In [1]:
```
#importing the libraries required
```

In [120]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn
```

In [121]:
```
#importing the dataset
from keras.datasets import cifar10
(X_train, y_train) , (X_test, y_test) = cifar10.load_data()
```

In [122]:
```
#getting the shape of the training and test set variables
X_train.shape
```

Out[122]:
```
(50000, 32, 32, 3)
```

In [123]:
```
X_test.shape
```

Out[123]:
```
(10000, 32, 32, 3)
```

In [124]:
```
y_train.shape
```

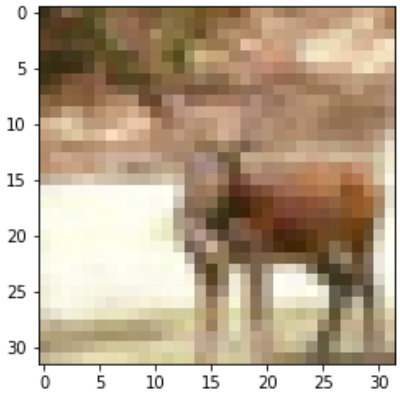
Out[124]:
```
(50000, 1)
```

In [125]:
```
y_test.shape
```

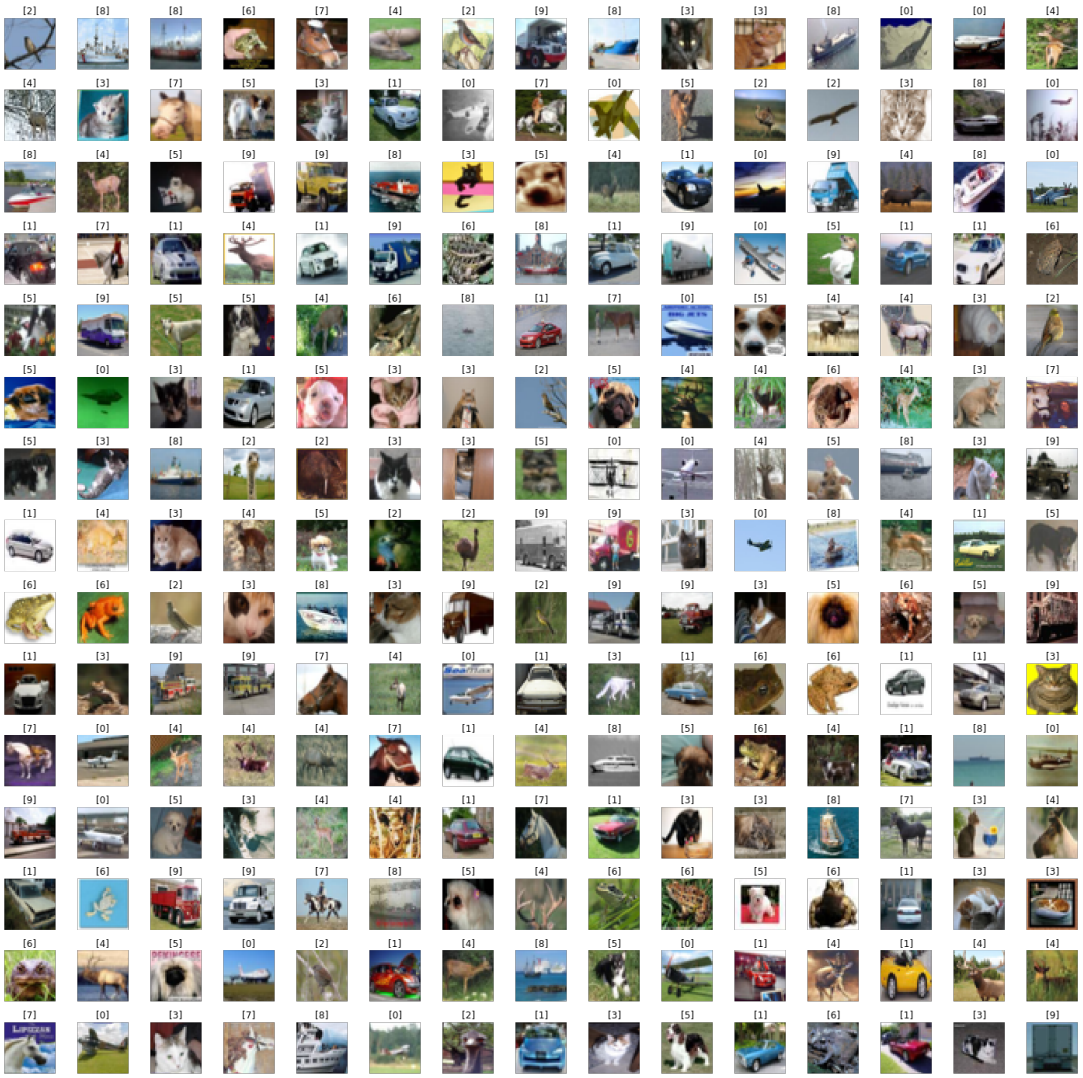
Out[125]:
```
(10000, 1)
```

In [126]:
```
#step 2 visulaising the data and checking
i = 1001
plt.imshow(X_train[i])
print(y_train[i])
```

