1. Importing Necessary Libraries

```
# import keras
# from keras.datasets import cifar10
# from keras.models import Model, Sequential
# from keras.layers import Dense, Dropout, Flatten, Input, AveragePooling2D, merge
# from keras.layers import Conv2D, MaxPooling2D, BatchNormalization
# from keras.layers import Concatenate
# from keras.optimizers import Adam
from tensorflow.keras import models, layers
from tensorflow.keras.models import Model
from tensorflow.keras.layers import BatchNormalization, Activation, Flatten
from tensorflow.keras.optimizers import Adam
```

The default version of TensorFlow in Colab will soon switch to TensorFlow 2.x.
We recommend you upgrade now or ensure your notebook will continue to use TensorFlow 1.x via the `%tensorflow_version 1.x` magic: more info.

```
# this part will prevent tensorflow to allocate all the avaliable GPU Memory
# backend
import tensorflow as tf

# Hyperparameters
batch_size = 128
num_classes = 10
epochs = 10
```

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```
dropout_rate = 0.2
```

2. Loading the dataset(Train and Test)

```
# load train and test dataset
def load_dataset():
  # load dataset
  (X_train, y_train), (X_test, y_test)= tf.keras.datasets.cifar10.load_data()
  # one hot encode target values
  y_train = tf.keras.utils.to_categorical(y_train, num_classes)
  y_test = tf.keras.utils.to_categorical(y_test, num_classes)
  return X_train,y_train,X_test,y_test

X_train, y_train,X_test,y_test = load_dataset()
img_height, img_width, channel = X_train.shape[1],X_train.shape[2],X_train.shape[3

# convert to one hot encoing
```

```
Downloading data from https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz
170500096/170498071 [==============================] - 4s 0us/step
```

```
X_train.shape
```

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

```
X_test.shape
```

```
(10000, 32, 32, 3)
```

3. Standardizing the dataset

```
#https://machinelearningmastery.com/how-to-develop-a-cnn-from-scratch-for-cifar-10
def prep_pixels(train, test):
  # convert from integers to floats
  train_norm = train.astype('float32')
  test_norm = test.astype('float32')
  # normalize to range 0-1
  train_norm = train_norm / 255.0
  test_norm = test_norm / 255.0
  # return normalized images
  return train_norm, test_norm

X_train,X_test=prep_pixels(X_train,X_test)
```

Saving...

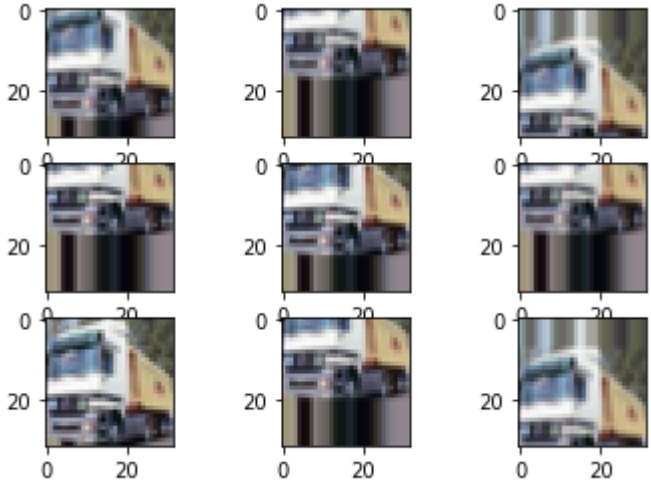
ample with Keras

```
#https://machinelearningmastery.com/how-to-configure-image-data-augmentation-when-
from numpy import expand_dims
from keras.preprocessing.image import load_img
from keras.preprocessing.image import img_to_array
from keras.preprocessing.image import ImageDataGenerator
from matplotlib import pyplot
first_image=X_train[1]
print(first_image.shape)
first_img = expand_dims(first_image, 0)
print(first_img.shape)
#pyplot.imshow(first_img[0])

# create image data augmentation generator
datagen = ImageDataGenerator(height_shift_range=0.5)
# prepare iterator
it = datagen.flow(first_img, batch_size=1)
# generate samples and plot
for i in range(9):
  # define subplot
  pyplot.subplot(330 + 1 + i)
  # generate batch of images
```

```
  batch = it.next()
  # convert to unsigned integers for viewing
  image = (batch[0]*255).astype('uint8')
  # plot raw pixel data
  pyplot.imshow(image)
# show the figure
pyplot.show()
```

```
Using TensorFlow backend.
(32, 32, 3)
(1, 32, 32, 3)
```



```
def summarize_diagnostics(history):
  # plot loss
  pyplot.subplot(211)
  pyplot.title('Cross Entropy Loss')
                                    oss'], color='blue', label='train')
                                    al_loss'], color='orange', label='test')
```


5. Creating the DenseNet Basic Blocks

```
from keras import regularizers
# Dense Block
def denseblock(input, num_filter = 12, dropout_rate = 0.2):
    global compression
    temp = input
    for _ in range(l):
        BatchNorm = layers.BatchNormalization()(temp)
        relu = layers.Activation('relu')(BatchNorm)
        Conv2D_3_3 = layers.Conv2D(int(num_filter*compression), (5,5), use_bias=Fa
        if dropout_rate>0:
            Conv2D_3_3 = layers.Dropout(dropout_rate)(Conv2D_3_3)
        concat = layers.Concatenate(axis=-1)([temp,Conv2D_3_3])

        temp = concat

    return temp

## transition Blosck
```

```
## transition Block
def transition(input, num_filter = 12, dropout_rate = 0.2):
    global compression
    BatchNorm = layers.BatchNormalization()(input)
    relu = layers.Activation('relu')(BatchNorm)
    Conv2D_BottleNeck = layers.Conv2D(int(num_filter*compression), (5,5), use_bias
    if dropout_rate>0:
         Conv2D_BottleNeck = layers.Dropout(dropout_rate)(Conv2D_BottleNeck)
    avg = layers.AveragePooling2D(pool_size=(2,2))(Conv2D_BottleNeck)
    return avg

#output layer
def output_layer(input):
    global compression
    BatchNorm = layers.BatchNormalization()(input)
    relu = layers.Activation('relu')(BatchNorm)
    AvgPooling = layers. MaxPooling2D(pool_size=(2,2))(relu)

    output = layers.Conv2D(filters=10,kernel_size=(2,2),activation='softmax')(AvgP

    flat = layers.Flatten()(output)
    return flat



num_filter = 12
dropout_rate = 0
l = 12
input = layers.Input(shape=(img_height, img_width, channel,))
First_Conv2D = layers.Conv2D(32, (3,3), use_bias=False ,padding='same')(input)

First_Block = denseblock(First_Conv2D,num_filter, dropout_rate)
First_Transition = transition(First_Block, 64, dropout_rate)

Second_Block = denseblock(First_Transition, num_filter, dropout_rate)
Second_Transition = transition(Second_Block, 64, dropout_rate)

Third_Block = denseblock(Second_Transition, num_filter, dropout_rate)
Third_Transition = transition(Third_Block, 32, dropout_rate)

Last_Block = denseblock(Third_Transition,  num_filter, dropout_rate)
output = output_layer(Last_Block)
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow_cor
Instructions for updating:
If using Keras pass *_constraint arguments to layers.
```

```
sgd = tf.keras.optimizers.SGD(lr = 0.1,momentum = 0.9,nesterov = True)
model = Model(inputs=[input], outputs=[output])
model.compile(sgd,loss='categorical_crossentropy', metrics=['accuracy'])
model.summary()
```

