Name: Hafsa Fatima   Student ID: 1001597654

Convolution Neutral Network

Model

The following image shows the summary of the model created. The first layer
extracts 32 feature from the image of size 32 X 32 X 3 and then activation
function called ReLu is applied which converts all negative numbers in matrix
to zero Similarly Max pooling is applied. More convolution layers are added
and increase the features, so we end up with 512 features of size 3X3 then 3D
output is flattened to 1D, then add one or more Dense layers on top. CIFAR
has 10 output classes, so you use a final Dense layer with 10 outputs and a
soft max activation. Addition of more convolution layers and tweaking the
hyper parameters improved the performance. Finally, Chose an optimizer that
converges relatively fast.

```
Model: "sequential_1"
_____
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_5 (Conv2D)            (None, 32, 32, 32)        896
_____
max_pooling2d_2 (MaxPooling2 (None, 16, 16, 32)        0
_____
conv2d_6 (Conv2D)            (None, 14, 14, 64)        18496
_____
conv2d_7 (Conv2D)            (None, 12, 12, 128)       73856
_____
conv2d_8 (Conv2D)            (None, 10, 10, 256)       295168
_____
max_pooling2d_3 (MaxPooling2 (None, 5, 5, 256)         0
_____
conv2d_9 (Conv2D)            (None, 3, 3, 512)         1180160
_____
flatten_1 (Flatten)          (None, 4608)              0
_____
dense_2 (Dense)              (None, 64)                294976
_____
dense_3 (Dense)              (None, 10)                650
=================================================================
Total params: 1,864,202
Trainable params: 1,864,202
Non-trainable params: 0
_____
```

Figure 1: Model

Optimizer

According to experiment in building this CNN, I observed that Adam optimizer
takes least time to converge and get a accurate model. .

1

Loss Function

Loss function is sparse categorical cross entropy. It is used to measure the dissimilarity between the distribution of observed class labels and the predicted probabilities of class membership and so it is best for multi class data.

Hyper Parameters

According to the experiment, Learning rate 0.001 gives the best result. Epochs is 10 because when the loss graph is observed, the model goes beyond local minima. data augmentation is also used such like horizontal and vertical flip, rotation, width shift, height shift. Although data augmentation did not show drastic result, it is still better to randomly shift the images and use it for training.

Matrix

Confusion Matrix

The classifier analysis is done by finding confusion matrix and it indicates number of predictions that are true. This matrix is useful in analysis of multi class label data set.

```
[[775  15  30  17  13   1   4  19  77  49]
 [ 13 827   3   2   1   6   5   3  21 119]
 [ 65   9 584  51 104  49  64  39  19  16]
 [ 18  13  53 450  79 189  73  60  13  52]
 [ 11   1  47  31 751  24  37  81   5  12]
 [  6   6  28 112  44 671  30  68   9  26]
 [  4   5  28  56  44  11 810  10  13  19]
 [ 13   1  17  28  44  40   5 821   5  26]
 [ 45  21  14   9   8   3   3   7 847  43]
 [ 13  40   4   5   3   5   2   6  19 903]]
```
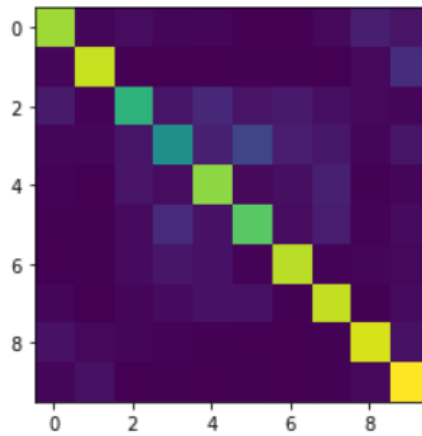
Figure 2: Confusion Matrix in Numbers

Figure 3: Confusion Matrix

Mean Accuracy of each class Matrix

This determines the average of accuracy found in each class will training and it is useful to analysis the weak set of class labels in data set.

```
Average accuracy of each class

Class  airplane  :  77.5  %
Class  automobile  :  82.7  %
Class  bird  :  58.4  %
Class  cat  :  45.0  %
Class  deer  :  75.1  %
Class  dog  :  67.1  %
Class  frog  :  81.0  %
Class  horse  :  82.1  %
Class  ship  :  84.7  %
Class  truck  :  90.3  %
```

