Problem Statement

- 10 Different Classes of Images from CIFAR Dataset
- 60,000 32X32 Color images
- 6000 Images of each class
- Images have low resolution of 32X32

0.airplane
1.automobile
2.bird
3.cat
4.deer
5.dog
6.frog
7.horse
8.ship
9.truck

Import Libraries

In [122]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import keras
```

Import Dataset

In [123]:

```
from keras.datasets import cifar10
```

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```
(X_train,y_train),(X_test,y_test)=cifar10.load_data()
```

Shape of Data

In [124]:

```
print("X_train shape",X_train.shape)
print("X_test shape",X_test.shape)
print("y_train shape",y_train.shape)
print("y_test shape",y_test.shape)
```

```
X_train shape (50000, 32, 32, 3)
X_test shape (10000, 32, 32, 3)
y_train shape (50000, 1)
y_test shape (10000, 1)
```

Visualize the Data

In [125]:

```
for i in range(2):
    random=np.random.randint(1000)
    print(y_train[random])
    plt.imshow(X_train[random])
    plt.axis("off")
    plt.show()
```

```
[9]
```

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[1]

Grid Plots

In [126]:
```
W_grid=15
L_grid=15
```

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```
fig,axes=plt.subplots(L_grid,W_grid,figsize=(25,25))
# For flattening
axes=axes.ravel()
n_training=len(X_train)

for i in np.arange(0,L_grid*W_grid):
    index=np.random.randint(0,n_training)
    axes[i].imshow(X_train[index])
    axes[i].set_title(y_train[index])
    axes[i].axis("off")
plt.subplots_adjust(hspace = 0.4)
```

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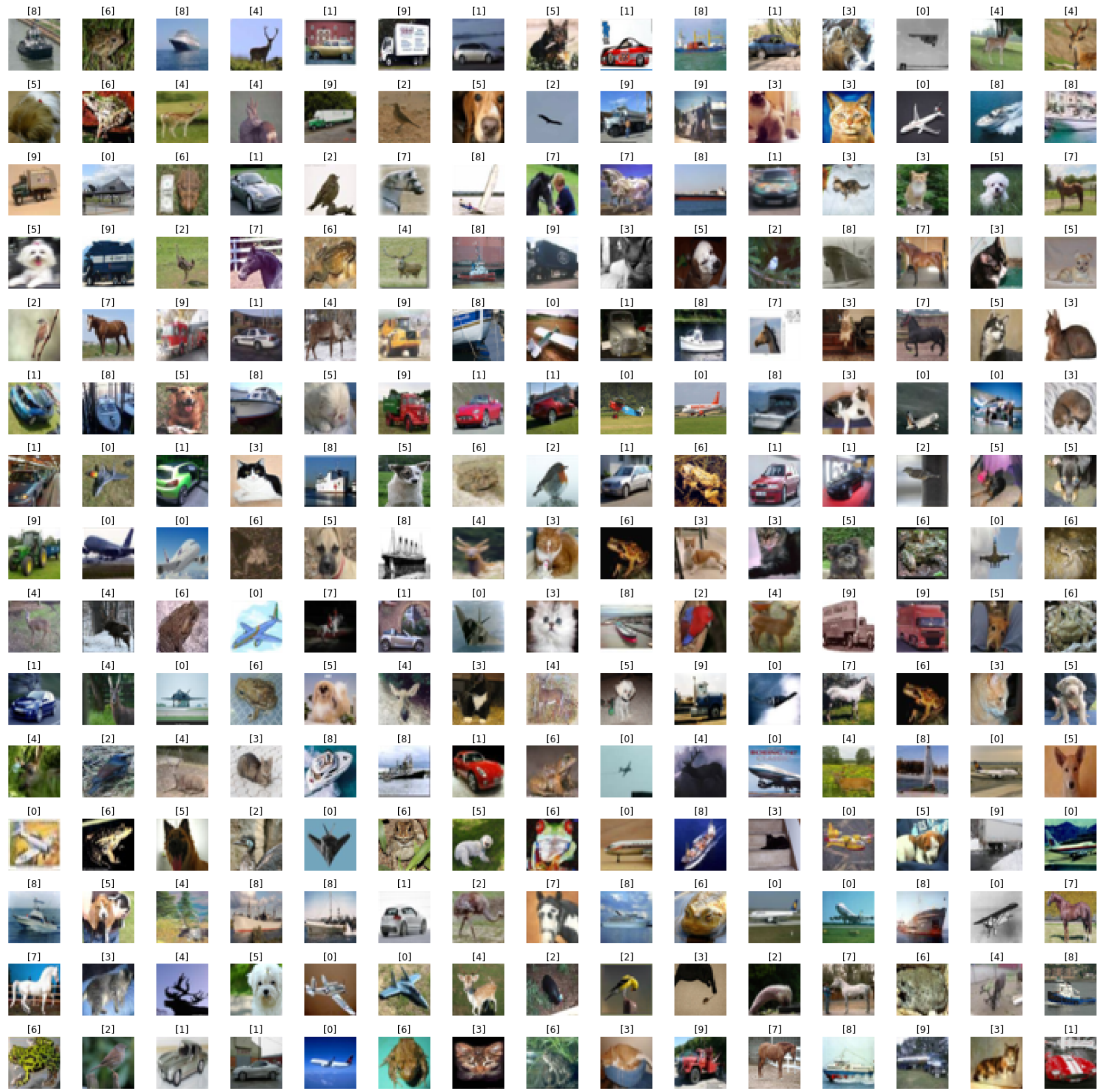

Data preparation

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Float conversion

In [127]:
```
X_train=X_train.astype("float32")
X_test=X_test.astype("float32")
```

Binary Encoding

In [128]:
```
y_train=keras.utils.to_categorical(y_train,10)
y_test=keras.utils.to_categorical(y_test,10)
```

Normalizing the Data

In [129]:
```
X_train=X_train/255
X_test=X_test/255
print(X_train.shape)
input_shape=X_train.shape[1:]
input_shape
```

