1. Please visit this link to access the state-of-art DenseNet code for reference - DenseNet - cifar10 notebook link
2. You need to create a copy of this and "retrain" this model to achieve 90+ test accuracy.
3. You cannot use Dense Layers (also called fully connected layers), or DropOut.
4. You MUST use Image Augmentation Techniques.
5. You cannot use an already trained model as a beginning points, you have to initilize as your own
6. You cannot run the program for more than 300 Epochs, and it should be clear from your log, that you have only used 300 Epochs
7. You cannot use test images for training the model.
8. You cannot change the general architecture of DenseNet (which means you must use Dense Block, Transition and Output blocks as mentioned in the code)
9. You are free to change Convolution types (e.g. from 3x3 normal convolution to Depthwise Separable, etc)
10. You cannot have more than 1 Million parameters in total
11. You are free to move the code from Keras to Tensorflow, Pytorch, MXNET etc.
12. You can use any optimization algorithm you need.
13. You can checkpoint your model and retrain the model from that checkpoint so that no need of training the model from first if you lost at any epoch while training. You can directly load that model and Train from that epoch.

In [2]:

```
%%time
import keras
import math
import numpy as np
from keras.datasets import cifar10
from keras.preprocessing.image import ImageDataGenerator
from keras.layers.normalization import BatchNormalization
from keras.layers import SeparableConv2D,Conv2D, Dense, Input, add, Activation, AveragePooling2D, G
lobalAveragePooling2D, Lambda, concatenate
from keras.initializers import he_normal
from keras.layers.merge import Concatenate
from keras.callbacks import LearningRateScheduler, TensorBoard, ModelCheckpoint
from keras.models import Model
from keras.optimizers import *
from keras.regularizers import *
from keras.utils import to_categorical
```

```
Using TensorFlow backend.
```

```
Wall time: 7.3 s
```

In [17]:

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

In [3]:

```
%%time
X_train = np.load('data.npz')['a']
X_test = np.load('data.npz')['b']
y_train = np.load('data.npz')['c']
y_test = np.load('data.npz')['d']
```

```
Wall time: 1.52 s
```

In [4]:

```
%%time
X_train = X_train.astype('float32')/255
X_test = X_test.astype('float32')/255
y_train = to_categorical(y_train,10)
y_test = to_categorical(y_test,10)
```

```
Wall time: 932 ms
```

In [5]:

In [5]:

```
def learning_scheduler(epoch):
    if epoch < 150:
        return 0.1
    if epoch < 225:
        return 0.01
    return 0.001
```

In [6]:

```
%%time
def conv(x, out_filters, k_size):
    return(SeparableConv2D(filters=out_filters,kernel_size=k_size,strides=(1,1), padding='same',ker
nel_initializer='he_normal',
                  kernel_regularizer=l2(weight_decay),use_bias=False)(x))

def dense_layer(x):
    return(Dense(units=classes_num,
                 activation='softmax',
                  kernel_initializer='he_normal',
                  kernel_regularizer=l2(weight_decay))(x))

def bn_relu(x):
    x = BatchNormalization(momentum=0.9, epsilon=1e-5)(x)
    x = Activation('relu')(x)
    return(x)

def bottleneck_layer(x):
    channels = growth_rate * 4
    x = bn_relu(x)
    x = conv(x, channels, (1,1))
    x = bn_relu(x)
    x = conv(x, growth_rate, (3,3))
    return(x)

def single(x):
    x = bn_relu(x)
    x = conv(x, growth_rate, (3,3))
    return(x)

def transition(x, inchannels):
    outchannels = int(inchannels * compression)
    x = bn_relu(x)
    x = conv(x, outchannels, (1,1))
    x = AveragePooling2D((2,2), strides=(2, 2))(x)
    return(x, outchannels)

def dense_block(x,blocks,nchannels):
    concat = x
    for i in range(blocks):
        x = bottleneck_layer(concat)
        concat = concatenate([x,concat], axis=-1)
        nchannels += growth_rate
    return(concat, nchannels)
def densenet(img_input,classes_num,depth,growth_rate,compression):
    #nblocks = (depth - 4) // 6
    nchannels = growth_rate * 2
    x = conv(img_input, nchannels, (3,3))
    x, nchannels = dense_block(x,nblocks,nchannels)
    x, nchannels = transition(x,nchannels)
    x, nchannels = dense_block(x,nblocks,nchannels)
    x, nchannels = transition(x,nchannels)
    x, nchannels = dense_block(x,nblocks,nchannels)
    x = bn_relu(x)
    x = GlobalAveragePooling2D()(x)
    x = dense_layer(x)
    return(Model(img_input,x))
```

```
Wall time: 0 ns
```

In [7]:

```
growth_rate= 12
depth = 64
```

```
compression = 0.5
batch_size = 64
nb_epochs = 300
iterations = 200
classes_num = 10
weight_decay = 1e-4
```

In [8]:

```
model = densenet(Input(shape=X_train.shape[1:]),10,depth,growth_rate,compression)
model.summary()
```

```
WARNING: Logging before flag parsing goes to stderr.
W0926 23:00:11.588988 16052 deprecation_wrapper.py:119] From C:\Users\patha\Anaconda3\lib\site-pac
kages\keras\backend\tensorflow_backend.py:4074: The name tf.nn.avg_pool is deprecated. Please use
tf.nn.avg_pool2d instead.
```

Model: "model_1"

Layer (type)	Output Shape	Param #	Connected to
input_1 (InputLayer)	(None, 32, 32, 3)	0	
separable_conv2d_1 (SeparableCo	(None, 32, 32, 24)	99	input_1[0][0]
batch_normalization_1 (BatchNor	(None, 32, 32, 24)	96	separable_conv2d_1[0][0]
activation_1 (Activation)	(None, 32, 32, 24)	0	batch_normalization_1[0][0]
separable_conv2d_2 (SeparableCo	(None, 32, 32, 48)	1176	activation_1[0][0]
batch_normalization_2 (BatchNor	(None, 32, 32, 48)	192	separable_conv2d_2[0][0]
activation_2 (Activation)	(None, 32, 32, 48)	0	batch_normalization_2[0][0]
separable_conv2d_3 (SeparableCo	(None, 32, 32, 12)	1008	activation_2[0][0]
concatenate_1 (Concatenate)	(None, 32, 32, 36)	0	separable_conv2d_3[0][0] separable_conv2d_1[0][0]
batch_normalization_3 (BatchNor	(None, 32, 32, 36)	144	concatenate_1[0][0]
activation_3 (Activation)	(None, 32, 32, 36)	0	batch_normalization_3[0][0]
separable_conv2d_4 (SeparableCo	(None, 32, 32, 48)	1764	activation_3[0][0]
batch_normalization_4 (BatchNor	(None, 32, 32, 48)	192	separable_conv2d_4[0][0]
activation_4 (Activation)	(None, 32, 32, 48)	0	batch_normalization_4[0][0]
separable_conv2d_5 (SeparableCo	(None, 32, 32, 12)	1008	activation_4[0][0]
concatenate_2 (Concatenate)	(None, 32, 32, 48)	0	separable_conv2d_5[0][0] concatenate_1[0][0]
batch_normalization_5 (BatchNor	(None, 32, 32, 48)	192	concatenate_2[0][0]
activation_5 (Activation)	(None, 32, 32, 48)	0	batch_normalization_5[0][0]
separable_conv2d_6 (SeparableCo	(None, 32, 32, 48)	2352	activation_5[0][0]
batch_normalization_6 (BatchNor	(None, 32, 32, 48)	192	separable_conv2d_6[0][0]
activation_6 (Activation)	(None, 32, 32, 48)	0	batch_normalization_6[0][0]
separable_conv2d_7 (SeparableCo	(None, 32, 32, 12)	1008	activation_6[0][0]
concatenate_3 (Concatenate)	(None, 32, 32, 60)	0	separable_conv2d_7[0][0] concatenate_2[0][0]
batch_normalization_7 (BatchNor	(None, 32, 32, 60)	240	concatenate_3[0][0]
activation_7 (Activation)	(None, 32, 32, 60)	0	batch_normalization_7[0][0]

