CSE-5368-001Neural Networks Fall 2022 Exam 2

Name	ID	Seat

Prob #	1	2	3	4	5
Points	12	24	24	24	16

Time: 80 Minutes

NOTES:

a. **Credit is only given to the correct numerical values.**
b. **All numerical values must be calculated with three digits of accuracy after the decimal point.**

Name	ID	Seat

$$F(\mathbf{x}) = F(\mathbf{x}^*) + \nabla F(\mathbf{x})^T\Big|_{\mathbf{x}=\mathbf{x}^*}(\mathbf{x}-\mathbf{x}^*) + \frac{1}{2}(\mathbf{x}-\mathbf{x}^*)^T\nabla^2 F(\mathbf{x})\Big|_{\mathbf{x}=\mathbf{x}^*}(\mathbf{x}-\mathbf{x}^*) + \cdots$$

$$\frac{\mathbf{p}^T\nabla F(\mathbf{x})}{\|\mathbf{p}\|} \qquad \frac{\mathbf{p}^T\nabla^2 F(\mathbf{x})\mathbf{p}}{\|\mathbf{p}\|^2} \qquad \alpha_k = -\frac{\mathbf{g}_k^T\mathbf{p}_k}{\mathbf{p}_k^T\mathbf{A}\mathbf{p}_k}$$

$$\mathbf{x}_{k+1} = \mathbf{x}_k - \alpha_k\mathbf{g}_k \qquad \mathbf{x}_{k+1} = \mathbf{x}_k + \alpha_k\mathbf{p}_k \qquad \mathbf{x}_{k+1} = \mathbf{x}_k - \mathbf{A}_k^{-1}\mathbf{g}_k$$

$$S(y_i) = \frac{e^{y_i}}{\sum_j e^{y_j}}$$

$$H(p,q) = -\sum_x p(x)log(q(x))$$

$$L_i = -log(\frac{e^{y_i}}{\sum_j e^{y_j}})$$

$$L_i = \sum_{j\neq i} max(0, y_j - y_i + \Delta)$$

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1. Consider a multi-layer neural network with two nodes at the last layer. The desired and actual outputs of this network for a given input is shown below:

Desired output=$\begin{bmatrix} \mathbf{0.25} \\ \mathbf{0.75} \end{bmatrix}$

Actual output=$\begin{bmatrix} \mathbf{-1.5} \\ \mathbf{0.8} \end{bmatrix}$

Calculate the cross entropy loss. **Use natural log.**

Name	ID	Seat

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2. Complete the following function using tensorflow (**do not use keras**) to create and train a **two-layer** neural network. The **first layer** should have **100 ReLU** nodes. The **output layer** should have **linear nodes**.
   Your loss function should be **mean squared error**.
   Anything not specified in this description should be **inferred from the function's parameters and not hardcoded.**
   Code should include initializing weights, training loop with forward pass, gradient calculation, and weight updates.
   You may assume the entire dataset is one batch and you do not need to split the data into batches.

```
import numpy as np
import tensorflow as tf
```

```
def create_and_train_nn(X, Y, num_epochs, alpha):
"""
:param X: Array of input [n_samples,input_dimensions]
:param y: Array of desired (target) outputs [n_samples , target_dimension].
:param num_epochs: No. of times training should be repeated over all data
:param alpha: Learning rate:"""
```

Name	ID	Seat

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3. Consider the expression: $\boldsymbol{f(x) = \frac{(x-y)}{y} + (x * y)}$

Given the inputs $\boldsymbol{x = 25,}$ $\boldsymbol{y = 5}$

Draw the computational graph.

Calculate the $\frac{\boldsymbol{\delta f(x,y)}}{\boldsymbol{\delta x}}$ $\boldsymbol{and}$ $\frac{\boldsymbol{\delta f(x,y)}}{\boldsymbol{\delta y}}$

You must show all the numerical values as they flow in the forward and backward path.

Name	ID	Seat

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4. Consider the following performance surface

$$F(X) = 2x_1^2 + x_2 - 3x_1x_2$$

Given the initial point $\begin{bmatrix} 2 \\ 1 \end{bmatrix}$, take **two steps** of the **steepest descent algorithm**, minimizing along a line **at each step**.

You must show the resulting position after each step.

Name	ID	Seat

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5. Consider a convolutional neural network.

Note: **Do NOT consider Biases**.

Input layer:

Input to this CNN are color images of size **256x256x3** with the batch size = **32**

Next layer is Conv2D layer:

number of filters: **8**, filter size: **7x7** ; stride: **5x5** ; padding: **8x8**

What is the shape of the weight matrix for this layer? _____

What is the shape of the output (tensor) of this layer? _____

Next layer is Conv2D layer:

number of filters: **16**, filter size: **6x6** ; stride: **6x6** ; padding: **4x4**

What is the shape of the weight matrix for this layer? _____

What is the shape of the output (tensor) of this layer? _____

Next layer is Max Pooling layer:

pool size: **4x4** ; stride: **2x2** ; padding: **2x2**

What is the shape of the output (tensor) for this layer? _____

Next layer is Flatten layer:

What is the shape of the output (tensor) for this layer? _____

Next layer is Dense layer:

number of nodes: **10**

What is the shape of the weight matrix (tensor) for this layer? _____

What is the shape of the output (tensor) for this layer? _____

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