```
(50000, 32, 32, 3)
```

Out[129]:
```
(32, 32, 3)
```

Creating and Training the model

In [130]:
```
from keras.models import Sequential
from keras.layers import Conv2D,MaxPooling2D, AveragePooling2D, Dense,
Flatten,Dropout
from keras.optimizers import Adam
from keras.callbacks import TensorBoard
```

In [10]:
```
cnn_model=Sequential()
```

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```
# First CNN Layer
cnn_model.add(Conv2D(filters=32,kernel_size=(3,3),activation='relu',inp
ut_shape=input_shape))
# Second CNN Layer
cnn_model.add(Conv2D(filters=32,kernel_size=(3,3),activation='relu'))
# MaxPooling 2D
cnn_model.add(MaxPooling2D(2,2))
# Dropout 30% of Neurons along with their weight
cnn_model.add(Dropout(0.3))

#Adding more depth with 64 filters
cnn_model.add(Conv2D(filters=64,kernel_size=(3,3),activation='relu'))
cnn_model.add(Conv2D(filters=64,kernel_size=(3,3),activation='relu'))
cnn_model.add(MaxPooling2D(2,2))
# Dropout 20% of Neurons along with their weight
cnn_model.add(Dropout(0.3))

## Flattening the data
cnn_model.add(Flatten())
## Adding Dense Layers
cnn_model.add(Dense(units=512,activation='relu'))
cnn_model.add(Dense(units=512,activation='relu'))
## Output Layer
cnn_model.add(Dense(units=10,activation='softmax'))
```

Compiling the model

In [11]:

```
cnn_model.compile(loss='categorical_crossentropy',optimizer=keras.optim
izers.rmsprop(lr=0.001),metrics=['accuracy'])
```

Fitting the training data with Shuffling

In [12]:

```
history=cnn_model.fit(X_train,y_train,batch_size=128,epochs=10,shuffle=
True)
```

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```
Epoch 1/10
50000/50000 [==============================] - 273s 5ms/step - loss: 1.
8270 - acc: 0.3377
Epoch 2/10
50000/50000 [==============================] - 271s 5ms/step - loss: 1.
3717 - acc: 0.5109
Epoch 3/10
50000/50000 [==============================] - 271s 5ms/step - loss: 1.
1602 - acc: 0.5916
Epoch 4/10
50000/50000 [==============================] - 271s 5ms/step - loss: 1.
0032 - acc: 0.6485
Epoch 5/10
50000/50000 [==============================] - 274s 5ms/step - loss: 0.
8847 - acc: 0.6915
Epoch 6/10
50000/50000 [==============================] - 272s 5ms/step - loss: 0.
7983 - acc: 0.7208
Epoch 7/10
50000/50000 [==============================] - 272s 5ms/step - loss: 0.
7255 - acc: 0.7450
Epoch 8/10
50000/50000 [==============================] - 273s 5ms/step - loss: 0.
6628 - acc: 0.7673
Epoch 9/10
50000/50000 [==============================] - 271s 5ms/step - loss: 0.
6122 - acc: 0.7853
Epoch 10/10
50000/50000 [==============================] - 272s 5ms/step - loss: 0.
5668 - acc: 0.8010
```

Evaluate the Model

In [131]:

```
print("Test accuracy",cnn_model.evaluate(X_test,y_test)[1])

## predictions
predicted_classes=cnn_model.predict(X_test)
```

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```
10000/10000 [==============================] - 20s 2ms/step
Test accuracy 0.7602
```

Making Predicting and True Value Matrix

In [132]:
```
pred=[]
test=[]
for i in range(y_test.shape[0]):
    pred.append(np.argmax(predicted_classes[i]))
    test.append(np.argmax(y_test[i]))
predicted=np.array(pred)
true=np.array(test)
classes=np.unique(true)
```

Plotting confusion Matrix

In [133]:
```
from sklearn.metrics import confusion_matrix
from sklearn.utils.multiclass import unique_labels

def plot_confusion_matrix(y_true, y_pred, classes,
                          normalize=False,
                          title=None,
                          cmap=plt.cm.Blues):
    """
    This function prints and plots the confusion matrix.
    Normalization can be applied by setting `normalize=True`.
    """

    # Compute confusion matrix
    cm = confusion_matrix(y_true, y_pred)
    # Only use the labels that appear in the data
    classes = classes[unique_labels(y_true, y_pred)]
    fig, ax = plt.subplots()
    im = ax.imshow(cm, interpolation='nearest', cmap=cmap)
    ax.figure.colorbar(im, ax=ax)
```

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```
    # We want to show all ticks...
    ax.set(xticks=np.arange(cm.shape[1]),
           yticks=np.arange(cm.shape[0]),
           # ... and label them with the respective list entries
           xticklabels=classes, yticklabels=classes,
           title=title,
           ylabel='True label',
           xlabel='Predicted label')

    # Rotate the tick labels and set their alignment.
    plt.setp(ax.get_xticklabels(), rotation=45, ha="right",
             rotation_mode="anchor")

    # Loop over data dimensions and create text annotations.
    fmt = '.2f' if normalize else 'd'
    thresh = cm.max() / 2.
    for i in range(cm.shape[0]):
        for j in range(cm.shape[1]):
            ax.text(j, i, format(cm[i, j], fmt),
                    ha="center", va="center",
                    color="white" if cm[i, j] > thresh else "black")
    fig.tight_layout()
    return ax


np.set_printoptions(precision=2)
```

In [134]:

```
plot_confusion_matrix(true,pred,classes=classes)
plt.show()
```

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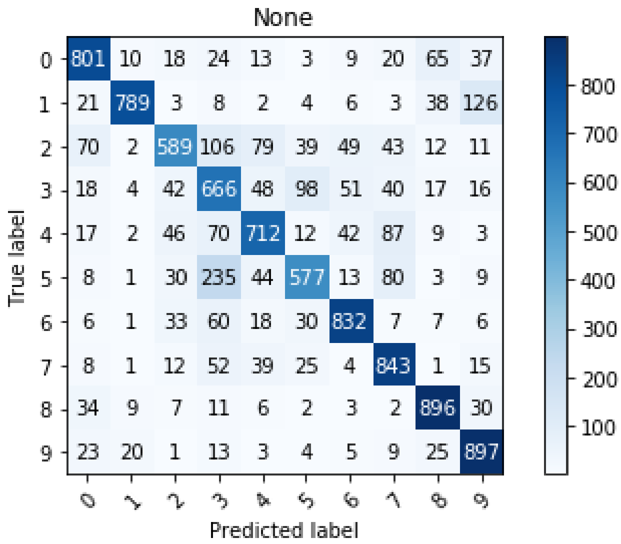

Saving the Model

In [135]:
```
import os
directory=os.path.join(os.getcwd(),"Saved Model")

if not os.path.isdir(directory):
    os.makedirs(directory)
model_path=os.path.join(directory,'Keras_CIFAR10_Trained_Model.h5')
cnn_model.save(model_path)
```

Improving the model with data Augmentation

Model Training using Augmented Dataset

In [140]:
```
datagen=ImageDataGenerator(
                            rotation_range=90,
```

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```
                                width_shift_range=0.1,
                                horizontal_flip=True,
                                vertical_flip=True
                                )
```

In [141]:
```
datagen.fit(X_train)
```

In [142]:
```
## Steps per epoch = 50000/128 , 50000 was image data size and 128 is t
he batch size
```

In [143]:
```
cnn_model.fit_generator(datagen.flow(X_train,y_train,batch_size=128),ep
ochs=5,steps_per_epoch=50000/128)
```

```
Epoch 1/5
391/390 [==============================] - 282s 721ms/step - loss: 1.47
01 - acc: 0.4760
Epoch 2/5
391/390 [==============================] - 284s 726ms/step - loss: 1.40
63 - acc: 0.5049
Epoch 3/5
391/390 [==============================] - 283s 725ms/step - loss: 1.36
72 - acc: 0.5180
Epoch 4/5
391/390 [==============================] - 283s 723ms/step - loss: 1.34
37 - acc: 0.5256
Epoch 5/5
391/390 [==============================] - 283s 724ms/step - loss: 1.31
90 - acc: 0.5352
```

Out[143]:
```
<keras.callbacks.History at 0x19baf6ad1d0>
```

Saving Augmented Model

In [144]:
```
import os
directory=os.path.join(os.getcwd(),"Saved Model")
```

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```python
if not os.path.isdir(directory):
    os.makedirs(directory)
model_path=os.path.join(directory,'Keras_CIFAR10_Augmented_Model.h5')
cnn_model.save(model_path)
```

In [ ]:

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