separable_conv2d_8 (SeparableCo	(None, 32, 32, 48)	2940	activation_7[0][0]	
batch_normalization_8 (BatchNor	(None, 32, 32, 48)	192	separable_conv2d_8[0][0]	
activation_8 (Activation)	(None, 32, 32, 48)	0	batch_normalization_8[0][0]	
separable_conv2d_9 (SeparableCo	(None, 32, 32, 12)	1008	activation_8[0][0]	
concatenate_4 (Concatenate)	(None, 32, 32, 72)	0	separable_conv2d_9[0][0] concatenate_3[0][0]	
batch_normalization_9 (BatchNor	(None, 32, 32, 72)	288	concatenate_4[0][0]	
activation_9 (Activation)	(None, 32, 32, 72)	0	batch_normalization_9[0][0]	
separable_conv2d_10 (SeparableC	(None, 32, 32, 48)	3528	activation_9[0][0]	
batch_normalization_10 (BatchNo	(None, 32, 32, 48)	192	separable_conv2d_10[0][0]	
activation_10 (Activation)	(None, 32, 32, 48)	0	batch_normalization_10[0][0]	
separable_conv2d_11 (SeparableC	(None, 32, 32, 12)	1008	activation_10[0][0]	
concatenate_5 (Concatenate)	(None, 32, 32, 84)	0	separable_conv2d_11[0][0] concatenate_4[0][0]	
batch_normalization_11 (BatchNo	(None, 32, 32, 84)	336	concatenate_5[0][0]	
activation_11 (Activation)	(None, 32, 32, 84)	0	batch_normalization_11[0][0]	
separable_conv2d_12 (SeparableC	(None, 32, 32, 48)	4116	activation_11[0][0]	
batch_normalization_12 (BatchNo	(None, 32, 32, 48)	192	separable_conv2d_12[0][0]	
activation_12 (Activation)	(None, 32, 32, 48)	0	batch_normalization_12[0][0]	
separable_conv2d_13 (SeparableC	(None, 32, 32, 12)	1008	activation_12[0][0]	
concatenate_6 (Concatenate)	(None, 32, 32, 96)	0	separable_conv2d_13[0][0] concatenate_5[0][0]	
batch_normalization_13 (BatchNo	(None, 32, 32, 96)	384	concatenate_6[0][0]	
activation_13 (Activation)	(None, 32, 32, 96)	0	batch_normalization_13[0][0]	
separable_conv2d_14 (SeparableC	(None, 32, 32, 48)	4704	activation_13[0][0]	
batch_normalization_14 (BatchNo	(None, 32, 32, 48)	192	separable_conv2d_14[0][0]	
activation_14 (Activation)	(None, 32, 32, 48)	0	batch_normalization_14[0][0]	
separable_conv2d_15 (SeparableC	(None, 32, 32, 12)	1008	activation_14[0][0]	
concatenate_7 (Concatenate)	(None, 32, 32, 108)	0	separable_conv2d_15[0][0] concatenate_6[0][0]	
batch_normalization_15 (BatchNo	(None, 32, 32, 108)	432	concatenate_7[0][0]	
activation_15 (Activation)	(None, 32, 32, 108)	0	batch_normalization_15[0][0]	
separable_conv2d_16 (SeparableC	(None, 32, 32, 48)	5292	activation_15[0][0]	
batch_normalization_16 (BatchNo	(None, 32, 32, 48)	192	separable_conv2d_16[0][0]	
activation_16 (Activation)	(None, 32, 32, 48)	0	batch_normalization_16[0][0]	
separable_conv2d_17 (SeparableC	(None, 32, 32, 12)	1008	activation_16[0][0]	
concatenate_8 (Concatenate)	(None, 32, 32, 120)	0	separable_conv2d_17[0][0] concatenate_7[0][0]	
batch_normalization_17 (BatchNo	(None, 32, 32, 120)	480	concatenate_8[0][0]	
activation_17 (Activation)	(None, 32, 32, 120)	0	batch_normalization_17[0][0]	
separable_conv2d_18 (SeparableC	(None, 32, 32, 48)	5880	activation_17[0][0]	

batch_normalization_18 (BatchNo	(None, 32, 32, 48)	192	separable_conv2d_18[0][0]
activation_18 (Activation)	(None, 32, 32, 48)	0	batch_normalization_18[0][0]
separable_conv2d_19 (SeparableC	(None, 32, 32, 12)	1008	activation_18[0][0]
concatenate_9 (Concatenate)	(None, 32, 32, 132)	0	separable_conv2d_19[0][0] concatenate_8[0][0]
batch_normalization_19 (BatchNo	(None, 32, 32, 132)	528	concatenate_9[0][0]
activation_19 (Activation)	(None, 32, 32, 132)	0	batch_normalization_19[0][0]
separable_conv2d_20 (SeparableC	(None, 32, 32, 48)	6468	activation_19[0][0]
batch_normalization_20 (BatchNo	(None, 32, 32, 48)	192	separable_conv2d_20[0][0]
activation_20 (Activation)	(None, 32, 32, 48)	0	batch_normalization_20[0][0]
separable_conv2d_21 (SeparableC	(None, 32, 32, 12)	1008	activation_20[0][0]
concatenate_10 (Concatenate)	(None, 32, 32, 144)	0	separable_conv2d_21[0][0] concatenate_9[0][0]
batch_normalization_21 (BatchNo	(None, 32, 32, 144)	576	concatenate_10[0][0]
activation_21 (Activation)	(None, 32, 32, 144)	0	batch_normalization_21[0][0]
separable_conv2d_22 (SeparableC	(None, 32, 32, 72)	10512	activation_21[0][0]
average_pooling2d_1 (AveragePoo	(None, 16, 16, 72)	0	separable_conv2d_22[0][0]
batch_normalization_22 (BatchNo	(None, 16, 16, 72)	288	average_pooling2d_1[0][0]
activation_22 (Activation)	(None, 16, 16, 72)	0	batch_normalization_22[0][0]
separable_conv2d_23 (SeparableC	(None, 16, 16, 48)	3528	activation_22[0][0]
batch_normalization_23 (BatchNo	(None, 16, 16, 48)	192	separable_conv2d_23[0][0]
activation_23 (Activation)	(None, 16, 16, 48)	0	batch_normalization_23[0][0]
separable_conv2d_24 (SeparableC	(None, 16, 16, 12)	1008	activation_23[0][0]
concatenate_11 (Concatenate)	(None, 16, 16, 84)	0	separable_conv2d_24[0][0] average_pooling2d_1[0][0]
batch_normalization_24 (BatchNo	(None, 16, 16, 84)	336	concatenate_11[0][0]
activation_24 (Activation)	(None, 16, 16, 84)	0	batch_normalization_24[0][0]
separable_conv2d_25 (SeparableC	(None, 16, 16, 48)	4116	activation_24[0][0]
batch_normalization_25 (BatchNo	(None, 16, 16, 48)	192	separable_conv2d_25[0][0]
activation_25 (Activation)	(None, 16, 16, 48)	0	batch_normalization_25[0][0]
separable_conv2d_26 (SeparableC	(None, 16, 16, 12)	1008	activation_25[0][0]
concatenate_12 (Concatenate)	(None, 16, 16, 96)	0	separable_conv2d_26[0][0] concatenate_11[0][0]
batch_normalization_26 (BatchNo	(None, 16, 16, 96)	384	concatenate_12[0][0]
activation_26 (Activation)	(None, 16, 16, 96)	0	batch_normalization_26[0][0]
separable_conv2d_27 (SeparableC	(None, 16, 16, 48)	4704	activation_26[0][0]
batch_normalization_27 (BatchNo	(None, 16, 16, 48)	192	separable_conv2d_27[0][0]
activation_27 (Activation)	(None, 16, 16, 48)	0	batch_normalization_27[0][0]
separable_conv2d_28 (SeparableC	(None, 16, 16, 12)	1008	activation_27[0][0]
concatenate_13 (Concatenate)	(None, 16, 16, 108)	0	separable_conv2d_28[0][0] concatenate_12[0][0]

batch_normalization_28 (BatchNo	(None, 16, 16, 108)	432	concatenate_13[0][0]	
activation_28 (Activation)	(None, 16, 16, 108)	0	batch_normalization_28[0][0]	
separable_conv2d_29 (SeparableC	(None, 16, 16, 48)	5292	activation_28[0][0]	
batch_normalization_29 (BatchNo	(None, 16, 16, 48)	192	separable_conv2d_29[0][0]	
activation_29 (Activation)	(None, 16, 16, 48)	0	batch_normalization_29[0][0]	
separable_conv2d_30 (SeparableC	(None, 16, 16, 12)	1008	activation_29[0][0]	
concatenate_14 (Concatenate)	(None, 16, 16, 120)	0	separable_conv2d_30[0][0] concatenate_13[0][0]	
batch_normalization_30 (BatchNo	(None, 16, 16, 120)	480	concatenate_14[0][0]	
activation_30 (Activation)	(None, 16, 16, 120)	0	batch_normalization_30[0][0]	
separable_conv2d_31 (SeparableC	(None, 16, 16, 48)	5880	activation_30[0][0]	
batch_normalization_31 (BatchNo	(None, 16, 16, 48)	192	separable_conv2d_31[0][0]	
activation_31 (Activation)	(None, 16, 16, 48)	0	batch_normalization_31[0][0]	
separable_conv2d_32 (SeparableC	(None, 16, 16, 12)	1008	activation_31[0][0]	
concatenate_15 (Concatenate)	(None, 16, 16, 132)	0	separable_conv2d_32[0][0] concatenate_14[0][0]	
batch_normalization_32 (BatchNo	(None, 16, 16, 132)	528	concatenate_15[0][0]	
activation_32 (Activation)	(None, 16, 16, 132)	0	batch_normalization_32[0][0]	
separable_conv2d_33 (SeparableC	(None, 16, 16, 48)	6468	activation_32[0][0]	
batch_normalization_33 (BatchNo	(None, 16, 16, 48)	192	separable_conv2d_33[0][0]	
activation_33 (Activation)	(None, 16, 16, 48)	0	batch_normalization_33[0][0]	
separable_conv2d_34 (SeparableC	(None, 16, 16, 12)	1008	activation_33[0][0]	
concatenate_16 (Concatenate)	(None, 16, 16, 144)	0	separable_conv2d_34[0][0] concatenate_15[0][0]	
batch_normalization_34 (BatchNo	(None, 16, 16, 144)	576	concatenate_16[0][0]	
activation_34 (Activation)	(None, 16, 16, 144)	0	batch_normalization_34[0][0]	
separable_conv2d_35 (SeparableC	(None, 16, 16, 48)	7056	activation_34[0][0]	
batch_normalization_35 (BatchNo	(None, 16, 16, 48)	192	separable_conv2d_35[0][0]	
activation_35 (Activation)	(None, 16, 16, 48)	0	batch_normalization_35[0][0]	
separable_conv2d_36 (SeparableC	(None, 16, 16, 12)	1008	activation_35[0][0]	
concatenate_17 (Concatenate)	(None, 16, 16, 156)	0	separable_conv2d_36[0][0] concatenate_16[0][0]	
batch_normalization_36 (BatchNo	(None, 16, 16, 156)	624	concatenate_17[0][0]	
activation_36 (Activation)	(None, 16, 16, 156)	0	batch_normalization_36[0][0]	
separable_conv2d_37 (SeparableC	(None, 16, 16, 48)	7644	activation_36[0][0]	
batch_normalization_37 (BatchNo	(None, 16, 16, 48)	192	separable_conv2d_37[0][0]	
activation_37 (Activation)	(None, 16, 16, 48)	0	batch_normalization_37[0][0]	
separable_conv2d_38 (SeparableC	(None, 16, 16, 12)	1008	activation_37[0][0]	
concatenate_18 (Concatenate)	(None, 16, 16, 168)	0	separable_conv2d_38[0][0] concatenate_17[0][0]	
batch_normalization_38 (BatchNo	(None, 16, 16, 168)	672	concatenate_18[0][0]	