```
[4]
```



In [127]:
```
#creating a matrix of pictures
W_grid = 15
L_grid = 15

fig, axes = plt.subplots(L_grid, W_grid, figsize = (25, 25))
axes = axes.ravel()

n_training = len(X_train)

#creating a for loop to plot an image
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)
```



In [128]:
```
#step 3 data preparation
```

In [129]:
```
#convert actual images into float type
X_train = X_train.astype('float32')
X_test = X_test.astype('float32')
number_cat = 10 #number of categories
```

In [130]:
```
y_train
```

Out[130]:
```
array([[6],
       [9],
       [9],
       ...,
       [9],
       [1],
       [1]], dtype=uint8)
```

In [131]:
```
import keras
#converting y decimal values into binaries
y_train = keras.utils.to_categorical(y_train, number_cat)
```

In [132]:
```
y_train
```

Out[132]:
```
array([[0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 1.],
       [0., 0., 0., ..., 0., 0., 1.],
       ...,
       [0., 0., 0., ..., 0., 0., 1.],
       [0., 1., 0., ..., 0., 0., 0.],
       [0., 1., 0., ..., 0., 0., 0.]], dtype=float32)
```

In [133]:
```
y_test
```

Out[133]:
```
array([[3],
       [8],
       [8],
       ...,
       [5],
       [1],
       [7]])
```

In [134]:
```
#converting y_test into binary values
y_test = keras.utils.to_categorical(y_test, number_cat)
```

In [135]:
```
y_test
```

Out[135]:
```
array([[0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 1., 0.],
       [0., 0., 0., ..., 0., 1., 0.],
       ...,
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 1., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 1., 0., 0.]], dtype=float32)
```

In [136]:
```
#normalising the values
X_train = X_train/255
X_test = X_test/255
```

In [137]:
```
X_train
```

```
Out[137]: array([[[[0.23137255, 0.24313726, 0.24705882],
                   [0.16862746, 0.18039216, 0.1764706 ],
                   [0.19607843, 0.1882353 , 0.16862746],
                   ...,
                   [0.61960787, 0.5176471 , 0.42352942],
                   [0.59607846, 0.49019608, 0.4       ],
                   [0.5803922 , 0.4862745 , 0.40392157]],

                  [[0.0627451 , 0.07843138, 0.07843138],
                   [0.        , 0.        , 0.        ],
                   [0.07058824, 0.03137255, 0.        ],
                   ...,
                   [0.48235294, 0.34509805, 0.21568628],
                   [0.46666667, 0.3254902 , 0.19607843],
                   [0.47843137, 0.34117648, 0.22352941]],

                  [[0.09803922, 0.09411765, 0.08235294],
                   [0.0627451 , 0.02745098, 0.        ],
                   [0.19215687, 0.10588235, 0.03137255],
                   ...,
                   [0.4627451 , 0.32941177, 0.19607843],
                   [0.47058824, 0.32941177, 0.19607843],
                   [0.42745098, 0.28627452, 0.16470589]],

                  ...,

                  [[0.8156863 , 0.6666667 , 0.3764706 ],
                   [0.7882353 , 0.6       , 0.13333334],
                   [0.7764706 , 0.6313726 , 0.10196079],
                   ...,
                   [0.627451  , 0.52156866, 0.27450982],
                   [0.21960784, 0.12156863, 0.02745098],
                   [0.20784314, 0.13333334, 0.07843138]],

