

## **NEURAL NETWORK AND DEEP LEARNING ASSIGNMENT-8**

GITHUB LINK: <https://github.com/aknomula/DL-NN-Assign8.git>

RECORDINGLINK: [https://drive.google.com/file/d/1H9IJZ4pFkRM-egdsMz64kgfiMj40cPQ/view?usp=share link](https://drive.google.com/file/d/1H9IJZ4pFkRM-egdsMz64kgfiMj40cPQ/view?usp=share_link)

### **In class programming:**

1. Add one more hidden layer to autoencoder
2. Do the prediction on the test data and then visualize one of the reconstructed version of that test data.

Also, visualize the same test data before reconstruction using Matplotlib

3. Repeat the question 2 on the denoising autoencoder
4. plot loss and accuracy using the history object

```
import keras
from keras.models import Sequential
from keras.preprocessing import image
from keras.layers import Activation,Dense,Dropout,Conv2D,Flatten,MaxPooling2D,BatchNormalization
from keras.datasets import cifar10
from keras import optimizers
from matplotlib import pyplot as plt

#generate cifar10 data
(x_train,y_train),(x_test,y_test) = cifar10.load_data()

Downloading data from https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz
170498071/170498071 [=====] - 3s 0us/step

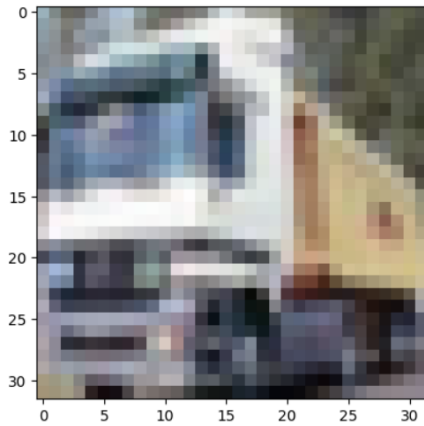
#config parameters
num_classes = 10
input_shape = x_train.shape[1:4]
optimizer = optimizers.Adam(lr=0.001)

WARNING:absl:`lr` is deprecated in Keras optimizer, please use `learning_rate` or use the legacy optimizer, e.g.,tf.keras.optimizers.legacy.Adam.

#convert label to one-hot
one_hot_y_train = keras.utils.to_categorical(y_train,num_classes=num_classes)
one_hot_y_test = keras.utils.to_categorical(y_test,num_classes=num_classes)
```

```
# check data
plt.imshow(x_train[1])
print(x_train[1].shape)
```

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



```
# build model(similar to VGG16, only change the input and output shape)
model = Sequential()
model.add(Conv2D(64,(3,3),activation='relu',input_shape=input_shape,padding='same'))
model.add(BatchNormalization())
model.add(Conv2D(64,(3,3),activation='relu',padding='same'))
model.add(BatchNormalization())
model.add(MaxPooling2D(pool_size=(2,2),strides=(2,2)))
model.add(Dropout(0.25))

model.add(Conv2D(128,(3,3),activation='relu',padding='same'))
model.add(BatchNormalization())
model.add(Conv2D(128,(3,3),activation='relu',padding='same'))
model.add(BatchNormalization())
model.add(MaxPooling2D(pool_size=(2,2),strides=(2,2)))
model.add(Dropout(0.25))

model.add(Conv2D(256,(3,3),activation='relu',padding='same'))
model.add(BatchNormalization())
model.add(Conv2D(256,(3,3),activation='relu',padding='same'))
model.add(BatchNormalization())
model.add(Conv2D(256,(3,3),activation='relu',padding='same'))
model.add(BatchNormalization())
model.add(MaxPooling2D(pool_size=(2,2),strides=(2,2)))
model.add(Dropout(0.25))

model.add(Conv2D(512,(3,3),activation='relu',padding='same'))
model.add(BatchNormalization())
model.add(Conv2D(512,(3,3),activation='relu',padding='same'))
model.add(BatchNormalization())
model.add(Conv2D(512,(3,3),activation='relu',padding='same'))
model.add(BatchNormalization())
model.add(MaxPooling2D(pool_size=(2,2),strides=(2,2)))
model.add(Dropout(0.25))
```

```
model.add(Conv2D(512,(3,3),activation='relu',padding='same'))
model.add(BatchNormalization())
model.add(Conv2D(512,(3,3),activation='relu',padding='same'))
model.add(BatchNormalization())
model.add(Conv2D(512,(3,3),activation='relu',padding='same'))
model.add(BatchNormalization())
model.add(MaxPooling2D(pool_size=(2,2),strides=(2,2)))
model.add(Dropout(0.25))

model.add(Flatten())
model.add(Dense(4096,activation='relu'))
model.add(Dense(2048,activation='relu'))
model.add(Dense(1024,activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(num_classes))
model.add(Activation('softmax'))
```

```
] model.compile(optimizer=optimizer, loss='categorical_crossentropy', metrics=['accuracy'])
```