activation_38 (Activation)	(None, 16, 16, 168)	0	batch_normalization_38[0][0]
separable_conv2d_39 (SeparableC	(None, 16, 16, 48)	8232	activation_38[0][0]
batch_normalization_39 (BatchNo	(None, 16, 16, 48)	192	separable_conv2d_39[0][0]
activation_39 (Activation)	(None, 16, 16, 48)	0	batch_normalization_39[0][0]
separable_conv2d_40 (SeparableC	(None, 16, 16, 12)	1008	activation_39[0][0]
concatenate_19 (Concatenate)	(None, 16, 16, 180)	0	separable_conv2d_40[0][0] concatenate_18[0][0]
batch_normalization_40 (BatchNo	(None, 16, 16, 180)	720	concatenate_19[0][0]
activation_40 (Activation)	(None, 16, 16, 180)	0	batch_normalization_40[0][0]
separable_conv2d_41 (SeparableC	(None, 16, 16, 48)	8820	activation_40[0][0]
batch_normalization_41 (BatchNo	(None, 16, 16, 48)	192	separable_conv2d_41[0][0]
activation_41 (Activation)	(None, 16, 16, 48)	0	batch_normalization_41[0][0]
separable_conv2d_42 (SeparableC	(None, 16, 16, 12)	1008	activation_41[0][0]
concatenate_20 (Concatenate)	(None, 16, 16, 192)	0	separable_conv2d_42[0][0] concatenate_19[0][0]
batch_normalization_42 (BatchNo	(None, 16, 16, 192)	768	concatenate_20[0][0]
activation_42 (Activation)	(None, 16, 16, 192)	0	batch_normalization_42[0][0]
separable_conv2d_43 (SeparableC	(None, 16, 16, 96)	18624	activation_42[0][0]
average_pooling2d_2 (AveragePoo	(None, 8, 8, 96)	0	separable_conv2d_43[0][0]
batch_normalization_43 (BatchNo	(None, 8, 8, 96)	384	average_pooling2d_2[0][0]
activation_43 (Activation)	(None, 8, 8, 96)	0	batch_normalization_43[0][0]
separable_conv2d_44 (SeparableC	(None, 8, 8, 48)	4704	activation_43[0][0]
batch_normalization_44 (BatchNo	(None, 8, 8, 48)	192	separable_conv2d_44[0][0]
activation_44 (Activation)	(None, 8, 8, 48)	0	batch_normalization_44[0][0]
separable_conv2d_45 (SeparableC	(None, 8, 8, 12)	1008	activation_44[0][0]
concatenate_21 (Concatenate)	(None, 8, 8, 108)	0	separable_conv2d_45[0][0] average_pooling2d_2[0][0]
batch_normalization_45 (BatchNo	(None, 8, 8, 108)	432	concatenate_21[0][0]
activation_45 (Activation)	(None, 8, 8, 108)	0	batch_normalization_45[0][0]
separable_conv2d_46 (SeparableC	(None, 8, 8, 48)	5292	activation_45[0][0]
batch_normalization_46 (BatchNo	(None, 8, 8, 48)	192	separable_conv2d_46[0][0]
activation_46 (Activation)	(None, 8, 8, 48)	0	batch_normalization_46[0][0]
separable_conv2d_47 (SeparableC	(None, 8, 8, 12)	1008	activation_46[0][0]
concatenate_22 (Concatenate)	(None, 8, 8, 120)	0	separable_conv2d_47[0][0] concatenate_21[0][0]
batch_normalization_47 (BatchNo	(None, 8, 8, 120)	480	concatenate_22[0][0]
activation_47 (Activation)	(None, 8, 8, 120)	0	batch_normalization_47[0][0]
separable_conv2d_48 (SeparableC	(None, 8, 8, 48)	5880	activation_47[0][0]
batch_normalization_48 (BatchNo	(None, 8, 8, 48)	192	separable_conv2d_48[0][0]
activation_48 (Activation)	(None, 8, 8, 48)	0	batch_normalization_48[0][0]
separable_conv2d_49 (SeparableC	(None, 8, 8, 12)	1008	activation_48[0][0]

separable_conv2d_49 (SeparableC	(None, 8, 8, 12)	1008	activation_48[0][0]
concatenate_23 (Concatenate)	(None, 8, 8, 132)	0	separable_conv2d_49[0][0] concatenate_22[0][0]
batch_normalization_49 (BatchNo	(None, 8, 8, 132)	528	concatenate_23[0][0]
activation_49 (Activation)	(None, 8, 8, 132)	0	batch_normalization_49[0][0]
separable_conv2d_50 (SeparableC	(None, 8, 8, 48)	6468	activation_49[0][0]
batch_normalization_50 (BatchNo	(None, 8, 8, 48)	192	separable_conv2d_50[0][0]
activation_50 (Activation)	(None, 8, 8, 48)	0	batch_normalization_50[0][0]
separable_conv2d_51 (SeparableC	(None, 8, 8, 12)	1008	activation_50[0][0]
concatenate_24 (Concatenate)	(None, 8, 8, 144)	0	separable_conv2d_51[0][0] concatenate_23[0][0]
batch_normalization_51 (BatchNo	(None, 8, 8, 144)	576	concatenate_24[0][0]
activation_51 (Activation)	(None, 8, 8, 144)	0	batch_normalization_51[0][0]
separable_conv2d_52 (SeparableC	(None, 8, 8, 48)	7056	activation_51[0][0]
batch_normalization_52 (BatchNo	(None, 8, 8, 48)	192	separable_conv2d_52[0][0]
activation_52 (Activation)	(None, 8, 8, 48)	0	batch_normalization_52[0][0]
separable_conv2d_53 (SeparableC	(None, 8, 8, 12)	1008	activation_52[0][0]
concatenate_25 (Concatenate)	(None, 8, 8, 156)	0	separable_conv2d_53[0][0] concatenate_24[0][0]
batch_normalization_53 (BatchNo	(None, 8, 8, 156)	624	concatenate_25[0][0]
activation_53 (Activation)	(None, 8, 8, 156)	0	batch_normalization_53[0][0]
separable_conv2d_54 (SeparableC	(None, 8, 8, 48)	7644	activation_53[0][0]
batch_normalization_54 (BatchNo	(None, 8, 8, 48)	192	separable_conv2d_54[0][0]
activation_54 (Activation)	(None, 8, 8, 48)	0	batch_normalization_54[0][0]
separable_conv2d_55 (SeparableC	(None, 8, 8, 12)	1008	activation_54[0][0]
concatenate_26 (Concatenate)	(None, 8, 8, 168)	0	separable_conv2d_55[0][0] concatenate_25[0][0]
batch_normalization_55 (BatchNo	(None, 8, 8, 168)	672	concatenate_26[0][0]
activation_55 (Activation)	(None, 8, 8, 168)	0	batch_normalization_55[0][0]
separable_conv2d_56 (SeparableC	(None, 8, 8, 48)	8232	activation_55[0][0]
batch_normalization_56 (BatchNo	(None, 8, 8, 48)	192	separable_conv2d_56[0][0]
activation_56 (Activation)	(None, 8, 8, 48)	0	batch_normalization_56[0][0]
separable_conv2d_57 (SeparableC	(None, 8, 8, 12)	1008	activation_56[0][0]
concatenate_27 (Concatenate)	(None, 8, 8, 180)	0	separable_conv2d_57[0][0] concatenate_26[0][0]
batch_normalization_57 (BatchNo	(None, 8, 8, 180)	720	concatenate_27[0][0]
activation_57 (Activation)	(None, 8, 8, 180)	0	batch_normalization_57[0][0]
separable_conv2d_58 (SeparableC	(None, 8, 8, 48)	8820	activation_57[0][0]
batch_normalization_58 (BatchNo	(None, 8, 8, 48)	192	separable_conv2d_58[0][0]
activation_58 (Activation)	(None, 8, 8, 48)	0	batch_normalization_58[0][0]
separable_conv2d_59 (SeparableC	(None, 8, 8, 12)	1008	activation_58[0][0]
concatenate_28 (Concatenate)	(None, 8, 8, 192)	0	separable_conv2d_59[0][0]

```
concatenate_28 (Concatenate)    (None, 8, 8, 192)    0           separable_conv2d_59[0][0]
                                                                 concatenate_27[0][0]
____________________________________________________________________________________________________
batch_normalization_59 (BatchNo (None, 8, 8, 192)    768         concatenate_28[0][0]
____________________________________________________________________________________________________
activation_59 (Activation)      (None, 8, 8, 192)    0           batch_normalization_59[0][0]
____________________________________________________________________________________________________
separable_conv2d_60 (SeparableC (None, 8, 8, 48)     9408        activation_59[0][0]
____________________________________________________________________________________________________
batch_normalization_60 (BatchNo (None, 8, 8, 48)     192         separable_conv2d_60[0][0]
____________________________________________________________________________________________________
activation_60 (Activation)      (None, 8, 8, 48)     0           batch_normalization_60[0][0]
____________________________________________________________________________________________________
separable_conv2d_61 (SeparableC (None, 8, 8, 12)     1008        activation_60[0][0]
____________________________________________________________________________________________________
concatenate_29 (Concatenate)    (None, 8, 8, 204)    0           separable_conv2d_61[0][0]
                                                                 concatenate_28[0][0]
____________________________________________________________________________________________________
batch_normalization_61 (BatchNo (None, 8, 8, 204)    816         concatenate_29[0][0]
____________________________________________________________________________________________________
activation_61 (Activation)      (None, 8, 8, 204)    0           batch_normalization_61[0][0]
____________________________________________________________________________________________________
separable_conv2d_62 (SeparableC (None, 8, 8, 48)     9996        activation_61[0][0]
____________________________________________________________________________________________________
batch_normalization_62 (BatchNo (None, 8, 8, 48)     192         separable_conv2d_62[0][0]
____________________________________________________________________________________________________
activation_62 (Activation)      (None, 8, 8, 48)     0           batch_normalization_62[0][0]
____________________________________________________________________________________________________
separable_conv2d_63 (SeparableC (None, 8, 8, 12)     1008        activation_62[0][0]
____________________________________________________________________________________________________
concatenate_30 (Concatenate)    (None, 8, 8, 216)    0           separable_conv2d_63[0][0]
                                                                 concatenate_29[0][0]
____________________________________________________________________________________________________
batch_normalization_63 (BatchNo (None, 8, 8, 216)    864         concatenate_30[0][0]
____________________________________________________________________________________________________
activation_63 (Activation)      (None, 8, 8, 216)    0           batch_normalization_63[0][0]
____________________________________________________________________________________________________
global_average_pooling2d_1 (Glo (None, 216)          0           activation_63[0][0]
____________________________________________________________________________________________________
dense_1 (Dense)                 (None, 10)           2170        global_average_pooling2d_1[0][0]
====================================================================================================
Total params: 257,233
Trainable params: 246,169
Non-trainable params: 11,064
____________________________________________________________________________________________________
```