                  [[0.7058824 , 0.54509807, 0.3764706 ],
                   [0.6784314 , 0.48235294, 0.16470589],
                   [0.7294118 , 0.5647059 , 0.11764706],
                   ...,
                   [0.72156864, 0.5803922 , 0.36862746],
                   [0.38039216, 0.24313726, 0.13333334],
                   [0.3254902 , 0.20784314, 0.13333334]],

                  [[0.69411767, 0.5647059 , 0.45490196],
                   [0.65882355, 0.5058824 , 0.36862746],
                   [0.7019608 , 0.5568628 , 0.34117648],
                   ...,
                   [0.84705883, 0.72156864, 0.54901963],
                   [0.5921569 , 0.4627451 , 0.32941177],
                   [0.48235294, 0.36078432, 0.28235295]]],


                 [[[0.6039216 , 0.69411767, 0.73333335],
                   [0.49411765, 0.5372549 , 0.53333336],
                   [0.4117647 , 0.40784314, 0.37254903],
                   ...,
                   [0.35686275, 0.37254903, 0.2784314 ],
                   [0.34117648, 0.3529412 , 0.2784314 ],
                   [0.30980393, 0.31764707, 0.27450982]],

                  [[0.54901963, 0.627451  , 0.6627451 ],
                   [0.5686275 , 0.6       , 0.6039216 ],
                   [0.49019608, 0.49019608, 0.4627451 ],
                   ...,
```

In [138]:
```
X_train.shape
```

Out[138]:
```
(50000, 32, 32, 3)
```

In [139]:
```
#getting the dimension of the image
Input_shape = X_train.shape[1:]
Input_shape
```

Out[139]:
```
(32, 32, 3)
```

In [140]:
```
#step 4 training the model
from keras.models import Sequential
from keras.layers import Conv2D, MaxPooling2D, AveragePooling2D, Dense, Fla
tten, Dropout
from keras.optimizers import Adam
from keras.callbacks import TensorBoard
```

In [141]:
```
#building the model
```

In [142]:
```
cnn_model = Sequential()
cnn_model.add(Conv2D(filters = 32, kernel_size = (3,3), activation = 'relu'
, input_shape = Input_shape))
cnn_model.add(Conv2D(filters = 32, kernel_size = (3, 3), activation = 'relu
'))
cnn_model.add(MaxPooling2D(2, 2))
cnn_model.add(Dropout(0.3))
```

In [143]:
```
#adding extra convolution layers
```

In [144]:
```
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))
cnn_model.add(Dropout(0.2))
```

In [145]:
```
#creating fully connected neurons
cnn_model.add(Flatten())
cnn_model.add(Dense(units = 512, activation = 'relu'))
cnn_model.add(Dense(units = 512, activation = 'relu'))
```

In [146]:
```
#building the output layer
```

In [147]:
```
cnn_model.add(Dense(units = 10, activation = 'softmax'))
```

In [148]:
```
cnn_model.compile(loss = 'categorical_crossentropy', optimizer = keras.opti
mizers.rmsprop(lr = 0.001), metrics = ['accuracy'])
```

In [149]:
```
history = cnn_model.fit(X_train, y_train, batch_size = 32, epochs = 2, shuf
fle =  True)
```

```
Epoch 1/2
50000/50000 [==============================] - 176s 4ms/step - loss: 1.5488
- acc: 0.4400
Epoch 2/2
50000/50000 [==============================] - 179s 4ms/step - loss: 1.1269
- acc: 0.6048
```

In [150]:
```
#step 5 evaluating the model created
```

In [151]:
```
evaluation = cnn_model.evaluate(X_test, y_test)
print('Test Accuracy: {}'.format(evaluation[1]))
```