```
Model: "model"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_1 (InputLayer)            [(None, 32, 32, 3)]  0
__________________________________________________________________________________________________
conv2d (Conv2D)                 (None, 32, 32, 32)   864         input_1[0][0
__________________________________________________________________________________________________
batch_normalization (BatchNorma (None, 32, 32, 32)   128         conv2d[0][0]
__________________________________________________________________________________________________
activation (Activation)         (None, 32, 32, 32)   0           batch_normal
__________________________________________________________________________________________________
conv2d_1 (Conv2D)               (None, 32, 32, 6)    4800        activation[0
__________________________________________________________________________________________________
concatenate (Concatenate)       (None, 32, 32, 38)   0           conv2d[0][0]
                                                                 conv2d_1[0][
__________________________________________________________________________________________________
batch_normalization_1 (BatchNor (None, 32, 32, 38)   152         concatenate[
__________________________________________________________________________________________________
activation_1 (Activation)       (None, 32, 32, 38)   0           batch_normal
__________________________________________________________________________________________________
conv2d_2 (Conv2D)               (None, 32, 32, 6)    5700        activation_1
__________________________________________________________________________________________________
concatenate_1 (Concatenate)     (None, 32, 32, 44)   0           concatenate[
                                                                 conv2d_2[0][
__________________________________________________________________________________________________
batch_normalization_2 (BatchNor (None, 32, 32, 44)   176         concatenate_
__________________________________________________________________________________________________
activation_2 (Activation)       (None, 32, 32, 44)   0           batch_normal
__________________________________________________________________________________________________
conv2d_3 (Conv2D)               (None, 32, 32, 6)    6600        activation_2
__________________________________________________________________________________________________
concatenate_2 (Concatenate)     (None, 32, 32, 50)   0           concatenate_
                                                                 conv2d_3[0][
__________________________________________________________________________________________________
                                Nor (None, 32, 32, 50)   200         concatenate_
__________________________________________________________________________________________________
activation_3 (Activation)       (None, 32, 32, 50)   0           batch_normal
__________________________________________________________________________________________________
conv2d_4 (Conv2D)               (None, 32, 32, 6)    7500        activation_3
__________________________________________________________________________________________________
concatenate_3 (Concatenate)     (None, 32, 32, 56)   0           concatenate_
                                                                 conv2d_4[0][
__________________________________________________________________________________________________
batch_normalization_4 (BatchNor (None, 32, 32, 56)   224         concatenate_
__________________________________________________________________________________________________
activation_4 (Activation)       (None, 32, 32, 56)   0           batch_normal
__________________________________________________________________________________________________
conv2d_5 (Conv2D)               (None, 32, 32, 6)    8400        activation_4
__________________________________________________________________________________________________
concatenate_4 (Concatenate)     (None, 32, 32, 62)   0           concatenate_
                                                                 conv2d_5[0][
__________________________________________________________________________________________________
batch_normalization_5 (BatchNor (None, 32, 32, 62)   248         concatenate_
__________________________________________________________________________________________________
activation_5 (Activation)       (None, 32, 32, 62)   0           batch_normal
__________________________________________________________________________________________________
conv2d_6 (Conv2D)               (None, 32, 32, 6)    9300        activation_5
__________________________________________________________________________________________________
concatenate_5 (Concatenate)     (None, 32, 32, 68)   0           concatenate_
                                                                 conv2d_6[0][
```

batch_normalization_6 (BatchNor	(None, 32, 32, 68)	272	concatenate_
activation_6 (Activation)	(None, 32, 32, 68)	0	batch_normal
conv2d_7 (Conv2D)	(None, 32, 32, 6)	10200	activation_6
concatenate_6 (Concatenate)	(None, 32, 32, 74)	0	concatenate_ conv2d_7[0][
batch_normalization_7 (BatchNor	(None, 32, 32, 74)	296	concatenate_
activation_7 (Activation)	(None, 32, 32, 74)	0	batch_normal
conv2d_8 (Conv2D)	(None, 32, 32, 6)	11100	activation_7
concatenate_7 (Concatenate)	(None, 32, 32, 80)	0	concatenate_ conv2d_8[0][
batch_normalization_8 (BatchNor	(None, 32, 32, 80)	320	concatenate_
activation_8 (Activation)	(None, 32, 32, 80)	0	batch_normal
conv2d_9 (Conv2D)	(None, 32, 32, 6)	12000	activation_8
concatenate_8 (Concatenate)	(None, 32, 32, 86)	0	concatenate_ conv2d_9[0][
batch_normalization_9 (BatchNor	(None, 32, 32, 86)	344	concatenate_
activation_9 (Activation)	(None, 32, 32, 86)	0	batch_normal
conv2d_10 (Conv2D)	(None, 32, 32, 6)	12900	activation_9
	(None, 32, 32, 92)	0	concatenate_ conv2d_10[0]
batch_normalization_10 (BatchNo	(None, 32, 32, 92)	368	concatenate_
activation_10 (Activation)	(None, 32, 32, 92)	0	batch_normal
conv2d_11 (Conv2D)	(None, 32, 32, 6)	13800	activation_1
concatenate_10 (Concatenate)	(None, 32, 32, 98)	0	concatenate_ conv2d_11[0]
batch_normalization_11 (BatchNo	(None, 32, 32, 98)	392	concatenate_
activation_11 (Activation)	(None, 32, 32, 98)	0	batch_normal
conv2d_12 (Conv2D)	(None, 32, 32, 6)	14700	activation_1
concatenate_11 (Concatenate)	(None, 32, 32, 104)	0	concatenate_ conv2d_12[0]
batch_normalization_12 (BatchNo	(None, 32, 32, 104)	416	concatenate_
activation_12 (Activation)	(None, 32, 32, 104)	0	batch_normal
conv2d_13 (Conv2D)	(None, 32, 32, 32)	83200	activation_1
average_pooling2d (AveragePooli	(None, 16, 16, 32)	0	conv2d_13[0]

batch_normalization_13 (BatchNo	(None, 16, 16, 32)	128	average_pool
activation_13 (Activation)	(None, 16, 16, 32)	0	batch_normal
conv2d_14 (Conv2D)	(None, 16, 16, 6)	4800	activation_1
concatenate_12 (Concatenate)	(None, 16, 16, 38)	0	average_pool conv2d_14[0]
batch_normalization_14 (BatchNo	(None, 16, 16, 38)	152	concatenate_
activation_14 (Activation)	(None, 16, 16, 38)	0	batch_normal
conv2d_15 (Conv2D)	(None, 16, 16, 6)	5700	activation_1
concatenate_13 (Concatenate)	(None, 16, 16, 44)	0	concatenate_ conv2d_15[0]
batch_normalization_15 (BatchNo	(None, 16, 16, 44)	176	concatenate_
activation_15 (Activation)	(None, 16, 16, 44)	0	batch_normal
conv2d_16 (Conv2D)	(None, 16, 16, 6)	6600	activation_1
concatenate_14 (Concatenate)	(None, 16, 16, 50)	0	concatenate_ conv2d_16[0]
batch_normalization_16 (BatchNo	(None, 16, 16, 50)	200	concatenate_
activation_16 (Activation)	(None, 16, 16, 50)	0	batch_normal
conv2d_17 (Conv2D)	(None, 16, 16, 6)	7500	activation_1
	(None, 16, 16, 56)	0	concatenate_ conv2d_17[0]
batch_normalization_17 (BatchNo	(None, 16, 16, 56)	224	concatenate_
activation_17 (Activation)	(None, 16, 16, 56)	0	batch_normal
conv2d_18 (Conv2D)	(None, 16, 16, 6)	8400	activation_1
concatenate_16 (Concatenate)	(None, 16, 16, 62)	0	concatenate_ conv2d_18[0]
batch_normalization_18 (BatchNo	(None, 16, 16, 62)	248	concatenate_
activation_18 (Activation)	(None, 16, 16, 62)	0	batch_normal
conv2d_19 (Conv2D)	(None, 16, 16, 6)	9300	activation_1
concatenate_17 (Concatenate)	(None, 16, 16, 68)	0	concatenate_ conv2d_19[0]
batch_normalization_19 (BatchNo	(None, 16, 16, 68)	272	concatenate_
activation_19 (Activation)	(None, 16, 16, 68)	0	batch_normal
conv2d_20 (Conv2D)	(None, 16, 16, 6)	10200	activation_1

concatenate_18 (Concatenate)	(None, 16, 16, 74)	0	concatenate_ conv2d_20[0]
batch_normalization_20 (BatchNo	(None, 16, 16, 74)	296	concatenate_
activation_20 (Activation)	(None, 16, 16, 74)	0	batch_normal
conv2d_21 (Conv2D)	(None, 16, 16, 6)	11100	activation_2
concatenate_19 (Concatenate)	(None, 16, 16, 80)	0	concatenate_ conv2d_21[0]
batch_normalization_21 (BatchNo	(None, 16, 16, 80)	320	concatenate_
activation_21 (Activation)	(None, 16, 16, 80)	0	batch_normal
conv2d_22 (Conv2D)	(None, 16, 16, 6)	12000	activation_2
concatenate_20 (Concatenate)	(None, 16, 16, 86)	0	concatenate_ conv2d_22[0]
batch_normalization_22 (BatchNo	(None, 16, 16, 86)	344	concatenate_
activation_22 (Activation)	(None, 16, 16, 86)	0	batch_normal
conv2d_23 (Conv2D)	(None, 16, 16, 6)	12900	activation_2
concatenate_21 (Concatenate)	(None, 16, 16, 92)	0	concatenate_ conv2d_23[0]
batch_normalization_23 (BatchNo	(None, 16, 16, 92)	368	concatenate_
activation_23 (Activation)	(None, 16, 16, 92)	0	batch_normal
	(None, 16, 16, 6)	13800	activation_2
	(None, 16, 16, 98)	0	concatenate_ conv2d_24[0]
batch_normalization_24 (BatchNo	(None, 16, 16, 98)	392	concatenate_
activation_24 (Activation)	(None, 16, 16, 98)	0	batch_normal
conv2d_25 (Conv2D)	(None, 16, 16, 6)	14700	activation_2
concatenate_23 (Concatenate)	(None, 16, 16, 104)	0	concatenate_ conv2d_25[0]
batch_normalization_25 (BatchNo	(None, 16, 16, 104)	416	concatenate_
activation_25 (Activation)	(None, 16, 16, 104)	0	batch_normal
conv2d_26 (Conv2D)	(None, 16, 16, 32)	83200	activation_2
average_pooling2d_1 (AveragePoo	(None, 8, 8, 32)	0	conv2d_26[0]
batch_normalization_26 (BatchNo	(None, 8, 8, 32)	128	average_pool
activation_26 (Activation)	(None, 8, 8, 32)	0	batch_normal
conv2d_27 (Conv2D)	(None, 8, 8, 6)	4800	activation_2

concatenate_24 (Concatenate)	(None, 8, 8, 38)	0	average_pool conv2d_27[0]
batch_normalization_27 (BatchNo	(None, 8, 8, 38)	152	concatenate_
activation_27 (Activation)	(None, 8, 8, 38)	0	batch_normal
conv2d_28 (Conv2D)	(None, 8, 8, 6)	5700	activation_2
concatenate_25 (Concatenate)	(None, 8, 8, 44)	0	concatenate_ conv2d_28[0]
batch_normalization_28 (BatchNo	(None, 8, 8, 44)	176	concatenate_
activation_28 (Activation)	(None, 8, 8, 44)	0	batch_normal
conv2d_29 (Conv2D)	(None, 8, 8, 6)	6600	activation_2
concatenate_26 (Concatenate)	(None, 8, 8, 50)	0	concatenate_ conv2d_29[0]
batch_normalization_29 (BatchNo	(None, 8, 8, 50)	200	concatenate_
activation_29 (Activation)	(None, 8, 8, 50)	0	batch_normal
conv2d_30 (Conv2D)	(None, 8, 8, 6)	7500	activation_2
concatenate_27 (Concatenate)	(None, 8, 8, 56)	0	concatenate_ conv2d_30[0]
batch_normalization_30 (BatchNo	(None, 8, 8, 56)	224	concatenate_
activation_30 (Activation)	(None, 8, 8, 56)	0	batch_normal
	(None, 8, 8, 6)	8400	activation_3
concatenate_28 (Concatenate)	(None, 8, 8, 62)	0	concatenate_ conv2d_31[0]
batch_normalization_31 (BatchNo	(None, 8, 8, 62)	248	concatenate_
activation_31 (Activation)	(None, 8, 8, 62)	0	batch_normal
conv2d_32 (Conv2D)	(None, 8, 8, 6)	9300	activation_3
concatenate_29 (Concatenate)	(None, 8, 8, 68)	0	concatenate_ conv2d_32[0]
batch_normalization_32 (BatchNo	(None, 8, 8, 68)	272	concatenate_
activation_32 (Activation)	(None, 8, 8, 68)	0	batch_normal
conv2d_33 (Conv2D)	(None, 8, 8, 6)	10200	activation_3
concatenate_30 (Concatenate)	(None, 8, 8, 74)	0	concatenate_ conv2d_33[0]
batch_normalization_33 (BatchNo	(None, 8, 8, 74)	296	concatenate_
activation_33 (Activation)	(None, 8, 8, 74)	0	batch_normal

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conv2d_34 (Conv2D)	(None, 8, 8, 6)	11100	activation_3
concatenate_31 (Concatenate)	(None, 8, 8, 80)	0	concatenate_ conv2d_34[0]
batch_normalization_34 (BatchNo	(None, 8, 8, 80)	320	concatenate_
activation_34 (Activation)	(None, 8, 8, 80)	0	batch_normal
conv2d_35 (Conv2D)	(None, 8, 8, 6)	12000	activation_3
concatenate_32 (Concatenate)	(None, 8, 8, 86)	0	concatenate_ conv2d_35[0]
batch_normalization_35 (BatchNo	(None, 8, 8, 86)	344	concatenate_
activation_35 (Activation)	(None, 8, 8, 86)	0	batch_normal
conv2d_36 (Conv2D)	(None, 8, 8, 6)	12900	activation_3
concatenate_33 (Concatenate)	(None, 8, 8, 92)	0	concatenate_ conv2d_36[0]
batch_normalization_36 (BatchNo	(None, 8, 8, 92)	368	concatenate_
activation_36 (Activation)	(None, 8, 8, 92)	0	batch_normal
conv2d_37 (Conv2D)	(None, 8, 8, 6)	13800	activation_3
concatenate_34 (Concatenate)	(None, 8, 8, 98)	0	concatenate_ conv2d_37[0]
batch_normalization_37 (BatchNo	(None, 8, 8, 98)	392	concatenate_
	(None, 8, 8, 98)	0	batch_normal
	(None, 8, 8, 6)	14700	activation_3
concatenate_35 (Concatenate)	(None, 8, 8, 104)	0	concatenate_ conv2d_38[0]
batch_normalization_38 (BatchNo	(None, 8, 8, 104)	416	concatenate_
activation_38 (Activation)	(None, 8, 8, 104)	0	batch_normal
conv2d_39 (Conv2D)	(None, 8, 8, 16)	41600	activation_3
average_pooling2d_2 (AveragePoo	(None, 4, 4, 16)	0	conv2d_39[0]
batch_normalization_39 (BatchNo	(None, 4, 4, 16)	64	average_pool
activation_39 (Activation)	(None, 4, 4, 16)	0	batch_normal
conv2d_40 (Conv2D)	(None, 4, 4, 6)	2400	activation_3
concatenate_36 (Concatenate)	(None, 4, 4, 22)	0	average_pool conv2d_40[0]
batch_normalization_40 (BatchNo	(None, 4, 4, 22)	88	concatenate_
activation_40 (Activation)	(None, 4, 4, 22)	0	batch_normal

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conv2d_41 (Conv2D)	(None, 4, 4, 6)	3300	activation_4
concatenate_37 (Concatenate)	(None, 4, 4, 28)	0	concatenate_ conv2d_41[0]
batch_normalization_41 (BatchNo	(None, 4, 4, 28)	112	concatenate_
activation_41 (Activation)	(None, 4, 4, 28)	0	batch_normal
conv2d_42 (Conv2D)	(None, 4, 4, 6)	4200	activation_4
concatenate_38 (Concatenate)	(None, 4, 4, 34)	0	concatenate_ conv2d_42[0]
batch_normalization_42 (BatchNo	(None, 4, 4, 34)	136	concatenate_
activation_42 (Activation)	(None, 4, 4, 34)	0	batch_normal
conv2d_43 (Conv2D)	(None, 4, 4, 6)	5100	activation_4
concatenate_39 (Concatenate)	(None, 4, 4, 40)	0	concatenate_ conv2d_43[0]
batch_normalization_43 (BatchNo	(None, 4, 4, 40)	160	concatenate_
activation_43 (Activation)	(None, 4, 4, 40)	0	batch_normal
conv2d_44 (Conv2D)	(None, 4, 4, 6)	6000	activation_4
concatenate_40 (Concatenate)	(None, 4, 4, 46)	0	concatenate_ conv2d_44[0]
batch_normalization_44 (BatchNo	(None, 4, 4, 46)	184	concatenate_
	(None, 4, 4, 46)	0	batch_normal
conv2d_45 (Conv2D)	(None, 4, 4, 6)	6900	activation_4
concatenate_41 (Concatenate)	(None, 4, 4, 52)	0	concatenate_ conv2d_45[0]
batch_normalization_45 (BatchNo	(None, 4, 4, 52)	208	concatenate_
activation_45 (Activation)	(None, 4, 4, 52)	0	batch_normal
conv2d_46 (Conv2D)	(None, 4, 4, 6)	7800	activation_4
concatenate_42 (Concatenate)	(None, 4, 4, 58)	0	concatenate_ conv2d_46[0]
batch_normalization_46 (BatchNo	(None, 4, 4, 58)	232	concatenate_
activation_46 (Activation)	(None, 4, 4, 58)	0	batch_normal
conv2d_47 (Conv2D)	(None, 4, 4, 6)	8700	activation_4
concatenate_43 (Concatenate)	(None, 4, 4, 64)	0	concatenate_ conv2d_47[0]
batch_normalization_47 (BatchNo	(None, 4, 4, 64)	256	concatenate_

Saving...