In [10]:

```
tb_cb     = TensorBoard(log_dir='./densenet/', histogram_freq=0)
change_lr = LearningRateScheduler(learning_scheduler)
ckpt      = ModelCheckpoint('./ckpt.h5', save_best_only=False, mode='auto', period=10)
cbks      = [change_lr,tb_cb,ckpt]
```

In [11]:

```
datagen = ImageDataGenerator(horizontal_flip=True,width_shift_range=0.125,height_shift_range=0.125
,fill_mode='nearest',cval=0.)
datagen.fit(X_train)
```

In [12]:

```
sgd = SGD(lr=.001, momentum=0.9, nesterov=True)
model.compile(loss='categorical_crossentropy', optimizer=sgd, metrics=['accuracy'])
```

In [13]:

```
%%time
model.fit_generator(datagen.flow(X_train, y_train,
                                 batch_size=batch_size),
                    epochs=nb_epochs,
                    validation_data=(X_test, y_test),callbacks=cbks,steps_per_epoch=iterations,
                    workers=4)
```

```
W0926 23:01:04.521609 16052 deprecation_wrapper.py:119] From C:\Users\patha\Anaconda3\lib\site-pac
kages\keras\backend\tensorflow_backend.py:422: The name tf.global_variables is deprecated. Please
use tf.compat.v1.global_variables instead.

W0926 23:01:04.534597 16052 deprecation_wrapper.py:119] From C:\Users\patha\Anaconda3\lib\site-pac
kages\keras\callbacks\tensorboard_v1.py:200: The name tf.summary.merge_all is deprecated. Please u
se tf.compat.v1.summary.merge_all instead.

W0926 23:01:04.535587 16052 deprecation_wrapper.py:119] From C:\Users\patha\Anaconda3\lib\site-pac
kages\keras\callbacks\tensorboard_v1.py:203: The name tf.summary.FileWriter is deprecated. Please
use tf.compat.v1.summary.FileWriter instead.


Epoch 1/300
200/200 [==============================] - 72s 361ms/step - loss: 1.9063 - accuracy: 0.2834 - val_
loss: 1.8889 - val_accuracy: 0.3041

W0926 23:02:18.830979 16052 deprecation_wrapper.py:119] From C:\Users\patha\Anaconda3\lib\site-pac
kages\keras\callbacks\tensorboard_v1.py:343: The name tf.Summary is deprecated. Please use
tf.compat.v1.Summary instead.


Epoch 2/300
200/200 [==============================] - 62s 311ms/step - loss: 1.5894 - accuracy: 0.4134 - val_
loss: 2.0820 - val_accuracy: 0.3291
Epoch 3/300
200/200 [==============================] - 62s 310ms/step - loss: 1.3914 - accuracy: 0.4960 - val_
loss: 1.4050 - val_accuracy: 0.5001
Epoch 4/300
200/200 [==============================] - 62s 309ms/step - loss: 1.2474 - accuracy: 0.5541 - val_
loss: 1.2844 - val_accuracy: 0.5363
Epoch 5/300
200/200 [==============================] - 61s 307ms/step - loss: 1.1475 - accuracy: 0.5887 - val_
loss: 1.5610 - val_accuracy: 0.5167
Epoch 6/300
200/200 [==============================] - 62s 308ms/step - loss: 1.0964 - accuracy: 0.6190 - val_
loss: 1.3549 - val_accuracy: 0.5353
Epoch 7/300
200/200 [==============================] - 62s 308ms/step - loss: 1.0229 - accuracy: 0.6393 - val_
loss: 1.1992 - val_accuracy: 0.5914
Epoch 8/300
200/200 [==============================] - 62s 308ms/step - loss: 0.9655 - accuracy: 0.6654 - val_
loss: 1.0213 - val_accuracy: 0.6503
Epoch 9/300
200/200 [==============================] - 62s 308ms/step - loss: 0.9181 - accuracy: 0.6825 - val_
loss: 0.9037 - val_accuracy: 0.6934
Epoch 10/300
200/200 [==============================] - 61s 307ms/step - loss: 0.8732 - accuracy: 0.6948 - val_
loss: 0.9438 - val_accuracy: 0.6927
Epoch 11/300
200/200 [==============================] - 62s 309ms/step - loss: 0.8647 - accuracy: 0.7056 - val_
loss: 0.8372 - val_accuracy: 0.7121
Epoch 12/300
200/200 [==============================] - 62s 308ms/step - loss: 0.8004 - accuracy: 0.7191 - val_
loss: 0.8248 - val_accuracy: 0.7212
Epoch 13/300
200/200 [==============================] - 62s 308ms/step - loss: 0.7711 - accuracy: 0.7352 - val_
loss: 0.8711 - val_accuracy: 0.7136
Epoch 14/300
200/200 [==============================] - 62s 308ms/step - loss: 0.7532 - accuracy: 0.7420 - val_
loss: 0.9547 - val_accuracy: 0.6943
Epoch 15/300
200/200 [==============================] - 62s 308ms/step - loss: 0.7373 - accuracy: 0.7525 - val_
loss: 0.7745 - val_accuracy: 0.7446
Epoch 16/300
200/200 [==============================] - 62s 309ms/step - loss: 0.7144 - accuracy: 0.7591 - val_
loss: 0.8613 - val_accuracy: 0.7247
Epoch 17/300
200/200 [==============================] - 61s 307ms/step - loss: 0.7029 - accuracy: 0.7606 - val_
loss: 0.8026 - val_accuracy: 0.7407
Epoch 18/300
200/200 [==============================] - 61s 307ms/step - loss: 0.6621 - accuracy: 0.7723 - val_
loss: 0.8024 - val_accuracy: 0.7381
Epoch 19/300
200/200 [==============================] - 61s 307ms/step - loss: 0.6702 - accuracy: 0.7767 - val
```

```
loss: 0.8047 - val_accuracy: 0.7380
Epoch 20/300
200/200 [==============================] - 61s 307ms/step - loss: 0.6367 - accuracy: 0.7837 - val_
loss: 0.7800 - val_accuracy: 0.7433
Epoch 21/300
200/200 [==============================] - 61s 307ms/step - loss: 0.6413 - accuracy: 0.7836 - val_
loss: 0.6967 - val_accuracy: 0.7722
Epoch 22/300
200/200 [==============================] - 62s 308ms/step - loss: 0.6109 - accuracy: 0.7920 - val_
loss: 0.6584 - val_accuracy: 0.7820
Epoch 23/300
200/200 [==============================] - 61s 307ms/step - loss: 0.6166 - accuracy: 0.7942 - val_
loss: 0.6644 - val_accuracy: 0.7791
Epoch 24/300
200/200 [==============================] - 61s 307ms/step - loss: 0.5918 - accuracy: 0.8021 - val_
loss: 0.6744 - val_accuracy: 0.7797
Epoch 25/300
200/200 [==============================] - 61s 307ms/step - loss: 0.5783 - accuracy: 0.8035 - val_
loss: 0.6845 - val_accuracy: 0.7736
Epoch 26/300
200/200 [==============================] - 61s 307ms/step - loss: 0.5895 - accuracy: 0.8020 - val_
loss: 0.6151 - val_accuracy: 0.8010
Epoch 27/300
200/200 [==============================] - 61s 306ms/step - loss: 0.5568 - accuracy: 0.8131 - val_
loss: 0.5854 - val_accuracy: 0.8090
Epoch 28/300
200/200 [==============================] - 61s 307ms/step - loss: 0.5364 - accuracy: 0.8207 - val_
loss: 0.8365 - val_accuracy: 0.7445
Epoch 29/300
200/200 [==============================] - 61s 307ms/step - loss: 0.5426 - accuracy: 0.8184 - val_
loss: 0.5873 - val_accuracy: 0.8079
Epoch 30/300
200/200 [==============================] - 61s 306ms/step - loss: 0.5562 - accuracy: 0.8132 - val_
loss: 0.6226 - val_accuracy: 0.7989
Epoch 31/300
200/200 [==============================] - 61s 307ms/step - loss: 0.5426 - accuracy: 0.8169 - val_
loss: 0.6226 - val_accuracy: 0.7965
Epoch 32/300
200/200 [==============================] - 61s 307ms/step - loss: 0.5130 - accuracy: 0.8268 - val_
loss: 0.5771 - val_accuracy: 0.8058
Epoch 33/300
200/200 [==============================] - 61s 307ms/step - loss: 0.5236 - accuracy: 0.8229 - val_
loss: 0.7034 - val_accuracy: 0.7804
Epoch 34/300
200/200 [==============================] - 61s 307ms/step - loss: 0.5093 - accuracy: 0.8291 - val_
loss: 0.6250 - val_accuracy: 0.7894
Epoch 35/300
200/200 [==============================] - 61s 306ms/step - loss: 0.5075 - accuracy: 0.8313 - val_
loss: 0.6063 - val_accuracy: 0.8022
Epoch 36/300
200/200 [==============================] - 62s 308ms/step - loss: 0.4845 - accuracy: 0.8355 - val_
loss: 0.6792 - val_accuracy: 0.7815
Epoch 37/300
200/200 [==============================] - 61s 307ms/step - loss: 0.5029 - accuracy: 0.8328 - val_
loss: 0.5405 - val_accuracy: 0.8263
Epoch 38/300
200/200 [==============================] - 62s 308ms/step - loss: 0.4806 - accuracy: 0.8378 - val_
loss: 0.6056 - val_accuracy: 0.8045
Epoch 39/300
200/200 [==============================] - 61s 307ms/step - loss: 0.4794 - accuracy: 0.8398 - val_
loss: 0.5580 - val_accuracy: 0.8223
Epoch 40/300
200/200 [==============================] - 62s 308ms/step - loss: 0.4538 - accuracy: 0.8508 - val_
loss: 0.5291 - val_accuracy: 0.8272
Epoch 41/300
200/200 [==============================] - 62s 308ms/step - loss: 0.4691 - accuracy: 0.8427 - val_
loss: 0.6252 - val_accuracy: 0.7967
Epoch 42/300
200/200 [==============================] - 62s 308ms/step - loss: 0.4603 - accuracy: 0.8429 - val_
loss: 0.6716 - val_accuracy: 0.7847
Epoch 43/300
200/200 [==============================] - 61s 306ms/step - loss: 0.4753 - accuracy: 0.8415 - val_
loss: 0.6663 - val_accuracy: 0.7864
Epoch 44/300
200/200 [==============================] - 61s 307ms/step - loss: 0.4428 - accuracy: 0.8555 - val_
loss: 0.5029 - val_accuracy: 0.8361
Epoch 45/300
```

```
Epoch 45/300
200/200 [==============================] - 61s 307ms/step - loss: 0.4393 - accuracy: 0.8585 - val_
loss: 0.5025 - val_accuracy: 0.8399
Epoch 46/300
200/200 [==============================] - 62s 309ms/step - loss: 0.4506 - accuracy: 0.8495 - val_
loss: 0.5486 - val_accuracy: 0.8233
Epoch 47/300
200/200 [==============================] - 62s 308ms/step - loss: 0.4437 - accuracy: 0.8554 - val_
loss: 0.5239 - val_accuracy: 0.8294
Epoch 48/300
200/200 [==============================] - 61s 307ms/step - loss: 0.4336 - accuracy: 0.8552 - val_
loss: 0.5796 - val_accuracy: 0.8167
Epoch 49/300
200/200 [==============================] - 62s 308ms/step - loss: 0.4346 - accuracy: 0.8548 - val_
loss: 0.6112 - val_accuracy: 0.8074
Epoch 50/300
200/200 [==============================] - 62s 308ms/step - loss: 0.4277 - accuracy: 0.8593 - val_
loss: 0.5441 - val_accuracy: 0.8193
Epoch 51/300
200/200 [==============================] - 62s 308ms/step - loss: 0.4317 - accuracy: 0.8552 - val_
loss: 0.4934 - val_accuracy: 0.8424
Epoch 52/300
200/200 [==============================] - 61s 307ms/step - loss: 0.4110 - accuracy: 0.8648 - val_
loss: 0.5192 - val_accuracy: 0.8308
Epoch 53/300
200/200 [==============================] - 61s 306ms/step - loss: 0.4067 - accuracy: 0.8649 - val_
loss: 0.6001 - val_accuracy: 0.8172
Epoch 54/300
200/200 [==============================] - 61s 307ms/step - loss: 0.4162 - accuracy: 0.8583 - val_
loss: 0.5002 - val_accuracy: 0.8366
Epoch 55/300
200/200 [==============================] - 62s 308ms/step - loss: 0.4112 - accuracy: 0.8632 - val_
loss: 0.5995 - val_accuracy: 0.8104
Epoch 56/300
200/200 [==============================] - 62s 308ms/step - loss: 0.3873 - accuracy: 0.8736 - val_
loss: 0.4523 - val_accuracy: 0.8551
Epoch 57/300
200/200 [==============================] - 62s 310ms/step - loss: 0.3913 - accuracy: 0.8698 - val_
loss: 0.5052 - val_accuracy: 0.8322
Epoch 58/300
200/200 [==============================] - 61s 307ms/step - loss: 0.4059 - accuracy: 0.8659 - val_
loss: 0.6407 - val_accuracy: 0.7991
Epoch 59/300
200/200 [==============================] - 61s 306ms/step - loss: 0.4101 - accuracy: 0.8644 - val_
loss: 0.4718 - val_accuracy: 0.8484
Epoch 60/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3843 - accuracy: 0.8713 - val_
loss: 0.4835 - val_accuracy: 0.8452
Epoch 61/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3694 - accuracy: 0.8774 - val_
loss: 0.5543 - val_accuracy: 0.8283
Epoch 62/300
200/200 [==============================] - 61s 307ms/step - loss: 0.4125 - accuracy: 0.8650 - val_
loss: 0.4471 - val_accuracy: 0.8567
Epoch 63/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3999 - accuracy: 0.8675 - val_
loss: 0.5302 - val_accuracy: 0.8348
Epoch 64/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3782 - accuracy: 0.8773 - val_
loss: 0.4877 - val_accuracy: 0.8459
Epoch 65/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3839 - accuracy: 0.8729 - val_
loss: 0.4653 - val_accuracy: 0.8500
Epoch 66/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3774 - accuracy: 0.8766 - val_
loss: 0.4649 - val_accuracy: 0.8471
Epoch 67/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3593 - accuracy: 0.8803 - val_
loss: 0.4745 - val_accuracy: 0.8448
Epoch 68/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3656 - accuracy: 0.8800 - val_
loss: 0.5935 - val_accuracy: 0.8163
Epoch 69/300
200/200 [==============================] - 61s 306ms/step - loss: 0.3671 - accuracy: 0.8789 - val_
loss: 0.5546 - val_accuracy: 0.8275
Epoch 70/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3740 - accuracy: 0.8740 - val_
loss: 0.4833 - val_accuracy: 0.8481
```

```
loss: 0.4033 - val_accuracy: 0.8781
Epoch 71/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3564 - accuracy: 0.8835 - val_