model.summary()



|  |                   |         |
|--|-------------------|---------|
| batch_normalization_7 (Batch Normalization)  | (None, 4, 4, 512) | 2048    |
| conv2d_8 (Conv2D)                            | (None, 4, 4, 512) | 2359808 |
| batch_normalization_8 (Batch Normalization)  | (None, 4, 4, 512) | 2048    |
| conv2d_9 (Conv2D)                            | (None, 4, 4, 512) | 2359808 |
| batch_normalization_9 (Batch Normalization)  | (None, 4, 4, 512) | 2048    |
| max_pooling2d_3 (MaxPooling2D)               | (None, 2, 2, 512) | 0       |
| dropout_3 (Dropout)                          | (None, 2, 2, 512) | 0       |
| conv2d_10 (Conv2D)                           | (None, 2, 2, 512) | 2359808 |
| batch_normalization_10 (Batch Normalization) | (None, 2, 2, 512) | 2048    |
| conv2d_11 (Conv2D)                           | (None, 2, 2, 512) | 2359808 |
| batch_normalization_11 (Batch Normalization) | (None, 2, 2, 512) | 2048    |
| conv2d_12 (Conv2D)                           | (None, 2, 2, 512) | 2359808 |
| batch_normalization_12 (Batch Normalization) | (None, 2, 2, 512) | 2048    |
| max_pooling2d_4 (MaxPooling2D)               | (None, 1, 1, 512) | 0       |
| dropout_4 (Dropout)                          | (None, 1, 1, 512) | 0       |
| flatten (Flatten)                            | (None, 512)       | 0       |

|                         |              |         |
|-------------------------|--------------|---------|
| dense (Dense)           | (None, 4096) | 2101248 |
| dense_1 (Dense)         | (None, 2048) | 8390656 |
| dense_2 (Dense)         | (None, 1024) | 2098176 |
| dropout_5 (Dropout)     | (None, 1024) | 0       |
| dense_3 (Dense)         | (None, 10)   | 10250   |
| activation (Activation) | (None, 10)   | 0       |

