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

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

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

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

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

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

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

$$\frac{\partial \tanh(x)}{\partial x} = 1 - (\tanh(x))^2$$

$$\frac{\partial \sigma(x)}{\partial x} = (\sigma(x))(1-\sigma(x))$$

$$N = Wx + b$$

$$\frac{\partial loss}{\partial W} = \frac{\partial loss}{\partial N}x^T$$

$$\frac{\partial loss}{\partial x} = W^T\frac{\partial loss}{\partial N}$$

$$\frac{\partial loss}{\partial b} = \frac{\partial loss}{\partial N}$$

$$\frac{\partial(cross\ entopy\ loss)}{\partial y_j} = \sum_i \begin{cases} t_i(y_i - 1) & i = j \\ t_i y_j & i \neq j \end{cases}$$

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Quiz 9

Consider a convolutional neural network.

Note: **Do NOT consider Biases**.

Input layer:

Input to this CNN are color images of size **264x264x3** with the batch size = **50**

Next layer is Conv2D layer:

number of filters: **12**, filter size: **5x5** ; stride: **3x3** ; padding: **7x7**

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: **4x4** ; stride: **3x3** ; padding: **1x1**

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: **3x3** ; 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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Quiz 9

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Quiz 10

Consider the following performance surface

$$F(X) = 2x_1^2 - 3x_1x_2 + 5x_1 - 4x_2$$

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.

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Quiz 10

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Quiz 11

Using tensorflow, complete the following function to create and train a **two-layer** neural network. The **first layer** has **12 sigmoid** nodes. The **output layer** has **linear nodes**. Loss function should be **MSE**. Anything not specified in the 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.

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

```
def create_and_train_nn(X, Y, epochs, alpha):
"""
:param X: Array of input [n_samples,input_dimensions]
:param y: Array of desired outputs [n_samples , target_dimension].
:param epochs: number of epochs
:param alpha: Learning rate:
:return w1, w2 Weight matrices."""
```

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Quiz 11

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Quiz 12

Complete the following function. This function should only create and initialize the weights for an autoencoder using tensorflow. **DO NOT USE keras.**

Biases should be included in the weight as the first row of the weight matrix.

```
import numpy as np
import tensorflow as tf
def create_and_initialize_autoencoder(train,encoder_layers):
# train: numpy array of input [nof_train_samples,input_dimensions]
# encoder_layers: list of integers representing number of nodes in
# each layer. The last number represents the dimension of latent space
# return: List of weight matrices ,
# Notes:
# Initialize all the weights and biases to zeros.
# Assume all layers are fully connected.
# Assume the decoder has the same layer structure as the encoder in the
reverse order.
# Initialize the weights
```

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Quiz 12

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Quiz 13

Using tensorflow, complete the following function. This function should implement the forward pass of an RNN.

```
import numpy as np
import tensorflow as tf
def rnn_forward_pass(Wxh, Whh, Why, bh, by,input_sequence):
# input_sequence: numpy array [time_steps,embedded_dimension]
# return: output sequence, hidden state sequence
# You do not need to initialize the weights.
# The activation function for all layers is tanh()
# Assume the batch size is one.
```

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Quiz 13

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Quiz 14

Consider the expression:

$$f(x,y) = (x * y) - min(\left(\frac{x}{y}\right), x)$$

Given the inputs: $x = 100 \;\; , \;\; y = 5$

Draw the computational graph and calculate the $\frac{\delta f(x,y)}{\delta x}$ and $\frac{\delta f(x,y)}{\delta y}$ and show all the numerical values of the forward and backward pass.

For proper credit, you MUST SHOW computational graph, numerical values of all local derivatives, all the numerical values as they flow in the forward path, and numerical values in the backward path.

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Quiz 14