```
activation_47 (Activation)      (None, 4, 4, 64)     0           batch_normal
__________________________________________________________________________________
conv2d_48 (Conv2D)              (None, 4, 4, 6)      9600        activation_4
__________________________________________________________________________________
concatenate_44 (Concatenate)    (None, 4, 4, 70)     0           concatenate_
                                                                 conv2d_48[0]
__________________________________________________________________________________
batch_normalization_48 (BatchNo (None, 4, 4, 70)     280         concatenate_
__________________________________________________________________________________
activation_48 (Activation)      (None, 4, 4, 70)     0           batch_normal
__________________________________________________________________________________
conv2d_49 (Conv2D)              (None, 4, 4, 6)      10500       activation_4
__________________________________________________________________________________
concatenate_45 (Concatenate)    (None, 4, 4, 76)     0           concatenate_
                                                                 conv2d_49[0]
__________________________________________________________________________________
batch_normalization_49 (BatchNo (None, 4, 4, 76)     304         concatenate_
__________________________________________________________________________________
activation_49 (Activation)      (None, 4, 4, 76)     0           batch_normal
__________________________________________________________________________________
conv2d_50 (Conv2D)              (None, 4, 4, 6)      11400       activation_4
__________________________________________________________________________________
concatenate_46 (Concatenate)    (None, 4, 4, 82)     0           concatenate_
                                                                 conv2d_50[0]
__________________________________________________________________________________
batch_normalization_50 (BatchNo (None, 4, 4, 82)     328         concatenate_
__________________________________________________________________________________
activation_50 (Activation)      (None, 4, 4, 82)     0           batch_normal
__________________________________________________________________________________
conv2d_51 (Conv2D)              (None, 4, 4, 6)      12300       activation_5
__________________________________________________________________________________
concatenate_47 (Concatenate)    (None, 4, 4, 88)     0           concatenate_
                                                                 conv2d_51[0]
__________________________________________________________________________________
                                (None, 4, 4, 88)     352         concatenate_
__________________________________________________________________________________
                                (None, 4, 4, 88)     0           batch_normal
__________________________________________________________________________________
max_pooling2d (MaxPooling2D)    (None, 2, 2, 88)     0           activation_5
__________________________________________________________________________________
conv2d_52 (Conv2D)              (None, 1, 1, 10)     3530        max_pooling2
__________________________________________________________________________________
flatten (Flatten)               (None, 10)           0           conv2d_52[0]
==================================================================================
Total params: 664,906
Trainable params: 658,250
Non-trainable params: 6,656
__________________________________________________________________________________
```


6. Running the model with data augumentation

6.1 Model with SGD optimizer