loss: 0.5357 - val_accuracy: 0.8310
Epoch 72/300
200/200 [==============================] - 62s 310ms/step - loss: 0.3566 - accuracy: 0.8834 - val_
loss: 0.4826 - val_accuracy: 0.8451
Epoch 73/300
200/200 [==============================] - 61s 306ms/step - loss: 0.3469 - accuracy: 0.8861 - val_
loss: 0.4535 - val_accuracy: 0.8534
Epoch 74/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3481 - accuracy: 0.8855 - val_
loss: 0.4946 - val_accuracy: 0.8448
Epoch 75/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3499 - accuracy: 0.8802 - val_
loss: 0.4740 - val_accuracy: 0.8511
Epoch 76/300
200/200 [==============================] - 62s 308ms/step - loss: 0.3580 - accuracy: 0.8804 - val_
loss: 0.4789 - val_accuracy: 0.8406
Epoch 77/300
200/200 [==============================] - 61s 306ms/step - loss: 0.3363 - accuracy: 0.8854 - val_
loss: 0.4059 - val_accuracy: 0.8712
Epoch 78/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3430 - accuracy: 0.8860 - val_
loss: 0.4052 - val_accuracy: 0.8687
Epoch 79/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3350 - accuracy: 0.8900 - val_
loss: 0.4499 - val_accuracy: 0.8605
Epoch 80/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3374 - accuracy: 0.8905 - val_
loss: 0.4298 - val_accuracy: 0.8625
Epoch 81/300
200/200 [==============================] - 61s 306ms/step - loss: 0.3381 - accuracy: 0.8910 - val_
loss: 0.5176 - val_accuracy: 0.8315
Epoch 82/300
200/200 [==============================] - 62s 308ms/step - loss: 0.3356 - accuracy: 0.8884 - val_
loss: 0.4333 - val_accuracy: 0.8604
Epoch 83/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3215 - accuracy: 0.8921 - val_
loss: 0.4153 - val_accuracy: 0.8677
Epoch 84/300
200/200 [==============================] - 62s 308ms/step - loss: 0.3311 - accuracy: 0.8913 - val_
loss: 0.4356 - val_accuracy: 0.8650
Epoch 85/300
200/200 [==============================] - 62s 308ms/step - loss: 0.3344 - accuracy: 0.8909 - val_
loss: 0.3953 - val_accuracy: 0.8711
Epoch 86/300
200/200 [==============================] - 62s 308ms/step - loss: 0.3278 - accuracy: 0.8920 - val_
loss: 0.4980 - val_accuracy: 0.8418
Epoch 87/300
200/200 [==============================] - 62s 308ms/step - loss: 0.3142 - accuracy: 0.8966 - val_
loss: 0.4635 - val_accuracy: 0.8539
Epoch 88/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3265 - accuracy: 0.8916 - val_
loss: 0.4719 - val_accuracy: 0.8526
Epoch 89/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3197 - accuracy: 0.8955 - val_
loss: 0.4452 - val_accuracy: 0.8615
Epoch 90/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3255 - accuracy: 0.8908 - val_
loss: 0.4178 - val_accuracy: 0.8653
Epoch 91/300
200/200 [==============================] - 62s 308ms/step - loss: 0.3055 - accuracy: 0.8985 - val_
loss: 0.4402 - val_accuracy: 0.8598
Epoch 92/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3035 - accuracy: 0.8998 - val_
loss: 0.4184 - val_accuracy: 0.8693
Epoch 93/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3234 - accuracy: 0.8950 - val_
loss: 0.4584 - val_accuracy: 0.8523
Epoch 94/300
200/200 [==============================] - 61s 307ms/step - loss: 0.3196 - accuracy: 0.8940 - val_
loss: 0.3996 - val_accuracy: 0.8663
Epoch 95/300
200/200 [==============================] - 61s 306ms/step - loss: 0.3018 - accuracy: 0.9048 - val_
loss: 0.4398 - val_accuracy: 0.8594
Epoch 96/300
200/200 [==============================] - 62s 309ms/step - loss: 0.3011 - accuracy: 0.9018 - val_
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200/200 [==============================] - 62s 309ms/step - loss: 0.3011 - accuracy: 0.9010 - val_
loss: 0.4367 - val_accuracy: 0.8627
Epoch 97/300
200/200 [==============================] - 62s 308ms/step - loss: 0.3107 - accuracy: 0.8970 - val_
loss: 0.4136 - val_accuracy: 0.8727
Epoch 98/300
200/200 [==============================] - 62s 308ms/step - loss: 0.3010 - accuracy: 0.9011 - val_
loss: 0.3901 - val_accuracy: 0.8756
Epoch 99/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2907 - accuracy: 0.9055 - val_
loss: 0.4014 - val_accuracy: 0.8720
Epoch 100/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2911 - accuracy: 0.9055 - val_
loss: 0.4708 - val_accuracy: 0.8533
Epoch 101/300
200/200 [==============================] - 62s 308ms/step - loss: 0.3106 - accuracy: 0.8992 - val_
loss: 0.4083 - val_accuracy: 0.8708
Epoch 102/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2939 - accuracy: 0.9033 - val_
loss: 0.4025 - val_accuracy: 0.8696
Epoch 103/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2948 - accuracy: 0.9051 - val_
loss: 0.4414 - val_accuracy: 0.8641
Epoch 104/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2845 - accuracy: 0.9060 - val_
loss: 0.4416 - val_accuracy: 0.8653
Epoch 105/300
200/200 [==============================] - 62s 308ms/step - loss: 0.3043 - accuracy: 0.8965 - val_
loss: 0.4000 - val_accuracy: 0.8758
Epoch 106/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2852 - accuracy: 0.9059 - val_
loss: 0.4174 - val_accuracy: 0.8699
Epoch 107/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2873 - accuracy: 0.9046 - val_
loss: 0.4118 - val_accuracy: 0.8729
Epoch 108/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2877 - accuracy: 0.9019 - val_
loss: 0.4234 - val_accuracy: 0.8699
Epoch 109/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2867 - accuracy: 0.9069 - val_
loss: 0.3928 - val_accuracy: 0.8740
Epoch 110/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2808 - accuracy: 0.9075 - val_
loss: 0.3914 - val_accuracy: 0.8807
Epoch 111/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2801 - accuracy: 0.9101 - val_
loss: 0.4030 - val_accuracy: 0.8781
Epoch 112/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2878 - accuracy: 0.9074 - val_
loss: 0.3912 - val_accuracy: 0.8791
Epoch 113/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2984 - accuracy: 0.9032 - val_
loss: 0.4235 - val_accuracy: 0.8655
Epoch 114/300
200/200 [==============================] - 62s 309ms/step - loss: 0.2743 - accuracy: 0.9097 - val_
loss: 0.4459 - val_accuracy: 0.8652
Epoch 115/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2675 - accuracy: 0.9126 - val_
loss: 0.4425 - val_accuracy: 0.8611
Epoch 116/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2888 - accuracy: 0.9047 - val_
loss: 0.4252 - val_accuracy: 0.8666
Epoch 117/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2830 - accuracy: 0.9071 - val_
loss: 0.3977 - val_accuracy: 0.8734
Epoch 118/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2547 - accuracy: 0.9139 - val_
loss: 0.4208 - val_accuracy: 0.8741
Epoch 119/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2660 - accuracy: 0.9104 - val_
loss: 0.3850 - val_accuracy: 0.8797
Epoch 120/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2752 - accuracy: 0.9084 - val_
loss: 0.3797 - val_accuracy: 0.8811
Epoch 121/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2805 - accuracy: 0.9048 - val_
loss: 0.4129 - val_accuracy: 0.8719
Epoch 122/300

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Epoch 122/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2659 - accuracy: 0.9123 - val_
loss: 0.3755 - val_accuracy: 0.8827
Epoch 123/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2666 - accuracy: 0.9153 - val_
loss: 0.3962 - val_accuracy: 0.8715
Epoch 124/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2685 - accuracy: 0.9098 - val_
loss: 0.4080 - val_accuracy: 0.8759
Epoch 125/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2713 - accuracy: 0.9070 - val_
loss: 0.3728 - val_accuracy: 0.8830
Epoch 126/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2630 - accuracy: 0.9129 - val_
loss: 0.3974 - val_accuracy: 0.8804
Epoch 127/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2456 - accuracy: 0.9169 - val_
loss: 0.4016 - val_accuracy: 0.8754
Epoch 128/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2589 - accuracy: 0.9130 - val_
loss: 0.4092 - val_accuracy: 0.8730
Epoch 129/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2662 - accuracy: 0.9122 - val_
loss: 0.4554 - val_accuracy: 0.8575
Epoch 130/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2521 - accuracy: 0.9151 - val_
loss: 0.4385 - val_accuracy: 0.8677
Epoch 131/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2607 - accuracy: 0.9130 - val_
loss: 0.3828 - val_accuracy: 0.8858
Epoch 132/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2619 - accuracy: 0.9148 - val_
loss: 0.4196 - val_accuracy: 0.8755
Epoch 133/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2586 - accuracy: 0.9129 - val_
loss: 0.3741 - val_accuracy: 0.8807
Epoch 134/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2501 - accuracy: 0.9184 - val_
loss: 0.4218 - val_accuracy: 0.8709
Epoch 135/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2391 - accuracy: 0.9210 - val_
loss: 0.3772 - val_accuracy: 0.8818
Epoch 136/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2575 - accuracy: 0.9144 - val_
loss: 0.3721 - val_accuracy: 0.8874
Epoch 137/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2580 - accuracy: 0.9140 - val_
loss: 0.3823 - val_accuracy: 0.8836
Epoch 138/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2302 - accuracy: 0.9241 - val_
loss: 0.3786 - val_accuracy: 0.8825
Epoch 139/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2378 - accuracy: 0.9199 - val_
loss: 0.4286 - val_accuracy: 0.8712
Epoch 140/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2625 - accuracy: 0.9139 - val_
loss: 0.3461 - val_accuracy: 0.8901
Epoch 141/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2467 - accuracy: 0.9177 - val_
loss: 0.3875 - val_accuracy: 0.8823
Epoch 142/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2325 - accuracy: 0.9232 - val_
loss: 0.4280 - val_accuracy: 0.8732
Epoch 143/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2496 - accuracy: 0.9189 - val_
loss: 0.4038 - val_accuracy: 0.8780
Epoch 144/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2524 - accuracy: 0.9141 - val_
loss: 0.3542 - val_accuracy: 0.8856
Epoch 145/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2342 - accuracy: 0.9251 - val_
loss: 0.4109 - val_accuracy: 0.8776
Epoch 146/300
200/200 [==============================] - 62s 309ms/step - loss: 0.2382 - accuracy: 0.9216 - val_
loss: 0.4088 - val_accuracy: 0.8777
Epoch 147/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2301 - accuracy: 0.9257 - val_
loss: 0.3611 - val_accuracy: 0.8889
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loss: 0.3611 - val_accuracy: 0.8869
Epoch 148/300
200/200 [==============================] - 62s 309ms/step - loss: 0.2354 - accuracy: 0.9224 - val_
loss: 0.4033 - val_accuracy: 0.8733
Epoch 149/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2418 - accuracy: 0.9195 - val_
loss: 0.4058 - val_accuracy: 0.8786
Epoch 150/300
200/200 [==============================] - 62s 308ms/step - loss: 0.2203 - accuracy: 0.9273 - val_
loss: 0.4395 - val_accuracy: 0.8710
Epoch 151/300
200/200 [==============================] - 61s 307ms/step - loss: 0.2162 - accuracy: 0.9285 - val_
loss: 0.3335 - val_accuracy: 0.8978
Epoch 152/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1967 - accuracy: 0.9359 - val_
loss: 0.3244 - val_accuracy: 0.8979
Epoch 153/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1745 - accuracy: 0.9437 - val_
loss: 0.3229 - val_accuracy: 0.8997
Epoch 154/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1631 - accuracy: 0.9478 - val_
loss: 0.3220 - val_accuracy: 0.9001
Epoch 155/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1573 - accuracy: 0.9513 - val_
loss: 0.3238 - val_accuracy: 0.9013
Epoch 156/300
200/200 [==============================] - 62s 310ms/step - loss: 0.1588 - accuracy: 0.9477 - val_
loss: 0.3124 - val_accuracy: 0.9038
Epoch 157/300
200/200 [==============================] - 62s 310ms/step - loss: 0.1495 - accuracy: 0.9545 - val_
loss: 0.3172 - val_accuracy: 0.9016
Epoch 158/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1492 - accuracy: 0.9531 - val_
loss: 0.3217 - val_accuracy: 0.9004
Epoch 159/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1515 - accuracy: 0.9497 - val_