```
10000/10000 [==============================] - 10s 951us/step
Test Accuracy: 0.6648
```

In [152]:
```
predicted_classes = cnn_model.predict_classes(X_test)
predicted_classes
```

Out[152]:
```
array([3, 8, 8, ..., 5, 0, 7])
```

In [153]:
```
y_test
```

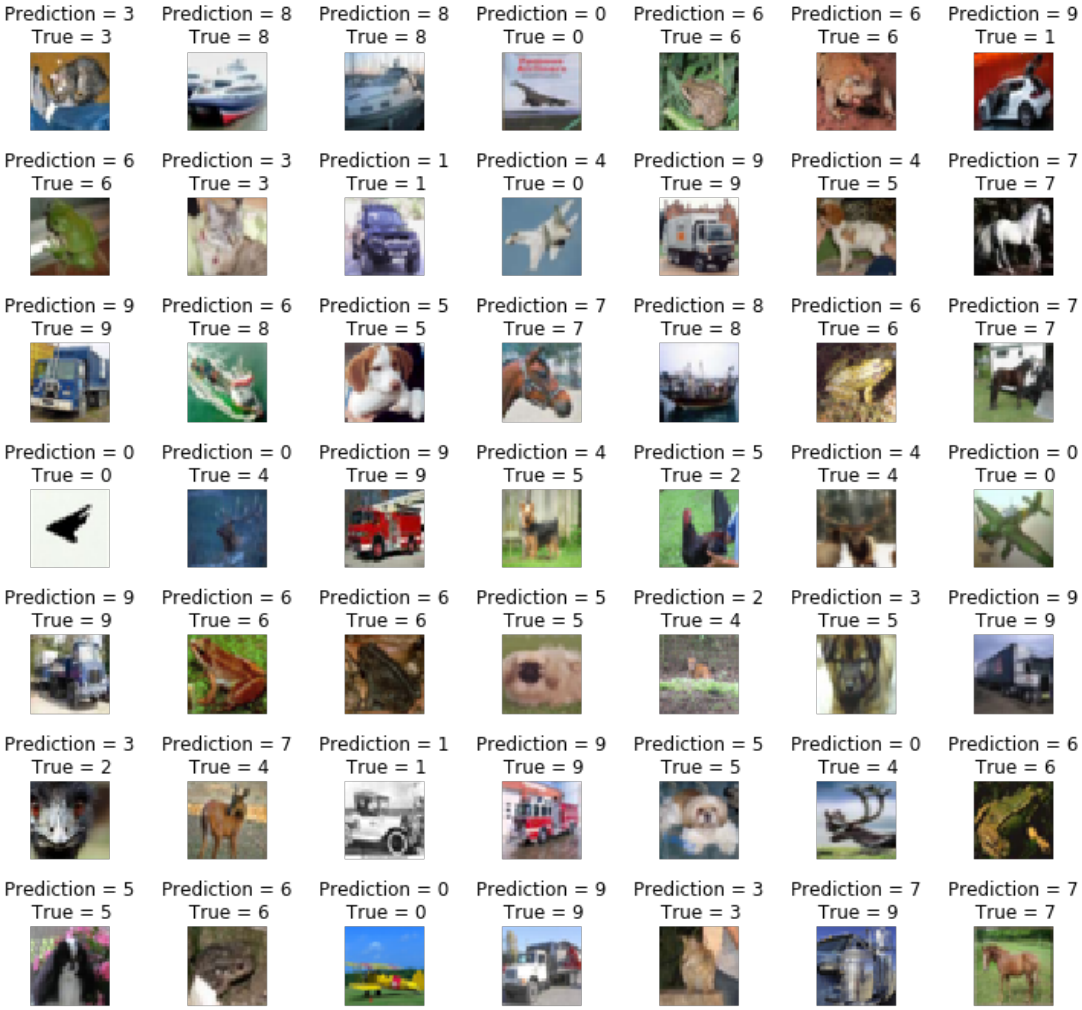
Out[153]:
```
array([[0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 1., 0.],
       [0., 0., 0., ..., 0., 1., 0.],