=====  
Total params: 27331914 (104.26 MB)

```
] history = model.fit(x=x_train, y=one_hot_y_train, batch_size=128, epochs=30, validation_split=0.1)
```

```
Epoch 2/30
352/352 [=====] - 27s 76ms/step - loss: 1.3414 - accuracy: 0.5145 - val_loss: 1.4610 - val_accuracy: 0.5336
Epoch 3/30
352/352 [=====] - 26s 75ms/step - loss: 1.0524 - accuracy: 0.6334 - val_loss: 1.1668 - val_accuracy: 0.6460
Epoch 4/30
352/352 [=====] - 27s 76ms/step - loss: 0.8878 - accuracy: 0.7010 - val_loss: 0.8616 - val_accuracy: 0.7158
Epoch 5/30
352/352 [=====] - 27s 78ms/step - loss: 0.7490 - accuracy: 0.7521 - val_loss: 0.7373 - val_accuracy: 0.7614
Epoch 6/30
352/352 [=====] - 27s 77ms/step - loss: 0.6575 - accuracy: 0.7859 - val_loss: 0.6574 - val_accuracy: 0.7858
Epoch 7/30
352/352 [=====] - 27s 78ms/step - loss: 0.5850 - accuracy: 0.8106 - val_loss: 0.7119 - val_accuracy: 0.7792
Epoch 8/30
352/352 [=====] - 27s 78ms/step - loss: 0.5202 - accuracy: 0.8329 - val_loss: 0.7351 - val_accuracy: 0.7812
Epoch 9/30
352/352 [=====] - 27s 76ms/step - loss: 0.4735 - accuracy: 0.8485 - val_loss: 0.5936 - val_accuracy: 0.8160
Epoch 10/30
352/352 [=====] - 28s 78ms/step - loss: 0.4209 - accuracy: 0.8649 - val_loss: 0.7012 - val_accuracy: 0.7878
Epoch 11/30
352/352 [=====] - 27s 76ms/step - loss: 0.3825 - accuracy: 0.8796 - val_loss: 0.5823 - val_accuracy: 0.8282
Epoch 12/30
352/352 [=====] - 27s 78ms/step - loss: 0.3312 - accuracy: 0.8956 - val_loss: 0.5935 - val_accuracy: 0.8372
```

```

Epoch 13/30
352/352 [=====] - 27s 76ms/step - loss: 0.2984 - accuracy: 0.9043 - val_loss: 0.5957 - val_accuracy: 0.8354
Epoch 14/30
352/352 [=====] - 27s 76ms/step - loss: 0.2744 - accuracy: 0.9130 - val_loss: 0.6478 - val_accuracy: 0.8296
Epoch 15/30
352/352 [=====] - 27s 76ms/step - loss: 0.2645 - accuracy: 0.9168 - val_loss: 0.5952 - val_accuracy: 0.8354
Epoch 16/30
352/352 [=====] - 28s 78ms/step - loss: 0.2290 - accuracy: 0.9286 - val_loss: 0.5574 - val_accuracy: 0.8468
Epoch 17/30
352/352 [=====] - 27s 78ms/step - loss: 0.1991 - accuracy: 0.9374 - val_loss: 0.6206 - val_accuracy: 0.8480
Epoch 18/30
352/352 [=====] - 27s 76ms/step - loss: 0.1837 - accuracy: 0.9432 - val_loss: 0.7272 - val_accuracy: 0.8214
Epoch 19/30
352/352 [=====] - 27s 78ms/step - loss: 0.1732 - accuracy: 0.9458 - val_loss: 0.7186 - val_accuracy: 0.8332
Epoch 20/30
352/352 [=====] - 27s 78ms/step - loss: 0.1652 - accuracy: 0.9492 - val_loss: 0.8003 - val_accuracy: 0.8114
Epoch 21/30
352/352 [=====] - 27s 78ms/step - loss: 0.2157 - accuracy: 0.9349 - val_loss: 0.5938 - val_accuracy: 0.8514
Epoch 22/30
352/352 [=====] - 27s 76ms/step - loss: 0.2040 - accuracy: 0.9387 - val_loss: 0.6173 - val_accuracy: 0.8342
Epoch 23/30
352/352 [=====] - 27s 78ms/step - loss: 0.1447 - accuracy: 0.9558 - val_loss: 0.6253 - val_accuracy: 0.8552
Epoch 24/30
352/352 [=====] - 27s 76ms/step - loss: 0.1185 - accuracy: 0.9638 - val_loss: 0.6210 - val_accuracy: 0.8526
Epoch 25/30
352/352 [=====] - 27s 76ms/step - loss: 0.1094 - accuracy: 0.9677 - val_loss: 0.7091 - val_accuracy: 0.8418
Epoch 26/30
352/352 [=====] - 27s 77ms/step - loss: 0.0985 - accuracy: 0.9698 - val_loss: 0.7450 - val_accuracy: 0.8446
Epoch 27/30
352/352 [=====] - 27s 78ms/step - loss: 0.0897 - accuracy: 0.9716 - val_loss: 0.6288 - val_accuracy: 0.8560
Epoch 28/30
352/352 [=====] - 27s 78ms/step - loss: 0.0896 - accuracy: 0.9727 - val_loss: 0.7102 - val_accuracy: 0.8572
Epoch 29/30
352/352 [=====] - 27s 78ms/step - loss: 0.0917 - accuracy: 0.9723 - val_loss: 0.7767 - val_accuracy: 0.8402
Epoch 30/30
352/352 [=====] - 28s 78ms/step - loss: 0.0896 - accuracy: 0.9734 - val_loss: 0.7157 - val_accuracy: 0.8558