loss: 0.3177 - val_accuracy: 0.9022
Epoch 160/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1575 - accuracy: 0.9500 - val_
loss: 0.3134 - val_accuracy: 0.9023
Epoch 161/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1528 - accuracy: 0.9527 - val_
loss: 0.3176 - val_accuracy: 0.9011
Epoch 162/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1460 - accuracy: 0.9559 - val_
loss: 0.3102 - val_accuracy: 0.9036
Epoch 163/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1458 - accuracy: 0.9548 - val_
loss: 0.3139 - val_accuracy: 0.9041
Epoch 164/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1450 - accuracy: 0.9546 - val_
loss: 0.3068 - val_accuracy: 0.9061
Epoch 165/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1455 - accuracy: 0.9553 - val_
loss: 0.3150 - val_accuracy: 0.9060
Epoch 166/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1471 - accuracy: 0.9535 - val_
loss: 0.3063 - val_accuracy: 0.9043
Epoch 167/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1465 - accuracy: 0.9540 - val_
loss: 0.3112 - val_accuracy: 0.9039
Epoch 168/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1417 - accuracy: 0.9566 - val_
loss: 0.3176 - val_accuracy: 0.9033
Epoch 169/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1371 - accuracy: 0.9577 - val_
loss: 0.3144 - val_accuracy: 0.9025
Epoch 170/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1352 - accuracy: 0.9583 - val_
loss: 0.3200 - val_accuracy: 0.9027
Epoch 171/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1441 - accuracy: 0.9553 - val_
loss: 0.3129 - val_accuracy: 0.9042
Epoch 172/300
200/200 [==============================] - 61s 306ms/step - loss: 0.1414 - accuracy: 0.9560 - val_
loss: 0.3136 - val_accuracy: 0.9063
Epoch 173/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1326 - accuracy: 0.9590 - val_
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200/200 [==============================] - 62s 308ms/step - loss: 0.1336 - accuracy: 0.9589 - val_
loss: 0.3080 - val_accuracy: 0.9075
Epoch 174/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1317 - accuracy: 0.9584 - val_
loss: 0.3110 - val_accuracy: 0.9069
Epoch 175/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1291 - accuracy: 0.9608 - val_
loss: 0.3133 - val_accuracy: 0.9073
Epoch 176/300
200/200 [==============================] - 61s 306ms/step - loss: 0.1387 - accuracy: 0.9581 - val_
loss: 0.3130 - val_accuracy: 0.9067
Epoch 177/300
200/200 [==============================] - 61s 306ms/step - loss: 0.1289 - accuracy: 0.9613 - val_
loss: 0.3094 - val_accuracy: 0.9077
Epoch 178/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1309 - accuracy: 0.9605 - val_
loss: 0.3077 - val_accuracy: 0.9082
Epoch 179/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1348 - accuracy: 0.9571 - val_
loss: 0.3109 - val_accuracy: 0.9066
Epoch 180/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1306 - accuracy: 0.9578 - val_
loss: 0.3101 - val_accuracy: 0.9063
Epoch 181/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1292 - accuracy: 0.9594 - val_
loss: 0.3165 - val_accuracy: 0.9066
Epoch 182/300
200/200 [==============================] - 61s 306ms/step - loss: 0.1271 - accuracy: 0.9609 - val_
loss: 0.3134 - val_accuracy: 0.9065
Epoch 183/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1334 - accuracy: 0.9576 - val_
loss: 0.3072 - val_accuracy: 0.9062
Epoch 184/300
200/200 [==============================] - 61s 306ms/step - loss: 0.1280 - accuracy: 0.9602 - val_
loss: 0.3129 - val_accuracy: 0.9054
Epoch 185/300
200/200 [==============================] - 61s 306ms/step - loss: 0.1261 - accuracy: 0.9617 - val_
loss: 0.3094 - val_accuracy: 0.9065
Epoch 186/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1222 - accuracy: 0.9625 - val_
loss: 0.3163 - val_accuracy: 0.9069
Epoch 187/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1306 - accuracy: 0.9591 - val_
loss: 0.3114 - val_accuracy: 0.9086
Epoch 188/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1275 - accuracy: 0.9609 - val_
loss: 0.3100 - val_accuracy: 0.9065
Epoch 189/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1261 - accuracy: 0.9626 - val_
loss: 0.3154 - val_accuracy: 0.9057
Epoch 190/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1262 - accuracy: 0.9610 - val_
loss: 0.3190 - val_accuracy: 0.9030
Epoch 191/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1265 - accuracy: 0.9595 - val_
loss: 0.3179 - val_accuracy: 0.9072
Epoch 192/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1281 - accuracy: 0.9597 - val_
loss: 0.3089 - val_accuracy: 0.9081
Epoch 193/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1256 - accuracy: 0.9606 - val_
loss: 0.3203 - val_accuracy: 0.9054
Epoch 194/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1353 - accuracy: 0.9579 - val_
loss: 0.3152 - val_accuracy: 0.9074
Epoch 195/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1268 - accuracy: 0.9598 - val_
loss: 0.3143 - val_accuracy: 0.9063
Epoch 196/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1245 - accuracy: 0.9615 - val_
loss: 0.3095 - val_accuracy: 0.9079
Epoch 197/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1238 - accuracy: 0.9634 - val_
loss: 0.3245 - val_accuracy: 0.9035
Epoch 198/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1232 - accuracy: 0.9615 - val_
loss: 0.3215 - val_accuracy: 0.9052
Epoch 199/300
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Epoch 199/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1226 - accuracy: 0.9630 - val_
loss: 0.3222 - val_accuracy: 0.9059
Epoch 200/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1229 - accuracy: 0.9620 - val_
loss: 0.3231 - val_accuracy: 0.9047
Epoch 201/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1222 - accuracy: 0.9632 - val_
loss: 0.3238 - val_accuracy: 0.9050
Epoch 202/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1231 - accuracy: 0.9620 - val_
loss: 0.3160 - val_accuracy: 0.9070
Epoch 203/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1302 - accuracy: 0.9582 - val_
loss: 0.3128 - val_accuracy: 0.9062
Epoch 204/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1181 - accuracy: 0.9648 - val_
loss: 0.3167 - val_accuracy: 0.9077
Epoch 205/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1182 - accuracy: 0.9638 - val_
loss: 0.3156 - val_accuracy: 0.9067
Epoch 206/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1208 - accuracy: 0.9618 - val_
loss: 0.3215 - val_accuracy: 0.9051
Epoch 207/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1196 - accuracy: 0.9616 - val_
loss: 0.3223 - val_accuracy: 0.9059
Epoch 208/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1219 - accuracy: 0.9613 - val_
loss: 0.3196 - val_accuracy: 0.9082
Epoch 209/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1183 - accuracy: 0.9631 - val_
loss: 0.3190 - val_accuracy: 0.9089
Epoch 210/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1179 - accuracy: 0.9642 - val_
loss: 0.3171 - val_accuracy: 0.9076
Epoch 211/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1273 - accuracy: 0.9594 - val_
loss: 0.3148 - val_accuracy: 0.9069
Epoch 212/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1156 - accuracy: 0.9637 - val_
loss: 0.3144 - val_accuracy: 0.9066
Epoch 213/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1167 - accuracy: 0.9648 - val_
loss: 0.3180 - val_accuracy: 0.9079
Epoch 214/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1210 - accuracy: 0.9635 - val_
loss: 0.3239 - val_accuracy: 0.9060
Epoch 215/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1143 - accuracy: 0.9670 - val_
loss: 0.3225 - val_accuracy: 0.9055
Epoch 216/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1201 - accuracy: 0.9609 - val_
loss: 0.3196 - val_accuracy: 0.9057
Epoch 217/300
200/200 [==============================] - 62s 310ms/step - loss: 0.1185 - accuracy: 0.9627 - val_
loss: 0.3175 - val_accuracy: 0.9061
Epoch 218/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1186 - accuracy: 0.9624 - val_
loss: 0.3226 - val_accuracy: 0.9047
Epoch 219/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1129 - accuracy: 0.9640 - val_
loss: 0.3250 - val_accuracy: 0.9055
Epoch 220/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1144 - accuracy: 0.9647 - val_
loss: 0.3242 - val_accuracy: 0.9052
Epoch 221/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1152 - accuracy: 0.9641 - val_
loss: 0.3214 - val_accuracy: 0.9062
Epoch 222/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1109 - accuracy: 0.9666 - val_
loss: 0.3222 - val_accuracy: 0.9060
Epoch 223/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1136 - accuracy: 0.9676 - val_
loss: 0.3208 - val_accuracy: 0.9063
Epoch 224/300
200/200 [==============================] - 62s 310ms/step - loss: 0.1099 - accuracy: 0.9663 - val_
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loss: 0.3213 - val_accuracy: 0.9065
Epoch 225/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1171 - accuracy: 0.9641 - val_
loss: 0.3235 - val_accuracy: 0.9045
Epoch 226/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1202 - accuracy: 0.9624 - val_
loss: 0.3274 - val_accuracy: 0.9042
Epoch 227/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1120 - accuracy: 0.9651 - val_
loss: 0.3238 - val_accuracy: 0.9044
Epoch 228/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1084 - accuracy: 0.9668 - val_
loss: 0.3194 - val_accuracy: 0.9056
Epoch 229/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1064 - accuracy: 0.9674 - val_
loss: 0.3223 - val_accuracy: 0.9061
Epoch 230/300
200/200 [==============================] - 62s 310ms/step - loss: 0.1050 - accuracy: 0.9667 - val_
loss: 0.3245 - val_accuracy: 0.9050
Epoch 231/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1085 - accuracy: 0.9659 - val_
loss: 0.3150 - val_accuracy: 0.9085
Epoch 232/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1023 - accuracy: 0.9700 - val_
loss: 0.3215 - val_accuracy: 0.9064
Epoch 233/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1124 - accuracy: 0.9638 - val_
loss: 0.3210 - val_accuracy: 0.9073
Epoch 234/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1056 - accuracy: 0.9675 - val_
loss: 0.3181 - val_accuracy: 0.9075
Epoch 235/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1095 - accuracy: 0.9675 - val_
loss: 0.3173 - val_accuracy: 0.9081
Epoch 236/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1057 - accuracy: 0.9685 - val_
loss: 0.3248 - val_accuracy: 0.9049
Epoch 237/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1121 - accuracy: 0.9666 - val_
loss: 0.3234 - val_accuracy: 0.9062
Epoch 238/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1076 - accuracy: 0.9682 - val_
loss: 0.3243 - val_accuracy: 0.9058
Epoch 239/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1079 - accuracy: 0.9669 - val_
loss: 0.3190 - val_accuracy: 0.9082
Epoch 240/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1105 - accuracy: 0.9663 - val_
loss: 0.3211 - val_accuracy: 0.9071
Epoch 241/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1054 - accuracy: 0.9660 - val_
loss: 0.3166 - val_accuracy: 0.9086
Epoch 242/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1128 - accuracy: 0.9661 - val_
loss: 0.3214 - val_accuracy: 0.9073
Epoch 243/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1038 - accuracy: 0.9680 - val_
loss: 0.3219 - val_accuracy: 0.9063
Epoch 244/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1111 - accuracy: 0.9655 - val_
loss: 0.3154 - val_accuracy: 0.9082
Epoch 245/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1043 - accuracy: 0.9674 - val_
loss: 0.3157 - val_accuracy: 0.9082
Epoch 246/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1053 - accuracy: 0.9677 - val_
loss: 0.3207 - val_accuracy: 0.9069
Epoch 247/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1043 - accuracy: 0.9699 - val_
loss: 0.3260 - val_accuracy: 0.9063
Epoch 248/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1050 - accuracy: 0.9677 - val_
loss: 0.3184 - val_accuracy: 0.9079
Epoch 249/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1038 - accuracy: 0.9684 - val_
loss: 0.3223 - val_accuracy: 0.9072
Epoch 250/300
```

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200/200 [==============================] - 61s 307ms/step - loss: 0.1082 - accuracy: 0.9676 - val_
loss: 0.3171 - val_accuracy: 0.9082
Epoch 251/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1053 - accuracy: 0.9685 - val_
loss: 0.3151 - val_accuracy: 0.9082
Epoch 252/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1080 - accuracy: 0.9666 - val_
loss: 0.3220 - val_accuracy: 0.9068
Epoch 253/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1048 - accuracy: 0.9693 - val_
loss: 0.3180 - val_accuracy: 0.9074
Epoch 254/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1046 - accuracy: 0.9682 - val_
loss: 0.3143 - val_accuracy: 0.9082
Epoch 255/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1063 - accuracy: 0.9683 - val_
loss: 0.3176 - val_accuracy: 0.9074
Epoch 256/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1084 - accuracy: 0.9663 - val_
loss: 0.3165 - val_accuracy: 0.9083
Epoch 257/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1039 - accuracy: 0.9679 - val_
loss: 0.3155 - val_accuracy: 0.9075
Epoch 258/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1069 - accuracy: 0.9680 - val_
loss: 0.3251 - val_accuracy: 0.9070
Epoch 259/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1073 - accuracy: 0.9686 - val_
loss: 0.3206 - val_accuracy: 0.9078
Epoch 260/300
200/200 [==============================] - 62s 310ms/step - loss: 0.1118 - accuracy: 0.9669 - val_
loss: 0.3159 - val_accuracy: 0.9078
Epoch 261/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1036 - accuracy: 0.9688 - val_
loss: 0.3220 - val_accuracy: 0.9074
Epoch 262/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1049 - accuracy: 0.9679 - val_
loss: 0.3229 - val_accuracy: 0.9064
Epoch 263/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1067 - accuracy: 0.9677 - val_
loss: 0.3229 - val_accuracy: 0.9069
Epoch 264/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1020 - accuracy: 0.9691 - val_
loss: 0.3152 - val_accuracy: 0.9078
Epoch 265/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1004 - accuracy: 0.9696 - val_
loss: 0.3172 - val_accuracy: 0.9070
Epoch 266/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1009 - accuracy: 0.9700 - val_
loss: 0.3212 - val_accuracy: 0.9073
Epoch 267/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1038 - accuracy: 0.9689 - val_
loss: 0.3190 - val_accuracy: 0.9079
Epoch 268/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1087 - accuracy: 0.9653 - val_
loss: 0.3210 - val_accuracy: 0.9063
Epoch 269/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1055 - accuracy: 0.9702 - val_
loss: 0.3208 - val_accuracy: 0.9063
Epoch 270/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1097 - accuracy: 0.9659 - val_
loss: 0.3202 - val_accuracy: 0.9065
Epoch 271/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1015 - accuracy: 0.9704 - val_
loss: 0.3149 - val_accuracy: 0.9087
Epoch 272/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1023 - accuracy: 0.9689 - val_
loss: 0.3191 - val_accuracy: 0.9077
Epoch 273/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1063 - accuracy: 0.9686 - val_
loss: 0.3175 - val_accuracy: 0.9072
Epoch 274/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1090 - accuracy: 0.9666 - val_
loss: 0.3183 - val_accuracy: 0.9069
Epoch 275/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1071 - accuracy: 0.9682 - val_
loss: 0.3207 - val_accuracy: 0.9067
```