```
datagen = ImageDataGenerator( zoom_range=0.3,width_shift_range=0.1,rotation_range=
# prepare iterator
it_train = datagen.flow(X_train, y_train, batch_size=128)
```

```
# fit model
steps = int(X_train.shape[0] / 128)
history = model.fit_generator(it_train, steps_per_epoch=steps, epochs=150, validat
# evaluate model
_, acc = model.evaluate(X_test, y_test, verbose=0)
print('> %.3f' % (acc * 100.0))
# learning curves
summarize_diagnostics(history)
```

```
Epoch 1/150
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow_cor
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
389/390 [============================>.] - ETA: 0s - loss: 2.3142 - acc: 0.21
10000/390 [==============================================================
390/390 [==============================] - 136s 349ms/step - loss: 2.3141 - a
Epoch 2/150
389/390 [============================>.] - ETA: 0s - loss: 1.9132 - acc: 0.31
10000/390 [==============================================================
390/390 [==============================] - 122s 313ms/step - loss: 1.9130 - a
Epoch 3/150
389/390 [============================>.] - ETA: 0s - loss: 1.7051 - acc: 0.37
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 1.7047 - a
Epoch 4/150
389/390 [============================>.] - ETA: 0s - loss: 1.5894 - acc: 0.42
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 1.5894 - a
Epoch 5/150
389/390 [============================>.] - ETA: 0s - loss: 1.4996 - acc: 0.45
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 1.4993 - a
Epoch 6/150
389/390 [============================>.] - ETA: 0s - loss: 1.4130 - acc: 0.49
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 1.4132 - a
Epoch 7/150
389/390 [============================>.] - ETA: 0s - loss: 1.3398 - acc: 0.51
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 1.3398 - a
Epoch 8/150
389/390 [============================>.] - ETA: 0s - loss: 1.2637 - acc: 0.54
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 1.2639 - a
389/390 [============================>.] - ETA: 0s - loss: 1.2040 - acc: 0.57
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 1.2039 - a
Epoch 10/150
389/390 [============================>.] - ETA: 0s - loss: 1.1491 - acc: 0.59
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 1.1492 - a
Epoch 11/150
389/390 [============================>.] - ETA: 0s - loss: 1.0916 - acc: 0.61
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 1.0917 - a
Epoch 12/150
389/390 [============================>.] - ETA: 0s - loss: 1.0415 - acc: 0.63
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 1.0412 - a
Epoch 13/150
389/390 [============================>.] - ETA: 0s - loss: 0.9992 - acc: 0.64
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.9991 - a
Epoch 14/150
389/390 [============================>.] - ETA: 0s - loss: 0.9594 - acc: 0.66
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.9589 - a
Epoch 15/150
389/390 [============================>.] - ETA: 0s - loss: 0.9242 - acc: 0.67
```

Saving...

```
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.9243 - a
Epoch 16/150
389/390 [============================>.] - ETA: 0s - loss: 0.8879 - acc: 0.68
10000/390 [==================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.8874 - a
Epoch 17/150
389/390 [============================>.] - ETA: 0s - loss: 0.8643 - acc: 0.69
10000/390 [==================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.8641 - a
Epoch 18/150
389/390 [============================>.] - ETA: 0s - loss: 0.8247 - acc: 0.70
10000/390 [==================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.8245 - a
Epoch 19/150
389/390 [============================>.] - ETA: 0s - loss: 0.8015 - acc: 0.72
10000/390 [==================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.8015 - a
Epoch 20/150
389/390 [============================>.] - ETA: 0s - loss: 0.7694 - acc: 0.72
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.7691 - a
Epoch 21/150
389/390 [============================>.] - ETA: 0s - loss: 0.7491 - acc: 0.73
10000/390 [==================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.7491 - a
Epoch 22/150
389/390 [============================>.] - ETA: 0s - loss: 0.7216 - acc: 0.74
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.7221 - a
Epoch 23/150
389/390 [============================>.] - ETA: 0s - loss: 0.6993 - acc: 0.75
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.6993 - a
Saving...
=========>.] - ETA: 0s - loss: 0.6893 - acc: 0.75
=================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.6895 - a
Epoch 25/150
389/390 [============================>.] - ETA: 0s - loss: 0.6670 - acc: 0.76
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.6670 - a
Epoch 26/150
389/390 [============================>.] - ETA: 0s - loss: 0.6470 - acc: 0.77
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.6469 - a
Epoch 27/150
389/390 [============================>.] - ETA: 0s - loss: 0.6280 - acc: 0.78
10000/390 [==================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.6284 - a
Epoch 28/150
389/390 [============================>.] - ETA: 0s - loss: 0.6204 - acc: 0.78
10000/390 [==================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.6203 - a
Epoch 29/150
389/390 [============================>.] - ETA: 0s - loss: 0.6010 - acc: 0.79
10000/390 [==================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.6005 - a
Epoch 30/150
389/390 [============================>.] - ETA: 0s - loss: 0.5900 - acc: 0.79
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.5905 - a
```

```
Epoch 31/150
389/390 [============================>.] - ETA: 0s - loss: 0.5714 - acc: 0.80
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.5713 - a
Epoch 32/150
389/390 [============================>.] - ETA: 0s - loss: 0.5660 - acc: 0.80
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.5661 - a
Epoch 33/150
389/390 [============================>.] - ETA: 0s - loss: 0.5520 - acc: 0.80
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.5518 - a
Epoch 34/150
389/390 [============================>.] - ETA: 0s - loss: 0.5405 - acc: 0.81
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.5406 - a
Epoch 35/150
389/390 [============================>.] - ETA: 0s - loss: 0.5366 - acc: 0.81
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.5364 - a
Epoch 36/150
389/390 [============================>.] - ETA: 0s - loss: 0.5257 - acc: 0.81
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.5255 - a
Epoch 37/150
389/390 [============================>.] - ETA: 0s - loss: 0.5125 - acc: 0.82
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.5127 - a
Epoch 38/150
389/390 [============================>.] - ETA: 0s - loss: 0.5097 - acc: 0.82
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.5099 - a
Epoch 39/150
389/390 [============================>.] - ETA: 0s - loss: 0.5002 - acc: 0.82
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.5002 - a
Epoch 40/150
389/390 [============================>.] - ETA: 0s - loss: 0.4842 - acc: 0.83
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.4839 - a
Epoch 41/150
389/390 [============================>.] - ETA: 0s - loss: 0.4829 - acc: 0.83
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.4827 - a
Epoch 42/150
389/390 [============================>.] - ETA: 0s - loss: 0.4755 - acc: 0.83
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.4753 - a
Epoch 43/150
389/390 [============================>.] - ETA: 0s - loss: 0.4721 - acc: 0.83
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.4724 - a
Epoch 44/150
389/390 [============================>.] - ETA: 0s - loss: 0.4607 - acc: 0.84
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.4605 - a
Epoch 45/150
389/390 [============================>.] - ETA: 0s - loss: 0.4594 - acc: 0.83
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.4593 - a
Epoch 46/150
```

Saving...

```
389/390 [============================>.] - ETA: 0s - loss: 0.4481 - acc: 0.84
10000/390 [==============================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.4483 - a
Epoch 47/150
389/390 [============================>.] - ETA: 0s - loss: 0.4474 - acc: 0.84
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.4476 - a
Epoch 48/150
389/390 [============================>.] - ETA: 0s - loss: 0.4356 - acc: 0.84
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.4357 - a
Epoch 49/150
389/390 [============================>.] - ETA: 0s - loss: 0.4345 - acc: 0.85
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.4345 - a
Epoch 50/150
389/390 [============================>.] - ETA: 0s - loss: 0.4200 - acc: 0.85
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.4201 - a
Epoch 51/150
389/390 [============================>.] - ETA: 0s - loss: 0.4223 - acc: 0.85
10000/390 [==============================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.4228 - a
Epoch 52/150
389/390 [============================>.] - ETA: 0s - loss: 0.4175 - acc: 0.85
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.4175 - a
Epoch 53/150
389/390 [============================>.] - ETA: 0s - loss: 0.4102 - acc: 0.85
10000/390 [==============================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.4101 - a
Epoch 54/150
389/390 [============================>.] - ETA: 0s - loss: 0.4117 - acc: 0.85
10000/390 [==============================================================
                                ==========] - 123s 314ms/step - loss: 0.4116 - a
                                ==========>.] - ETA: 0s - loss: 0.3999 - acc: 0.86
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.4000 - a
Epoch 56/150
389/390 [============================>.] - ETA: 0s - loss: 0.3972 - acc: 0.86
10000/390 [==============================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.3970 - a
Epoch 57/150
389/390 [============================>.] - ETA: 0s - loss: 0.3930 - acc: 0.86
10000/390 [==============================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.3930 - a
Epoch 58/150
389/390 [============================>.] - ETA: 0s - loss: 0.3888 - acc: 0.86
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3890 - a
Epoch 59/150
389/390 [============================>.] - ETA: 0s - loss: 0.3837 - acc: 0.86
10000/390 [==============================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.3834 - a
Epoch 60/150
389/390 [============================>.] - ETA: 0s - loss: 0.3820 - acc: 0.86
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3820 - a
Epoch 61/150
389/390 [============================>.] - ETA: 0s - loss: 0.3772 - acc: 0.86
10000/390 [==============================================================
```

Saving...

```
390/390 [==============================] - 123s 314ms/step - loss: 0.3770 - a
Epoch 62/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3702 - acc: 0.87
10000/390 [==========================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3703 - a
Epoch 63/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3684 - acc: 0.87
10000/390 [==========================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3682 - a
Epoch 64/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3691 - acc: 0.87
10000/390 [==========================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3691 - a
Epoch 65/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3629 - acc: 0.87
10000/390 [==========================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3630 - a
Epoch 66/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3591 - acc: 0.87
10000/390 [==========================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3591 - a
Epoch 67/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3577 - acc: 0.87
10000/390 [==========================================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.3579 - a
Epoch 68/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3498 - acc: 0.87
10000/390 [==========================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3500 - a
Epoch 69/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3494 - acc: 0.87
10000/390 [==========================================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.3494 - a
Epoch 70/150
                                          ==========>.] - ETA: 0s - loss: 0.3468 - acc: 0.87
                                          ==========================================================
                                          ==============] - 122s 314ms/step - loss: 0.3469 - a
Epoch 71/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3443 - acc: 0.88
10000/390 [==========================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.3440 - a
Epoch 72/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3415 - acc: 0.88
10000/390 [==========================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.3413 - a
Epoch 73/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3408 - acc: 0.88
10000/390 [==========================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3406 - a
Epoch 74/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3338 - acc: 0.88
10000/390 [==========================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3337 - a
Epoch 75/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3338 - acc: 0.88
10000/390 [==========================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3336 - a
Epoch 76/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3316 - acc: 0.88
10000/390 [==========================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.3315 - a
```

Saving...

```
Epoch 77/150
389/390 [============================>.] - ETA: 0s - loss: 0.3293 - acc: 0.88
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.3296 - a
Epoch 78/150
389/390 [============================>.] - ETA: 0s - loss: 0.3201 - acc: 0.88
10000/390 [==================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3201 - a
Epoch 79/150
389/390 [============================>.] - ETA: 0s - loss: 0.3264 - acc: 0.88
10000/390 [==================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3264 - a
Epoch 80/150
389/390 [============================>.] - ETA: 0s - loss: 0.3180 - acc: 0.88
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.3179 - a
Epoch 81/150
389/390 [============================>.] - ETA: 0s - loss: 0.3173 - acc: 0.88
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.3172 - a
Epoch 82/150
389/390 [============================>.] - ETA: 0s - loss: 0.3195 - acc: 0.88
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.3194 - a
Epoch 83/150
389/390 [============================>.] - ETA: 0s - loss: 0.3138 - acc: 0.89
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.3139 - a
Epoch 84/150
389/390 [============================>.] - ETA: 0s - loss: 0.3098 - acc: 0.89
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.3097 - a
Epoch 85/150
389/390 [============================>.] - ETA: 0s - loss: 0.3087 - acc: 0.89
==================================================
============] - 122s 314ms/step - loss: 0.3086 - a
389/390 [============================>.] - ETA: 0s - loss: 0.3074 - acc: 0.89
10000/390 [==================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3071 - a
Epoch 87/150
389/390 [============================>.] - ETA: 0s - loss: 0.3033 - acc: 0.89
10000/390 [==================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.3032 - a
Epoch 88/150
389/390 [============================>.] - ETA: 0s - loss: 0.3078 - acc: 0.89
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.3079 - a
Epoch 89/150
389/390 [============================>.] - ETA: 0s - loss: 0.3004 - acc: 0.89
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.3005 - a
Epoch 90/150
389/390 [============================>.] - ETA: 0s - loss: 0.2964 - acc: 0.89
10000/390 [==================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.2966 - a
Epoch 91/150
389/390 [============================>.] - ETA: 0s - loss: 0.2936 - acc: 0.89
10000/390 [==================================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2931 - a
Epoch 92/150
389/390 [============================>.] - ETA: 0s - loss: 0.2959 - acc: 0.89
```

Saving...

```
10000/390 [==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2956 - a
Epoch 93/150
389/390 [============================>.] - ETA: 0s - loss: 0.2911 - acc: 0.89
10000/390 [==============================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.2910 - a
Epoch 94/150
389/390 [============================>.] - ETA: 0s - loss: 0.2983 - acc: 0.89
10000/390 [==============================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.2983 - a
Epoch 95/150
389/390 [============================>.] - ETA: 0s - loss: 0.2937 - acc: 0.89
10000/390 [==============================================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2937 - a
Epoch 96/150
389/390 [============================>.] - ETA: 0s - loss: 0.2883 - acc: 0.89
10000/390 [==============================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.2884 - a
Epoch 97/150
389/390 [============================>.] - ETA: 0s - loss: 0.2856 - acc: 0.90
10000/390 [==============================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.2857 - a
Epoch 98/150
389/390 [============================>.] - ETA: 0s - loss: 0.2813 - acc: 0.90
10000/390 [==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2813 - a
Epoch 99/150
389/390 [============================>.] - ETA: 0s - loss: 0.2836 - acc: 0.90
10000/390 [==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2834 - a
Epoch 100/150
389/390 [============================>.] - ETA: 0s - loss: 0.2808 - acc: 0.90
10000/390 [==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2810 - a
Saving...
==========>.] - ETA: 0s - loss: 0.2796 - acc: 0.90
==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2796 - a
Epoch 102/150
389/390 [============================>.] - ETA: 0s - loss: 0.2783 - acc: 0.90
10000/390 [==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2780 - a
Epoch 103/150
389/390 [============================>.] - ETA: 0s - loss: 0.2719 - acc: 0.90
10000/390 [==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2718 - a
Epoch 104/150
389/390 [============================>.] - ETA: 0s - loss: 0.2747 - acc: 0.90
10000/390 [==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2748 - a
Epoch 105/150
389/390 [============================>.] - ETA: 0s - loss: 0.2690 - acc: 0.90
10000/390 [==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2691 - a
Epoch 106/150
389/390 [============================>.] - ETA: 0s - loss: 0.2683 - acc: 0.90
10000/390 [==============================================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2689 - a
Epoch 107/150
389/390 [============================>.] - ETA: 0s - loss: 0.2693 - acc: 0.90
10000/390 [==============================================================================
```

```
390/390 [==============================] - 123s 314ms/step - loss: 0.2693 - a
Epoch 108/150
389/390 [============================>.] - ETA: 0s - loss: 0.2678 - acc: 0.90
10000/390 [==========================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2680 - a
Epoch 109/150
389/390 [============================>.] - ETA: 0s - loss: 0.2679 - acc: 0.90
10000/390 [==========================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2678 - a
Epoch 110/150
389/390 [============================>.] - ETA: 0s - loss: 0.2560 - acc: 0.91
10000/390 [==========================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2560 - a
Epoch 111/150
389/390 [============================>.] - ETA: 0s - loss: 0.2572 - acc: 0.91
10000/390 [==========================================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2573 - a
Epoch 112/150
389/390 [============================>.] - ETA: 0s - loss: 0.2626 - acc: 0.90
10000/390 [==========================================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2627 - a
Epoch 113/150
389/390 [============================>.] - ETA: 0s - loss: 0.2612 - acc: 0.90
10000/390 [==========================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2613 - a
Epoch 114/150
389/390 [============================>.] - ETA: 0s - loss: 0.2585 - acc: 0.90
10000/390 [==========================================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2585 - a
Epoch 115/150
389/390 [============================>.] - ETA: 0s - loss: 0.2542 - acc: 0.91
10000/390 [==========================================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2541 - a
Epoch 116/150
                                    ==========>.] - ETA: 0s - loss: 0.2554 - acc: 0.91
                                    ==========================================================
                                    ==========] - 123s 315ms/step - loss: 0.2558 - a
Epoch 117/150
389/390 [============================>.] - ETA: 0s - loss: 0.2526 - acc: 0.91
10000/390 [==========================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2526 - a
Epoch 118/150
389/390 [============================>.] - ETA: 0s - loss: 0.2514 - acc: 0.91
10000/390 [==========================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.2514 - a
Epoch 119/150
389/390 [============================>.] - ETA: 0s - loss: 0.2522 - acc: 0.91
10000/390 [==========================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.2521 - a
Epoch 120/150
389/390 [============================>.] - ETA: 0s - loss: 0.2501 - acc: 0.91
10000/390 [==========================================================================
390/390 [==============================] - 122s 312ms/step - loss: 0.2500 - a
Epoch 121/150
389/390 [============================>.] - ETA: 0s - loss: 0.2466 - acc: 0.91
10000/390 [==========================================================================
390/390 [==============================] - 122s 312ms/step - loss: 0.2467 - a
Epoch 122/150
389/390 [============================>.] - ETA: 0s - loss: 0.2466 - acc: 0.91
10000/390 [==========================================================================
390/390 [==============================] - 122s 313ms/step - loss: 0.2467 - a
Epoch 123/150
```

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389/390 [============================>.] - ETA: 0s - loss: 0.2453 - acc: 0.91
10000/390 [==============================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2453 - a
Epoch 124/150
389/390 [============================>.] - ETA: 0s - loss: 0.2432 - acc: 0.91
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2430 - a
Epoch 125/150
389/390 [============================>.] - ETA: 0s - loss: 0.2407 - acc: 0.91
10000/390 [==============================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2407 - a
Epoch 126/150
389/390 [============================>.] - ETA: 0s - loss: 0.2457 - acc: 0.91
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2459 - a
Epoch 127/150
389/390 [============================>.] - ETA: 0s - loss: 0.2400 - acc: 0.91
10000/390 [==============================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2400 - a
Epoch 128/150
389/390 [============================>.] - ETA: 0s - loss: 0.2350 - acc: 0.91
10000/390 [==============================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2348 - a
Epoch 129/150
389/390 [============================>.] - ETA: 0s - loss: 0.2354 - acc: 0.91
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2355 - a
Epoch 130/150
389/390 [============================>.] - ETA: 0s - loss: 0.2373 - acc: 0.91
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2374 - a
Epoch 131/150
389/390 [============================>.] - ETA: 0s - loss: 0.2295 - acc: 0.91
10000/390 [==============================================================
                                        ] - 123s 315ms/step - loss: 0.2296 - a
                                        ] - ETA: 0s - loss: 0.2346 - acc: 0.91
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2346 - a
Epoch 133/150
389/390 [============================>.] - ETA: 0s - loss: 0.2358 - acc: 0.91
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2357 - a
Epoch 134/150
389/390 [============================>.] - ETA: 0s - loss: 0.2306 - acc: 0.92
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2306 - a
Epoch 135/150
389/390 [============================>.] - ETA: 0s - loss: 0.2359 - acc: 0.91
10000/390 [==============================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2359 - a
Epoch 136/150
389/390 [============================>.] - ETA: 0s - loss: 0.2279 - acc: 0.92
10000/390 [==============================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2281 - a
Epoch 137/150
389/390 [============================>.] - ETA: 0s - loss: 0.2217 - acc: 0.92
10000/390 [==============================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2216 - a
Epoch 138/150
389/390 [============================>.] - ETA: 0s - loss: 0.2365 - acc: 0.91
```

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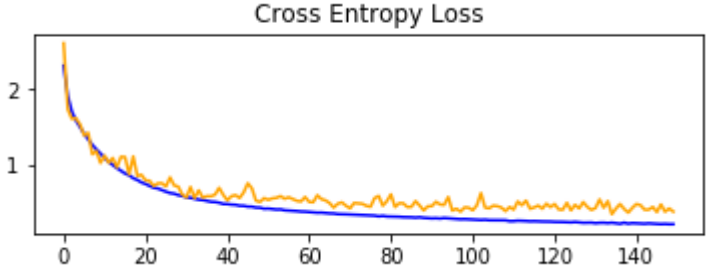
10000/390 [==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2365 - a
Epoch 139/150
389/390 [============================>.] - ETA: 0s - loss: 0.2232 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2230 - a
Epoch 140/150
389/390 [============================>.] - ETA: 0s - loss: 0.2307 - acc: 0.91
10000/390 [==============================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.2305 - a
Epoch 141/150
389/390 [============================>.] - ETA: 0s - loss: 0.2272 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2271 - a
Epoch 142/150
389/390 [============================>.] - ETA: 0s - loss: 0.2226 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.2226 - a
Epoch 143/150
389/390 [============================>.] - ETA: 0s - loss: 0.2221 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2222 - a
Epoch 144/150
389/390 [============================>.] - ETA: 0s - loss: 0.2265 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.2269 - a
Epoch 145/150
389/390 [============================>.] - ETA: 0s - loss: 0.2247 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2247 - a
Epoch 146/150
389/390 [============================>.] - ETA: 0s - loss: 0.2200 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2200 - a
Epoch 147/150
389/390 [============================>.] - ETA: 0s - loss: 0.2174 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2172 - a
Epoch 148/150
389/390 [============================>.] - ETA: 0s - loss: 0.2195 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 123s 315ms/step - loss: 0.2196 - a
Epoch 149/150
389/390 [============================>.] - ETA: 0s - loss: 0.2159 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 122s 314ms/step - loss: 0.2159 - a
Epoch 150/150
389/390 [============================>.] - ETA: 0s - loss: 0.2161 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 123s 314ms/step - loss: 0.2162 - a
> 88.400
```

6.2 Model with Adam Optimizer

```
datagen = ImageDataGenerator( zoom_range=0.3,width_shift_range=0.1,rotation_range=
# prepare iterator
it_train = datagen.flow(X_train, y_train, batch_size=128)
# fit model
steps = int(X_train.shape[0] / 128)
history = model.fit_generator(it_train, steps_per_epoch=steps, epochs=150, validat
# evaluate model
_, acc = model.evaluate(X_test, y_test, verbose=0)
print('> %.3f' % (acc * 100.0))
# learning curves
summarize_diagnostics(history)
```

```
Epoch 1/150
389/390 [============================>.] - ETA: 0s - loss: 1.6021 - acc: 0.41
10000/390 [=================================================================
390/390 [==============================] - 210s 538ms/step - loss: 1.6018 - a
Epoch 2/150
389/390 [============================>.] - ETA: 0s - loss: 1.2158 - acc: 0.56
10000/390 [=================================================================
390/390 [==============================] - 182s 468ms/step - loss: 1.2155 - a
Epoch 3/150
389/390 [============================>.] - ETA: 0s - loss: 1.0226 - acc: 0.63
10000/390 [=================================================================
390/390 [==============================] - 183s 469ms/step - loss: 1.0224 - a
Epoch 4/150
389/390 [============================>.] - ETA: 0s - loss: 0.8904 - acc: 0.68
10000/390 [=================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.8905 - a
Epoch 5/150
389/390 [============================>.] - ETA: 0s - loss: 0.8096 - acc: 0.71
10000/390 [=================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.8094 - a
Epoch 6/150
389/390 [============================>.] - ETA: 0s - loss: 0.7397 - acc: 0.74
10000/390 [=================================================================
390/390 [==============================] - 184s 471ms/step - loss: 0.7397 - a
Epoch 7/150
389/390 [============================>.] - ETA: 0s - loss: 0.6905 - acc: 0.75
10000/390 [=================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.6908 - a
Epoch 8/150
389/390 [============================>.] - ETA: 0s - loss: 0.6415 - acc: 0.77
10000/390 [=================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.6417 - a
Epoch 9/150
389/390 [============================>.] - ETA: 0s - loss: 0.6029 - acc: 0.78
Saving...                                 =================================================
                                          ============] - 182s 468ms/step - loss: 0.6028 - a
Epoch 10/150
389/390 [============================>.] - ETA: 0s - loss: 0.5786 - acc: 0.80
10000/390 [=================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.5787 - a
Epoch 11/150
389/390 [============================>.] - ETA: 0s - loss: 0.5597 - acc: 0.80
10000/390 [=================================================================
390/390 [==============================] - 184s 471ms/step - loss: 0.5596 - a
Epoch 12/150
389/390 [============================>.] - ETA: 0s - loss: 0.5296 - acc: 0.81
10000/390 [=================================================================
390/390 [==============================] - 184s 471ms/step - loss: 0.5294 - a
Epoch 13/150
389/390 [============================>.] - ETA: 0s - loss: 0.5150 - acc: 0.82
10000/390 [=================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.5151 - a
Epoch 14/150
389/390 [============================>.] - ETA: 0s - loss: 0.4937 - acc: 0.82
10000/390 [=================================================================
390/390 [==============================] - 184s 471ms/step - loss: 0.4939 - a
Epoch 15/150
389/390 [============================>.] - ETA: 0s - loss: 0.4752 - acc: 0.83
10000/390 [=================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.4753 - a
Epoch 16/150
```

```
389/390 [============================>.] - ETA: 0s - loss: 0.4636 - acc: 0.83
10000/390 [==============================================================================
390/390 [==============================] - 182s 468ms/step - loss: 0.4637 - a
Epoch 17/150
389/390 [============================>.] - ETA: 0s - loss: 0.4410 - acc: 0.84
10000/390 [==============================================================================
390/390 [==============================] - 182s 467ms/step - loss: 0.4409 - a
Epoch 18/150
389/390 [============================>.] - ETA: 0s - loss: 0.4353 - acc: 0.84
10000/390 [==============================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.4352 - a
Epoch 19/150
389/390 [============================>.] - ETA: 0s - loss: 0.4200 - acc: 0.85
10000/390 [==============================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.4201 - a
Epoch 20/150
389/390 [============================>.] - ETA: 0s - loss: 0.4109 - acc: 0.85
10000/390 [==============================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.4110 - a
Epoch 21/150
389/390 [============================>.] - ETA: 0s - loss: 0.4050 - acc: 0.85
10000/390 [==============================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.4049 - a
Epoch 22/150
389/390 [============================>.] - ETA: 0s - loss: 0.3936 - acc: 0.86
10000/390 [==============================================================================
390/390 [==============================] - 183s 468ms/step - loss: 0.3937 - a
Epoch 23/150
389/390 [============================>.] - ETA: 0s - loss: 0.3883 - acc: 0.86
10000/390 [==============================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.3883 - a
Epoch 24/150
389/390 [============================>.] - ETA: 0s - loss: 0.3777 - acc: 0.86
10000/390 [==============================================================================
                                ==========] - 182s 467ms/step - loss: 0.3775 - a

                                ==========>.] - ETA: 0s - loss: 0.3663 - acc: 0.87
10000/390 [==============================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.3661 - a
Epoch 26/150
389/390 [============================>.] - ETA: 0s - loss: 0.3612 - acc: 0.87
10000/390 [==============================================================================
390/390 [==============================] - 184s 471ms/step - loss: 0.3614 - a
Epoch 27/150
389/390 [============================>.] - ETA: 0s - loss: 0.3593 - acc: 0.87
10000/390 [==============================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.3596 - a
Epoch 28/150
389/390 [============================>.] - ETA: 0s - loss: 0.3451 - acc: 0.87
10000/390 [==============================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.3451 - a
Epoch 29/150
389/390 [============================>.] - ETA: 0s - loss: 0.3395 - acc: 0.88
10000/390 [==============================================================================
390/390 [==============================] - 184s 471ms/step - loss: 0.3395 - a
Epoch 30/150
389/390 [============================>.] - ETA: 0s - loss: 0.3354 - acc: 0.88
10000/390 [==============================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.3354 - a
Epoch 31/150
389/390 [============================>.] - ETA: 0s - loss: 0.3265 - acc: 0.88
10000/390 [==============================================================================
```

Saving...

```
390/390 [==============================] - 182s 467ms/step - loss: 0.3262 - a
Epoch 32/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3181 - acc: 0.88
10000/390 [==========================================================================
390/390 [==============================] - 183s 468ms/step - loss: 0.3182 - a
Epoch 33/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3182 - acc: 0.88
10000/390 [==========================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.3182 - a
Epoch 34/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3135 - acc: 0.89
10000/390 [==========================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.3134 - a
Epoch 35/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3094 - acc: 0.89
10000/390 [==========================================================================
390/390 [==============================] - 184s 471ms/step - loss: 0.3094 - a
Epoch 36/150
389/390 [==============================>.] - ETA: 0s - loss: 0.3042 - acc: 0.89
10000/390 [==========================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.3044 - a
Epoch 37/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2961 - acc: 0.89
10000/390 [==========================================================================
390/390 [==============================] - 184s 471ms/step - loss: 0.2963 - a
Epoch 38/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2954 - acc: 0.89
10000/390 [==========================================================================
390/390 [==============================] - 183s 468ms/step - loss: 0.2954 - a
Epoch 39/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2902 - acc: 0.89
10000/390 [==========================================================================
390/390 [==============================] - 182s 468ms/step - loss: 0.2902 - a
Epoch 40/150
                                          ==========>.] - ETA: 0s - loss: 0.2864 - acc: 0.89
                                          ==========================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.2867 - a
Epoch 41/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2813 - acc: 0.90
10000/390 [==========================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.2816 - a
Epoch 42/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2806 - acc: 0.90
10000/390 [==========================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.2804 - a
Epoch 43/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2723 - acc: 0.90
10000/390 [==========================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.2727 - a
Epoch 44/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2634 - acc: 0.90
10000/390 [==========================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.2633 - a
Epoch 45/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2699 - acc: 0.90
10000/390 [==========================================================================
390/390 [==============================] - 183s 468ms/step - loss: 0.2701 - a
Epoch 46/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2669 - acc: 0.90
10000/390 [==========================================================================
390/390 [==============================] - 182s 466ms/step - loss: 0.2670 - a
```

Saving...

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Epoch 47/150
389/390 [============================>.] - ETA: 0s - loss: 0.2621 - acc: 0.90
10000/390 [==================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.2620 - a
Epoch 48/150
389/390 [============================>.] - ETA: 0s - loss: 0.2569 - acc: 0.90
10000/390 [==================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.2568 - a
Epoch 49/150
389/390 [============================>.] - ETA: 0s - loss: 0.2554 - acc: 0.90
10000/390 [==================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.2554 - a
Epoch 50/150
389/390 [============================>.] - ETA: 0s - loss: 0.2499 - acc: 0.91
10000/390 [==================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.2497 - a
Epoch 51/150
389/390 [============================>.] - ETA: 0s - loss: 0.2487 - acc: 0.91
10000/390 [==================================================================
390/390 [==============================] - 182s 467ms/step - loss: 0.2485 - a
Epoch 52/150
389/390 [============================>.] - ETA: 0s - loss: 0.2420 - acc: 0.91
10000/390 [==================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.2424 - a
Epoch 53/150
389/390 [============================>.] - ETA: 0s - loss: 0.2465 - acc: 0.91
10000/390 [==================================================================
390/390 [==============================] - 183s 468ms/step - loss: 0.2462 - a
Epoch 54/150
389/390 [============================>.] - ETA: 0s - loss: 0.2473 - acc: 0.91
10000/390 [==================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.2477 - a
Epoch 55/150
389/390 [============================>.] - ETA: 0s - loss: 0.2334 - acc: 0.91
                  ===================================================
Saving...         ============] - 183s 469ms/step - loss: 0.2335 - a

389/390 [============================>.] - ETA: 0s - loss: 0.2344 - acc: 0.91
10000/390 [==================================================================
390/390 [==============================] - 184s 472ms/step - loss: 0.2345 - a
Epoch 57/150
389/390 [============================>.] - ETA: 0s - loss: 0.2339 - acc: 0.91
10000/390 [==================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.2339 - a
Epoch 58/150
389/390 [============================>.] - ETA: 0s - loss: 0.2352 - acc: 0.91
10000/390 [==================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.2352 - a
Epoch 59/150
389/390 [============================>.] - ETA: 0s - loss: 0.2277 - acc: 0.91
10000/390 [==================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.2277 - a
Epoch 60/150
389/390 [============================>.] - ETA: 0s - loss: 0.2235 - acc: 0.92
10000/390 [==================================================================
390/390 [==============================] - 182s 467ms/step - loss: 0.2233 - a
Epoch 61/150
389/390 [============================>.] - ETA: 0s - loss: 0.2237 - acc: 0.92
10000/390 [==================================================================
390/390 [==============================] - 182s 468ms/step - loss: 0.2235 - a
Epoch 62/150
389/390 [============================>.] - ETA: 0s - loss: 0.2224 - acc: 0.92
```

```
10000/390 [==============================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.2223 - a
Epoch 63/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2189 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.2186 - a
Epoch 64/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2125 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.2127 - a
Epoch 65/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2207 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 183s 470ms/step - loss: 0.2207 - a
Epoch 66/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2130 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 183s 469ms/step - loss: 0.2130 - a
Epoch 67/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2107 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 182s 467ms/step - loss: 0.2105 - a
Epoch 68/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2135 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 182s 466ms/step - loss: 0.2134 - a
Epoch 69/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2076 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 181s 465ms/step - loss: 0.2075 - a
Epoch 70/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2062 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.2062 - a
Saving...
==========>.] - ETA: 0s - loss: 0.2034 - acc: 0.92
==============================================================================
390/390 [==============================] - 180s 461ms/step - loss: 0.2034 - a
Epoch 72/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2019 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 180s 461ms/step - loss: 0.2017 - a
Epoch 73/150
389/390 [==============================>.] - ETA: 0s - loss: 0.1980 - acc: 0.93
10000/390 [==============================================================================
390/390 [==============================] - 180s 462ms/step - loss: 0.1983 - a
Epoch 74/150
389/390 [==============================>.] - ETA: 0s - loss: 0.1977 - acc: 0.93
10000/390 [==============================================================================
390/390 [==============================] - 180s 461ms/step - loss: 0.1980 - a
Epoch 75/150
389/390 [==============================>.] - ETA: 0s - loss: 0.2011 - acc: 0.92
10000/390 [==============================================================================
390/390 [==============================] - 180s 461ms/step - loss: 0.2010 - a
Epoch 76/150
389/390 [==============================>.] - ETA: 0s - loss: 0.1950 - acc: 0.93
10000/390 [==============================================================================
390/390 [==============================] - 180s 461ms/step - loss: 0.1949 - a
Epoch 77/150
389/390 [==============================>.] - ETA: 0s - loss: 0.1906 - acc: 0.93
10000/390 [==============================================================================
```

```
390/390 [==============================] - 180s 461ms/step - loss: 0.1909 - a
Epoch 78/150
389/390 [============================>.] - ETA: 0s - loss: 0.1924 - acc: 0.93
10000/390 [==========================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1926 - a
Epoch 79/150
389/390 [============================>.] - ETA: 0s - loss: 0.1922 - acc: 0.93
10000/390 [==========================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1924 - a
Epoch 80/150
389/390 [============================>.] - ETA: 0s - loss: 0.1923 - acc: 0.93
10000/390 [==========================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1922 - a
Epoch 81/150
389/390 [============================>.] - ETA: 0s - loss: 0.1881 - acc: 0.93
10000/390 [==========================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1880 - a
Epoch 82/150
389/390 [============================>.] - ETA: 0s - loss: 0.1800 - acc: 0.93
10000/390 [==========================================================================
390/390 [==============================] - 180s 463ms/step - loss: 0.1798 - a
Epoch 83/150
389/390 [============================>.] - ETA: 0s - loss: 0.1876 - acc: 0.93
10000/390 [==========================================================================
390/390 [==============================] - 180s 463ms/step - loss: 0.1877 - a
Epoch 84/150
389/390 [============================>.] - ETA: 0s - loss: 0.1796 - acc: 0.93
10000/390 [==========================================================================
390/390 [==============================] - 180s 462ms/step - loss: 0.1794 - a
Epoch 85/150
389/390 [============================>.] - ETA: 0s - loss: 0.1844 - acc: 0.93
10000/390 [==========================================================================
390/390 [==============================] - 180s 462ms/step - loss: 0.1846 - a
Epoch 86/150
                                          ==========>.] - ETA: 0s - loss: 0.1792 - acc: 0.93
                                          ==========================================================
                                          ==========] - 180s 462ms/step - loss: 0.1790 - a
Epoch 87/150
389/390 [============================>.] - ETA: 0s - loss: 0.1819 - acc: 0.93
10000/390 [==========================================================================
390/390 [==============================] - 180s 462ms/step - loss: 0.1818 - a
Epoch 88/150
389/390 [============================>.] - ETA: 0s - loss: 0.1818 - acc: 0.93
10000/390 [==========================================================================
390/390 [==============================] - 180s 462ms/step - loss: 0.1818 - a
Epoch 89/150
389/390 [============================>.] - ETA: 0s - loss: 0.1775 - acc: 0.93
10000/390 [==========================================================================
390/390 [==============================] - 181s 465ms/step - loss: 0.1776 - a
Epoch 90/150
389/390 [============================>.] - ETA: 0s - loss: 0.1770 - acc: 0.93
10000/390 [==========================================================================
390/390 [==============================] - 181s 465ms/step - loss: 0.1769 - a
Epoch 91/150
389/390 [============================>.] - ETA: 0s - loss: 0.1758 - acc: 0.93
10000/390 [==========================================================================
390/390 [==============================] - 181s 465ms/step - loss: 0.1758 - a
Epoch 92/150
389/390 [============================>.] - ETA: 0s - loss: 0.1718 - acc: 0.94
10000/390 [==========================================================================
390/390 [==============================] - 181s 465ms/step - loss: 0.1718 - a
Epoch 93/150
```

