Joint Tech Internship Program

ASSIGNMENT - 1

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Problem Description:

- ***Input:*** 28x28 grayscale images of Shapes.
- ***Output:*** Any shape between Circle, Rectangle, Square, Oval, Pentagon, Triangle.

Sample Data:

Image Index	Image	Label
0	28x28 sized image of a circle	Circle
1	28x28 sized image of a Rectangle	Rectangle
2	28x28 sized image of a Square	Square
3	28x28 sized image of an Oval	Oval
4	28x28 sized image of a Pentagon	Pentagon
5	28x28 sized image of a Triangle	Triangle

Key Terminologies and Parameters:

Neural Network: In simpler words, It is a method in Artificial intelligence that teaches the computer to process the data in a way human brain does using the interconnected nodes and neurons.

Neuron: Neurons are nodes through which the data and computations flow through the layers in neural network. According to our test data, each neuron processes pixel values of the 28x28 images.

Layer: A layer is a fundamental building block of neural networks in which each layes consists of set of neurons that processes data and pass the processed data to its next layer.For our test data, initial layers might detect the simple features and deep layers might detect complex shapes.

Input Layer: Initial layer of the neural network, which receives input from the user.It directly takes raw pixel values from our image dataset as input.

Hidden Layer: Intermediate layer in a neural network. They are responsible for the excellent performance and complexity of neural network. In our test data, hidden layers helps the neural network to learn and distinguish shapes.

Output Layer: Final layer in the neural network where desired predictions are obtained. For our data, it outputs the probabilities of each classes.

Convolutional Layer: A hidden layer that contains several convolutional units in a convolutional neural network (CNN) used for feature extraction. It's used to detect features like edges and shapes in the 28x28 image of a circle.

Convolutional Neural Network (CNN): A network architecture for deep learning that learns directly from data. Particularly used for finding patterns in images to recognize objects, classes and categories. Also used for classifying audio, time-series, and signal data.In our example, CNN is used to identify the various shapes in the image.

Recurrent Neural Network (RNN): A type of deep neural network wher both input and data and prior hidden states are fed into the network's layers. Used for language translation, natural language processing (NLP), speech recognition, and image captioning. It doesn't work for static dataset like our shapes dataset.

Activation function: A mathematical function that determines the output of a neuron based on its input data.

ReLU: Rectified Linear Unit. Used to introduce nonlinearity to a neural network. It outputs the input directly if the linear function is positive; otherwise, it will output zero.
$ReLU(x) = max(0, x)$

Sigmoid: Used for the models where we have to predict the probability as an output.

Tanh: hyperbolic tangent activation function. A mathematical function commonly used in artificial neural network (ANN). It transforms input values to produce output between -1 and 1.

Softmax: Oftenused as the last activation function of a neural network to normalise the output of a network to a probability distribution.

Forward Propagation: It is a process in neural network where the input data is passed through the network's layers to generate an output. In our case 28x28 pixel values are passed as the input though the network layers and probabilities are calculated as output.

Back Propagation: It is an iterative algorithm, that helps to minimise the cost function by determining which weights and biases should be adjusted. If the probability of predicted output for the class 'Circle' is very low, backprogpagation is used to update the weights.

Loss Function: Loss function also known as error function, is used to determine the difference between the predicted values produced by the model and the actual values. Also used to measure how well the built model is performing.Cross-Entropy loss is usually used to do classification tasks.

Cost function: Used to measure the error between predicted and actual values and helps the network adjust its weights and biases to make accurate predictions. It helps to determine the overall performance during the training of the model.

- ➔ Loss function and Cost function is ofter used interchangeably. But the key difference is the loss function is to capture the difference between the actual and predicted values for a single record whereas cost functions capture the difference for the entire training dataset.

Gradient Descent (GD) : It is an iterative optimisation algorithm used to find a local minimum / maximum of a given function.

Learning Rate (LR): It is a critical tuning parameter in training machine learning and deep learning models that determines the step size at each iteration while moving toward a minimum of a loss function.

Batch Size: The batch size is a hyperparameter that defines the number of samples to work through before updating the internal model parameters.

Epoch: The number of epochs is a hyperparameter that defines the number times that the learning algorithm will work through the entire training dataset.

Overfitting: Occurs when a model performs well and good on training data but performs poorly on unseen or test data. For example, if our model recognize the images of a perfect circle and fails on recognizing slightly different images of a circle.

Underfitting: Occurs when a model is unable to learn the patterns in the training data and generalize the new data. If our model fails to recognize even the perfect circles.
Training Set: The model sees and learns from this data to predict the outcome or to make the right decisions.

Validation Set: The validation set is used to finetune the hyperparameters of the model and is considered a part of the training of the model.

Test Set: This data has somewhat similar data compared to training data probability distribution of classes and it is used to evaluate the performance of the model.

Cross-Validation:Cross-validation is a technique for validating the model efficiency by training it on the subset of input data and testing on previously unseen subset of the input data.

Hyperparameters: Hyperparameters in Machine learning are those parameters that are explicitly defined by the user to control the learning process.

Model Parameters: A model parameter is a variable of the selected model that can be estimated by fitting the given data to the model.

Regularization: Regularization is a technique used to prevent overfitting by adding a penalty term to the loss function, discouraging the model from assigning too much importance to individual features.

Dropout: A regularization approach that randomly drops neurons during training to prevent overfitting.

Weight Initialization: Weights in neural networks are initialized randomly to break symmetry and prevent convergence to poor local minima.

Normalization: The process of transforming the columns in a dataset to the same scale (between 0 and 1).

Standardization: A data preprocessing technique used in statistics and machine learning to transform the features of your dataset so that they have a mean 0 and a standard deviation of 1.