```

```

[ ] # evaluate
    print(model.metrics_names)
    model.evaluate(x=x_test,y=one_hot_y_test,batch_size=512)

[ ] ['loss', 'accuracy']
20/20 [=====] - 5s 123ms/step - loss: 0.7212 - accuracy: 0.8502
[0.7211834192276001, 0.8501999974250793]

```

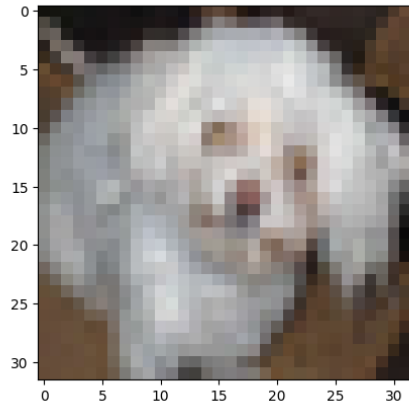
```

[ ] model.save("keras-VGG16-cifar10.h5")
    plt.imshow(x_test[1000])

    result = model.predict(x_test[1000:1001]).tolist()
    predict = 0
    expect = y_test[1000][0]
    for i,_ in enumerate(result[0]):
        if result[0][i] > result[0][predict]:
            predict = i
    print("predict class:",predict)
    print("expected class:",expect)

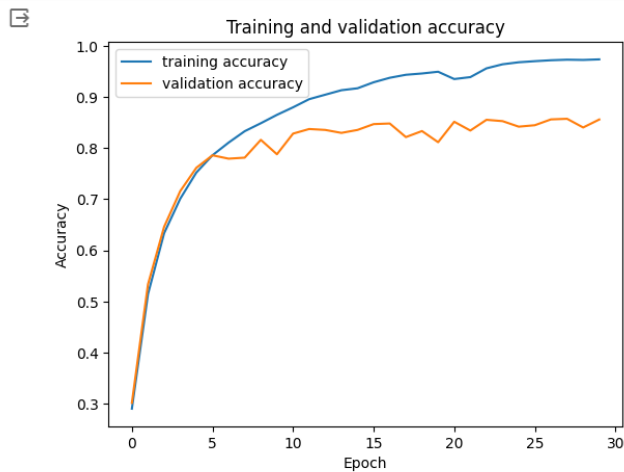
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/engine/training.py:3000: UserWarning: You are saving your model as an HDF5 file via `model.save()`. This
saving_api.save_model(
1/1 [=====] - 1s 784ms/step
predict class: 5
expected class: 5
```