Figure 4: Accuracy of each Class

Other Matrix

This matrix has useful information like precision and recall for each class label

	precision	recall	f1-score	support
airplane	0.80	0.78	0.79	1000
automobile	0.88	0.83	0.85	1000
bird	0.72	0.58	0.65	1000
cat	0.59	0.45	0.51	1000
deer	0.69	0.75	0.72	1000
dog	0.67	0.67	0.67	1000
frog	0.78	0.81	0.80	1000
horse	0.74	0.82	0.78	1000
ship	0.82	0.85	0.84	1000
truck	0.71	0.90	0.80	1000
accuracy			0.74	10000
macro avg	0.74	0.74	0.74	10000
weighted avg	0.74	0.74	0.74	10000

Figure 5: Matrix

Analysis

The accuracy of this classifier is 74.39.

Accuracy and Loss VS Epoch

The accuracy of this classifier is 74.39 in test data. The following all the experimental values of tensorboard. There is improvement as the model is changed. The green curve indicates the latest curve. The Loss graph is given below
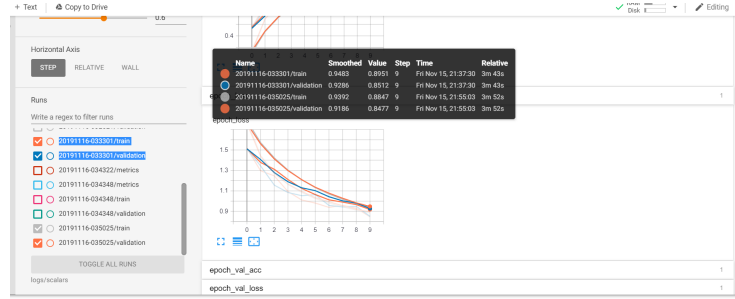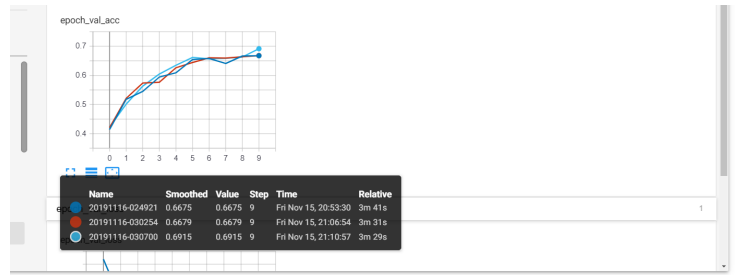

Figure 6: Loss

Validation Accuracy and Loss VS Epoch

The following all the experimental values of tensorboard. There is improvement as the model is changed. The green curve indicates the latest curve. The Loss graph is given below

Figure 7: Validation Accuracy

Validation Accuracy VS Accuracy

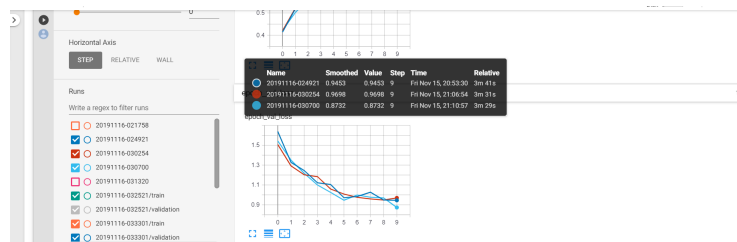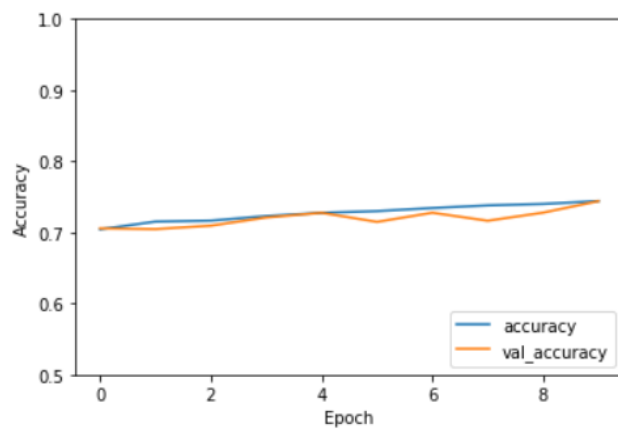While training the accuracy and validation accuracy fluctuates kept fluctuating. After data Augmentation the oscillation declined and the curve is as follows.

4

Figure 8: Loss

Figure 9: Acc VS Acc Validation