       ...,
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 1., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 1., 0., 0.]], dtype=float32)
```

In [154]:
```
y_test = y_test.argmax(1)
```

In [155]:
```
y_test
```

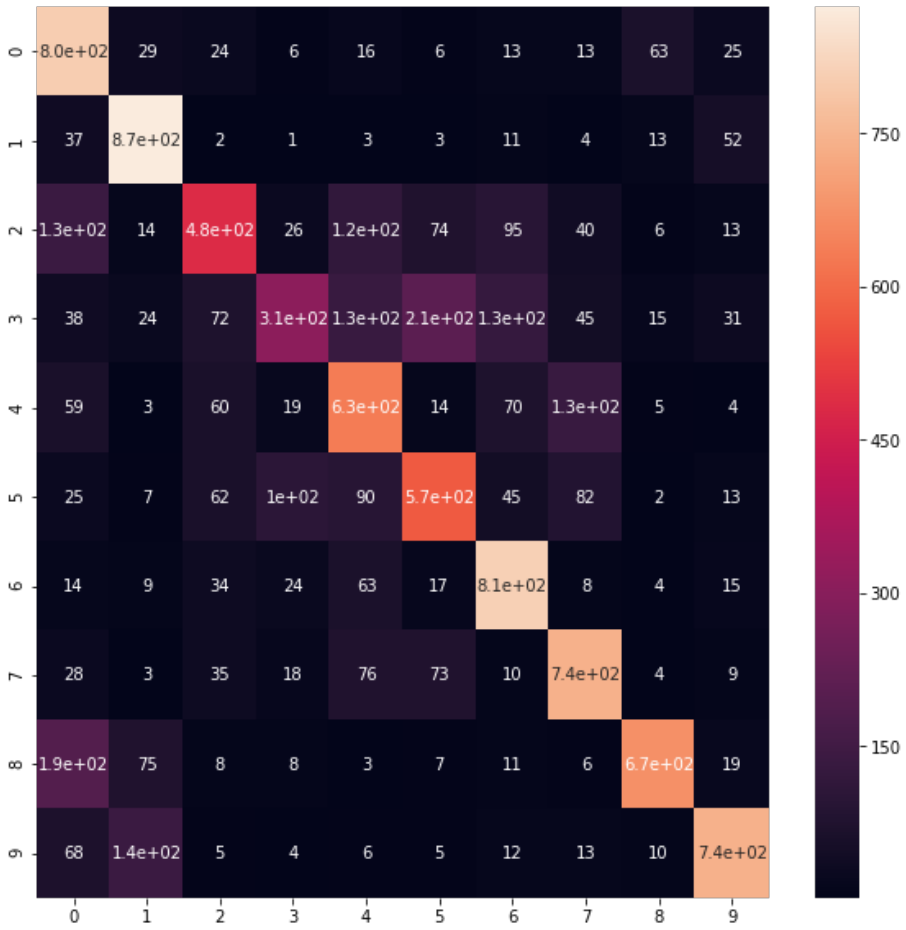
Out[155]:
```
array([3, 8, 8, ..., 5, 1, 7])
```

In [156]:
```
L = 7
W = 7
fig, axes = plt.subplots(L, W, figsize = (12, 12))
axes = axes.ravel()