```
Epoch 276/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1030 - accuracy: 0.9718 - val_
loss: 0.3175 - val_accuracy: 0.9066
Epoch 277/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1059 - accuracy: 0.9680 - val_
loss: 0.3188 - val_accuracy: 0.9059
Epoch 278/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1080 - accuracy: 0.9682 - val_
loss: 0.3199 - val_accuracy: 0.9061
Epoch 279/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1040 - accuracy: 0.9695 - val_
loss: 0.3163 - val_accuracy: 0.9079
Epoch 280/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1029 - accuracy: 0.9709 - val_
loss: 0.3175 - val_accuracy: 0.9081
Epoch 281/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1007 - accuracy: 0.9696 - val_
loss: 0.3170 - val_accuracy: 0.9086
Epoch 282/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1028 - accuracy: 0.9692 - val_
loss: 0.3212 - val_accuracy: 0.9083
Epoch 283/300
200/200 [==============================] - 62s 308ms/step - loss: 0.0985 - accuracy: 0.9723 - val_
loss: 0.3206 - val_accuracy: 0.9068
Epoch 284/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1086 - accuracy: 0.9674 - val_
loss: 0.3244 - val_accuracy: 0.9071
Epoch 285/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1017 - accuracy: 0.9709 - val_
loss: 0.3157 - val_accuracy: 0.9079
Epoch 286/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1034 - accuracy: 0.9686 - val_
loss: 0.3151 - val_accuracy: 0.9078
Epoch 287/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1012 - accuracy: 0.9694 - val_
loss: 0.3199 - val_accuracy: 0.9067
Epoch 288/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1070 - accuracy: 0.9666 - val_
loss: 0.3173 - val_accuracy: 0.9080
Epoch 289/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1046 - accuracy: 0.9671 - val_
loss: 0.3161 - val_accuracy: 0.9086
Epoch 290/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1013 - accuracy: 0.9686 - val_
loss: 0.3214 - val_accuracy: 0.9060
Epoch 291/300
200/200 [==============================] - 62s 308ms/step - loss: 0.0985 - accuracy: 0.9712 - val_
loss: 0.3168 - val_accuracy: 0.9072
Epoch 292/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1051 - accuracy: 0.9680 - val_
loss: 0.3167 - val_accuracy: 0.9082
Epoch 293/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1090 - accuracy: 0.9658 - val_
loss: 0.3215 - val_accuracy: 0.9069
Epoch 294/300
200/200 [==============================] - 62s 308ms/step - loss: 0.0990 - accuracy: 0.9702 - val_
loss: 0.3181 - val_accuracy: 0.9066
Epoch 295/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1014 - accuracy: 0.9705 - val_
loss: 0.3197 - val_accuracy: 0.9071
Epoch 296/300
200/200 [==============================] - 62s 310ms/step - loss: 0.1081 - accuracy: 0.9684 - val_
loss: 0.3204 - val_accuracy: 0.9070
Epoch 297/300
200/200 [==============================] - 62s 309ms/step - loss: 0.1047 - accuracy: 0.9700 - val_
loss: 0.3171 - val_accuracy: 0.9072
Epoch 298/300
200/200 [==============================] - 61s 307ms/step - loss: 0.1003 - accuracy: 0.9711 - val_
loss: 0.3204 - val_accuracy: 0.9069
Epoch 299/300
200/200 [==============================] - 62s 308ms/step - loss: 0.1115 - accuracy: 0.9656 - val_
loss: 0.3198 - val_accuracy: 0.9068
Epoch 300/300
200/200 [==============================] - 62s 308ms/step - loss: 0.0993 - accuracy: 0.9692 - val_
loss: 0.3217 - val_accuracy: 0.9064
Wall time: 5h 8min 40s
```

Out[13]:

```
<keras.callbacks.callbacks.History at 0x205b0270f28>
```

In [16]:

```
scores = model.evaluate(X_test, y_test,verbose = 1)
print("Accuracy = %f" % (100 * scores[1]))
```

```
10000/10000 [==============================] - 14s 1ms/step
Accuracy = 90.640002
```

In [ ]:

In [ ]:

In [ ]:

In [ ]:

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