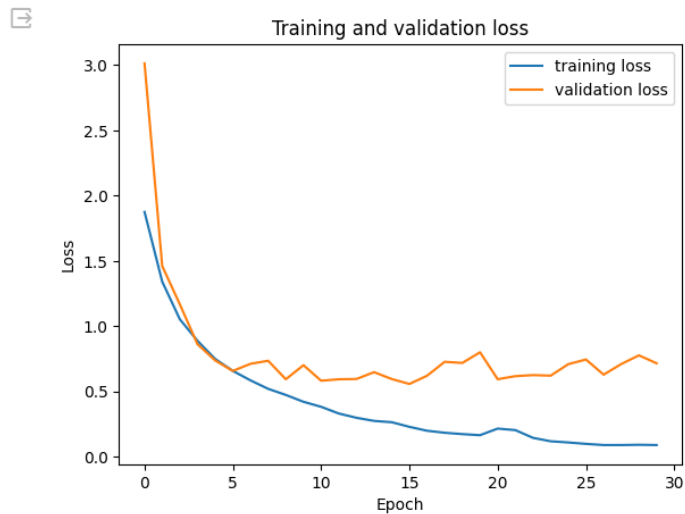


```
[ ] # save model
model.save("keras-VGG16-cifar10.h5")
```

```
#plot the training and validation accuracy
plt.plot(history.history['accuracy'], label='training accuracy')
plt.plot(history.history['val_accuracy'], label='validation accuracy')
plt.title('Training and validation accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```



```
#plot the training and validation loss
plt.plot(history.history['loss'], label='training loss')
plt.plot(history.history['val_loss'], label='validation loss')
plt.title('Training and validation loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.show()
```



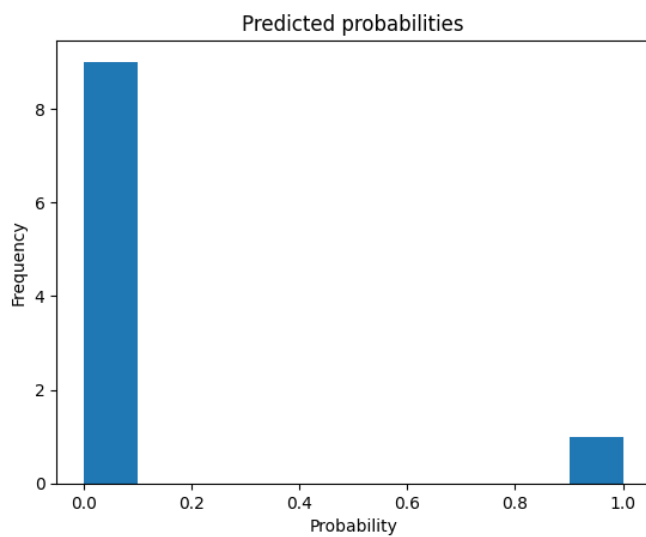
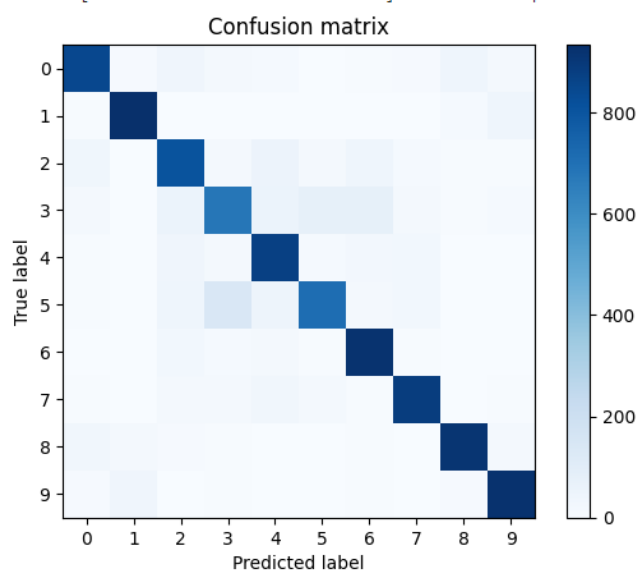
```
import numpy as np
from sklearn.metrics import confusion_matrix

# calculate the confusion matrix
y_pred = model.predict(x_test)
y_pred_classes = np.argmax(y_pred, axis=1)
y_true = y_test.ravel()
cm = confusion_matrix(y_true, y_pred_classes)

# plot the confusion matrix
plt.imshow(cm, interpolation='nearest', cmap=plt.cm.Blues)
plt.title('Confusion matrix')
plt.colorbar()
tick_marks = np.arange(num_classes)
plt.xticks(tick_marks, range(num_classes))
plt.yticks(tick_marks, range(num_classes))
plt.xlabel('Predicted label')
plt.ylabel('True label')
plt.show()

# plot a histogram of the predicted probabilities for a sample image
plt.hist(y_pred[1000])
plt.title('Predicted probabilities')
plt.xlabel('Probability')
plt.ylabel('Frequency')
plt.show()
```

313/313 [-----] - 4s 11ms/step



```
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import tensorflow as tf
from tensorflow.keras.datasets import mnist

from tensorflow.keras.optimizers import RMSprop
from keras.preprocessing import image
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.layers import Dense, Flatten, Conv2D, MaxPooling2D, Dropout, BatchNormalization
from keras.datasets import cifar10

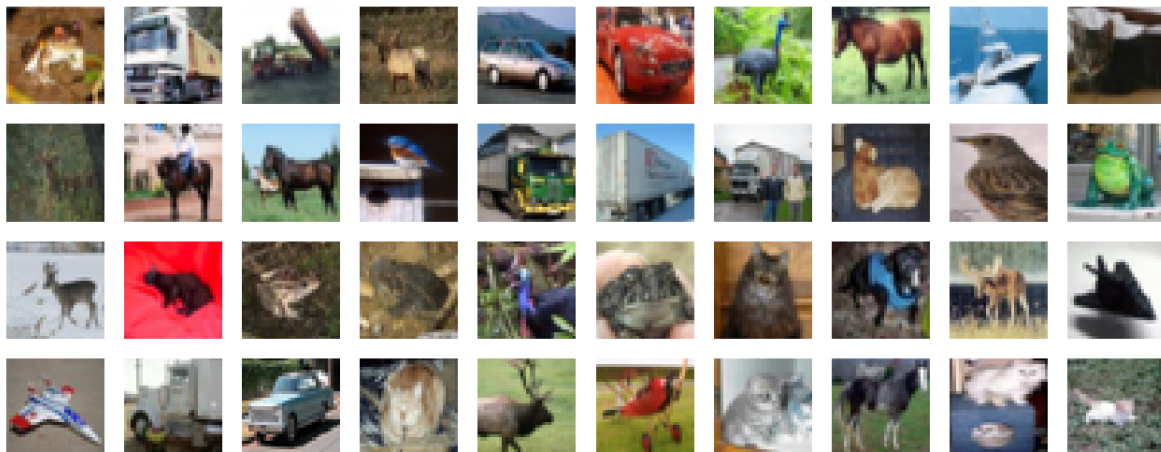
%matplotlib inline
```

```
#cifar100 = tf.keras.datasets.cifar100
(X_train,Y_train) , (X_test,Y_test) = cifar10.load_data()

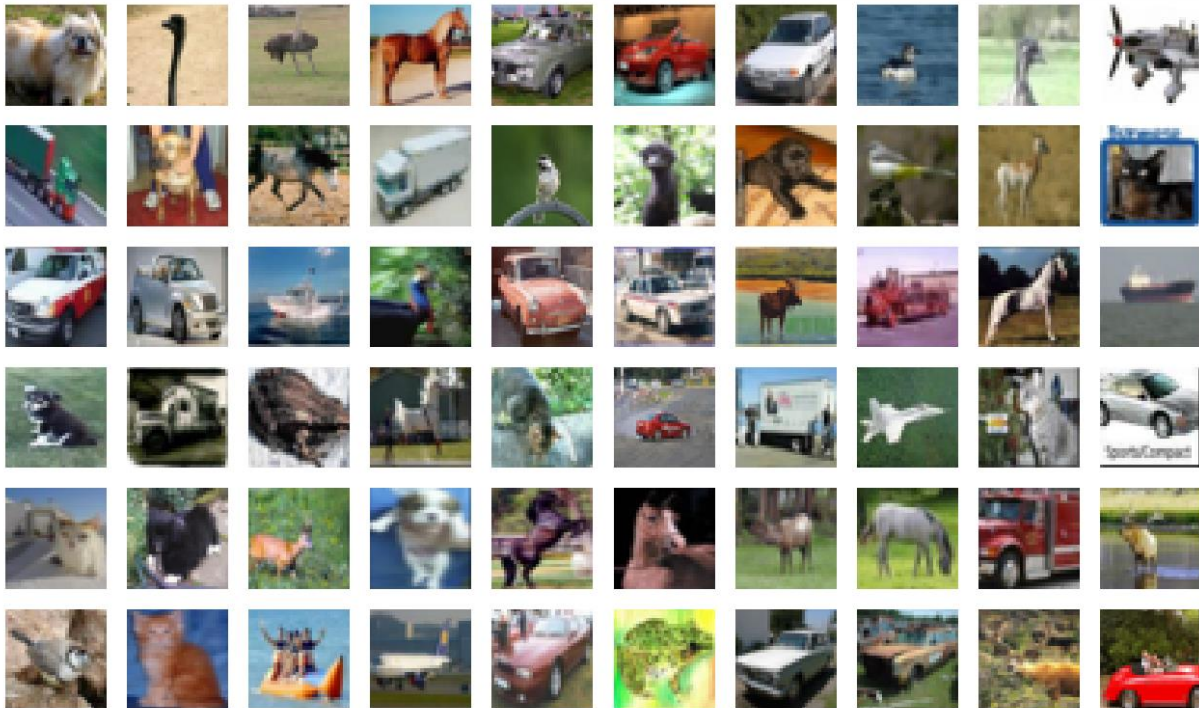
Downloading data from https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz
170498071/170498071 [=====] - 2s 0us/step
```

```
classes = ['airplane', 'automobile', 'bird', 'cat', 'deer', 'dog', 'frog', 'horse', 'ship', 'truck']
```

```
plt.figure(figsize = (16,16))
for i in range(100):
    plt.subplot(10,10,1+i)
    plt.axis('off')
    plt.imshow(X_train[i], cmap = 'gray')
```







```
[7] from sklearn.model_selection import train_test_split
x_train, x_val, y_train, y_val = train_test_split(X_train, Y_train, test_size=0.2)
```

```
[8] from tensorflow.keras.utils import to_categorical
y_train = to_categorical(y_train, num_classes = 10)
y_val = to_categorical(y_val, num_classes = 10)
```

```
[9] print(x_train.shape)
print(y_train.shape)
print(x_val.shape)
print(y_val.shape)
print(X_test.shape)
print(Y_test.shape)
```

```
(40000, 32, 32, 3)
(40000, 10)
(10000, 32, 32, 3)
(10000, 10)
(10000, 32, 32, 3)
(10000, 1)
```

```
[10] train_datagen = ImageDataGenerator(
    preprocessing_function = tf.keras.applications.vgg19.preprocess_input,
    rotation_range=10,
    zoom_range = 0.1,
    width_shift_range = 0.1,
    height_shift_range = 0.1,
    shear_range = 0.1,
    horizontal_flip = True
)
train_datagen.fit(x_train)

val_datagen = ImageDataGenerator(preprocessing_function = tf.keras.applications.vgg19.preprocess_input)
val_datagen.fit(x_val)
```

```
[11] from keras.callbacks import ReduceLROnPlateau
      learning_rate_reduction = ReduceLROnPlateau(monitor='val_accuracy',
                                                    patience=3,
                                                    verbose=1,
                                                    factor=0.5,
                                                    min_lr=0.00001)
```

```
[12] vgg_model = tf.keras.applications.VGG19(
      include_top=False,
      weights=None,
      input_shape=(32,32,3),
  )

      vgg_model.summary()
```

Model: "vgg19"

| Layer (type)               | Output Shape        | Param # |
|----------------------------|---------------------|---------|
| input_1 (InputLayer)       | [None, 32, 32, 3]   | 0       |
| block1_conv1 (Conv2D)      | (None, 32, 32, 64)  | 1792    |
| block1_conv2 (Conv2D)      | (None, 32, 32, 64)  | 36928   |
| block1_pool (MaxPooling2D) | (None, 16, 16, 64)  | 0       |
| block2_conv1 (Conv2D)      | (None, 16, 16, 128) | 73856   |
| block2_conv2 (Conv2D)      | (None, 16, 16, 128) | 147584  |
| block2_pool (MaxPooling2D) | (None, 8, 8, 128)   | 0       |
| block3_conv1 (Conv2D)      | (None, 8, 8, 256)   | 295168  |
| block3_conv2 (Conv2D)      | (None, 8, 8, 256)   | 590080  |
| block3_conv3 (Conv2D)      | (None, 8, 8, 256)   | 590080  |
| block3_conv4 (Conv2D)      | (None, 8, 8, 256)   | 590080  |
| block3_pool (MaxPooling2D) | (None, 4, 4, 256)   | 0       |
| block4_conv1 (Conv2D)      | (None, 4, 4, 512)   | 1180160 |
| block4_conv2 (Conv2D)      | (None, 4, 4, 512)   | 2359808 |
| block4_conv3 (Conv2D)      | (None, 4, 4, 512)   | 2359808 |
| block4_conv4 (Conv2D)      | (None, 4, 4, 512)   | 2359808 |
| block4_pool (MaxPooling2D) | (None, 2, 2, 512)   | 0       |
| block5_conv1 (Conv2D)      | (None, 2, 2, 512)   | 2359808 |
| block5_conv2 (Conv2D)      | (None, 2, 2, 512)   | 2359808 |
| block5_conv3 (Conv2D)      | (None, 2, 2, 512)   | 2359808 |

```

block5_conv4 (Conv2D)      (None, 2, 2, 512)      2359808
block5_pool (MaxPooling2D) (None, 1, 1, 512)      0

```

```

=====
Total params: 20024384 (76.39 MB)
Trainable params: 20024384 (76.39 MB)
Non-trainable params: 0 (0.00 Byte)
=====

```

```

1] model = tf.keras.Sequential()
model.add(vgg_model)
model.add(Flatten())
model.add(Dense(1024, activation = 'relu'))
model.add(BatchNormalization())
model.add(Dense(1024, activation = 'relu'))
model.add(BatchNormalization())
model.add(Dense(256, activation = 'relu'))
model.add(BatchNormalization())
model.add(Dropout(0.5))
model.add(Dense(10, activation = 'softmax'))

model.summary()

```

```

Model: "sequential"

```

| Layer (type)                                | Output Shape      | Param #  |
|---|-------------------|----------|
| vgg19 (Functional)                          | (None, 1, 1, 512) | 20024384 |
| flatten (Flatten)                           | (None, 512)       | 0        |
| dense (Dense)                               | (None, 1024)      | 525312   |
| batch_normalization (Batch Normalization)   | (None, 1024)      | 4096     |
| dense_1 (Dense)                             | (None, 1024)      | 1049600  |
| batch_normalization_1 (Batch Normalization) | (None, 1024)      | 4096     |
| dense_2 (Dense)                             | (None, 256)       | 262400   |
| batch_normalization_2 (Batch Normalization) | (None, 256)       | 1024     |
| dropout (Dropout)                           | (None, 256)       | 0        |
| dense_3 (Dense)                             | (None, 10)        | 2570     |

```

=====
Total params: 21873482 (83.44 MB)

```

```

=====
Total params: 21873482 (83.44 MB)
Trainable params: 21868874 (83.42 MB)
Non-trainable params: 4608 (18.00 KB)
=====

```

```

14] optimizer = tf.keras.optimizers.SGD(learning_rate = 0.001, momentum = 0.9)
model.compile(optimizer= optimizer,
              loss='categorical_crossentropy',
              metrics=['accuracy'])

```