for i in np.arange(0, L*W):
    axes[i].imshow(X_test[i])
    axes[i].set_title('Prediction = {}\n True = {}'.format(predicted_classe
s[i], y_test[i]))
    axes[i].axis('off')

plt.subplots_adjust(wspace = 1)
```



In [157]:
```
from sklearn.metrics import confusion_matrix
import seaborn as sns

cm = confusion_matrix(y_test, predicted_classes)
cm
plt.figure(figsize = (10, 10))
sns.heatmap(cm, annot = True)
#rows = model , columns = true
```

Out[157]: <matplotlib.axes._subplots.AxesSubplot at 0x7fc3daec5278>




In [158]:
```
#step 6 saving the model
```

In [159]:
```
import os

directory = os.path.join(os.getcwd(), 'saved_models')

if not os.path.isdir(directory):
    os.makedirs(directory)
model_path = os.path.join(directory, 'keras_CIFAR-10_trained_model.h5')
cnn_model.save(model_path)
```

In [113]:
```
#using augmentation to increase the accuracy of the model
#augmentation means we are increasing the variations in the images by enlar
ging them rotating them etc
```

In [114]:
```
import keras
from keras.datasets import cifar10
(X_train, y_train), (X_test, y_test) = cifar10.load_data()
X_train = X_train.astype('float32')
X_test = X_test.astype('float32')
```

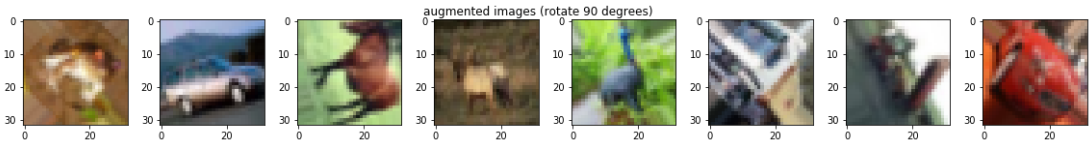
In [115]:
```
X_train.shape
```

Out[115]:
```
(50000, 32, 32, 3)
```

In [116]:
```
n = 8
X_train_samples = X_train[:n]
X_train_samples.shape
```

Out[116]:
```
(8, 32, 32, 3)
```

In [70]:
```
from keras.preprocessing.image import ImageDataGenerator
datagen_train = ImageDataGenerator(rotation_range = 90)
#datagen_train = ImageDataGenerator(vertical_flip = True)
#datagen_train = ImageDataGenerator(height_shift_range = 0.5)
#datagen_train = ImageDataGenerator(brightness_range = (1, 5))
datagen_train.fit(X_train)


from PIL import Image

fig = plt.figure(figsize = (20,2))
for x_batch in datagen_train.flow(X_train_samples, batch_size = n):
    for i in range(0, n):
        ax = fig.add_subplot(1, n, i+1)
        ax.imshow(Image.fromarray(np.uint8(x_batch[i])))
    fig.suptitle('augmented images (rotate 90 degrees)')
    plt.show()
    break;
```




In [68]:
```
# step 7.2 model training using augmented dataset
```

In [168]:
```
from keras.preprocessing.image import ImageDataGenerator

datagen = ImageDataGenerator(
                             rotation_range = 90,
                             width_shift_range = 0.1,
                             horizontal_flip = True,
                             vertical_flip = True
                              )
```

In [169]:
```
datagen.fit(X_train)
```

In [172]:
```
cnn_model.fit_generator(datagen.flow(X_train, y_train, batch_size = 32), ep
ochs = 2, steps_per_epoch = 10000)
```

```
Epoch 1/2
10000/10000 [==============================] - 1029s 103ms/step - loss: 1.53
34 - acc: 0.4553
Epoch 2/2
10000/10000 [==============================] - 1013s 101ms/step - loss: 1.46
35 - acc: 0.4869
```

Out[172]:
```
<keras.callbacks.History at 0x7fc3dae42940>
```

In [176]:
```
score = cnn_model.evaluate(X_test, y_test)
print('Test accuracy', score[10])
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-176-0540f0fd44ad> in <module>
----> 1 score = cnn_model.evaluate(X_test, y_test)
      2 print('Test accuracy', score[10])

/usr/local/lib/python3.5/dist-packages/keras/engine/training.py in evaluate(
self, x, y, batch_size, verbose, sample_weight, steps)
   1100             x, y,
   1101             sample_weight=sample_weight,
-> 1102             batch_size=batch_size)
   1103         # Prepare inputs, delegate logic to `test_loop`.
   1104         if self._uses_dynamic_learning_phase():

/usr/local/lib/python3.5/dist-packages/keras/engine/training.py in _standard
ize_user_data(self, x, y, sample_weight, class_weight, check_array_lengths,
batch_size)
    787                 feed_output_shapes,
    788                 check_batch_axis=False,  # Don't enforce the batch s
ize.
--> 789                 exception_prefix='target')
    790
    791             # Generate sample-wise weight values given the `sample_w
eight` and

/usr/local/lib/python3.5/dist-packages/keras/engine/training_utils.py in sta
ndardize_input_data(data, names, shapes, check_batch_axis, exception_prefix)
    136                             ': expected ' + names[i] + ' to have sha
pe ' +
    137                             str(shape) + ' but got array with shape
' +
--> 138                             str(data_shape))
    139     return data
    140

ValueError: Error when checking target: expected dense_9 to have shape (10,)
but got array with shape (1,)
```

In [174]:
```
# save the model
directory = os.path.join(os.getcwd(), 'saved_models')

if not os.path.isdir(directory):
    os.makedirs(directory)
model_path = os.path.join(directory, 'keras_cifar10_trained_model_Augmentat
ion.h5')
cnn_model.save(model_path)
```

In [ ]: