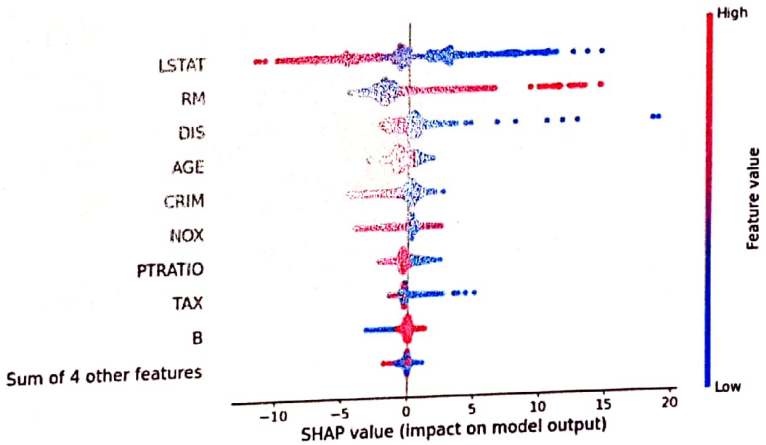



**FIGURE B**