Saving...

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389/390 [============================>.] - ETA: 0s - loss: 0.1716 - acc: 0.93
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1716 - a
Epoch 94/150
389/390 [============================>.] - ETA: 0s - loss: 0.1697 - acc: 0.93
10000/390 [==============================================================================
390/390 [==============================] - 181s 465ms/step - loss: 0.1698 - a
Epoch 95/150
389/390 [============================>.] - ETA: 0s - loss: 0.1690 - acc: 0.93
10000/390 [==============================================================================
390/390 [==============================] - 181s 465ms/step - loss: 0.1691 - a
Epoch 96/150
389/390 [============================>.] - ETA: 0s - loss: 0.1654 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1656 - a
Epoch 97/150
389/390 [============================>.] - ETA: 0s - loss: 0.1680 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1679 - a
Epoch 98/150
389/390 [============================>.] - ETA: 0s - loss: 0.1709 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 465ms/step - loss: 0.1709 - a
Epoch 99/150
389/390 [============================>.] - ETA: 0s - loss: 0.1640 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1638 - a
Epoch 100/150
389/390 [============================>.] - ETA: 0s - loss: 0.1631 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1631 - a
Epoch 101/150
389/390 [============================>.] - ETA: 0s - loss: 0.1614 - acc: 0.94
10000/390 [==============================================================================
                                        ] - 181s 465ms/step - loss: 0.1614 - a
                                        ] - ETA: 0s - loss: 0.1632 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 465ms/step - loss: 0.1632 - a
Epoch 103/150
389/390 [============================>.] - ETA: 0s - loss: 0.1617 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 465ms/step - loss: 0.1615 - a
Epoch 104/150
389/390 [============================>.] - ETA: 0s - loss: 0.1615 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1614 - a
Epoch 105/150
389/390 [============================>.] - ETA: 0s - loss: 0.1586 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1585 - a
Epoch 106/150
389/390 [============================>.] - ETA: 0s - loss: 0.1576 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1579 - a
Epoch 107/150
389/390 [============================>.] - ETA: 0s - loss: 0.1554 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1556 - a
Epoch 108/150
389/390 [============================>.] - ETA: 0s - loss: 0.1544 - acc: 0.94
```

Saving...

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10000/390 [==============================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1545 - a
Epoch 109/150
389/390 [============================>.] - ETA: 0s - loss: 0.1578 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1579 - a
Epoch 110/150
389/390 [============================>.] - ETA: 0s - loss: 0.1559 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1557 - a
Epoch 111/150
389/390 [============================>.] - ETA: 0s - loss: 0.1511 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1510 - a
Epoch 112/150
389/390 [============================>.] - ETA: 0s - loss: 0.1549 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1549 - a
Epoch 113/150
389/390 [============================>.] - ETA: 0s - loss: 0.1504 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1504 - a
Epoch 114/150
389/390 [============================>.] - ETA: 0s - loss: 0.1470 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 465ms/step - loss: 0.1468 - a
Epoch 115/150
389/390 [============================>.] - ETA: 0s - loss: 0.1511 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1510 - a
Epoch 116/150
389/390 [============================>.] - ETA: 0s - loss: 0.1473 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 465ms/step - loss: 0.1474 - a
Epoch 117/150
389/390 [============================>.] - ETA: 0s - loss: 0.1519 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1517 - a
Epoch 118/150
389/390 [============================>.] - ETA: 0s - loss: 0.1475 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1475 - a
Epoch 119/150
389/390 [============================>.] - ETA: 0s - loss: 0.1456 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1455 - a
Epoch 120/150
389/390 [============================>.] - ETA: 0s - loss: 0.1476 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1477 - a
Epoch 121/150
389/390 [============================>.] - ETA: 0s - loss: 0.1468 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1469 - a
Epoch 122/150
389/390 [============================>.] - ETA: 0s - loss: 0.1474 - acc: 0.94
10000/390 [==============================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1475 - a
Epoch 123/150
389/390 [============================>.] - ETA: 0s - loss: 0.1408 - acc: 0.95
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1408 - a
```

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Epoch 124/150
389/390 [============================>.] - ETA: 0s - loss: 0.1480 - acc: 0.94
10000/390 [==================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1479 - a
Epoch 125/150
389/390 [============================>.] - ETA: 0s - loss: 0.1458 - acc: 0.94
10000/390 [==================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1458 - a
Epoch 126/150
389/390 [============================>.] - ETA: 0s - loss: 0.1386 - acc: 0.95
10000/390 [==================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1387 - a
Epoch 127/150
389/390 [============================>.] - ETA: 0s - loss: 0.1370 - acc: 0.95
10000/390 [==================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1369 - a
Epoch 128/150
389/390 [============================>.] - ETA: 0s - loss: 0.1421 - acc: 0.94
10000/390 [==================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1420 - a
Epoch 129/150
389/390 [============================>.] - ETA: 0s - loss: 0.1441 - acc: 0.94
10000/390 [==================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1440 - a
Epoch 130/150
389/390 [============================>.] - ETA: 0s - loss: 0.1348 - acc: 0.95
10000/390 [==================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1348 - a
Epoch 131/150
389/390 [============================>.] - ETA: 0s - loss: 0.1372 - acc: 0.95
10000/390 [==================================================================
390/390 [==============================] - 182s 466ms/step - loss: 0.1373 - a
Epoch 132/150
389/390 [============================>.] - ETA: 0s - loss: 0.1386 - acc: 0.95
Saving...  ======================================================
           ============] - 181s 464ms/step - loss: 0.1385 - a
Epoch 133/150
389/390 [============================>.] - ETA: 0s - loss: 0.1367 - acc: 0.95
10000/390 [==================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1367 - a
Epoch 134/150
389/390 [============================>.] - ETA: 0s - loss: 0.1365 - acc: 0.95
10000/390 [==================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1365 - a
Epoch 135/150
389/390 [============================>.] - ETA: 0s - loss: 0.1373 - acc: 0.95
10000/390 [==================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1375 - a
Epoch 136/150
389/390 [============================>.] - ETA: 0s - loss: 0.1334 - acc: 0.95
10000/390 [==================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1333 - a
Epoch 137/150
389/390 [============================>.] - ETA: 0s - loss: 0.1342 - acc: 0.95
10000/390 [==================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1343 - a
Epoch 138/150
389/390 [============================>.] - ETA: 0s - loss: 0.1381 - acc: 0.95
10000/390 [==================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1382 - a
Epoch 139/150
```

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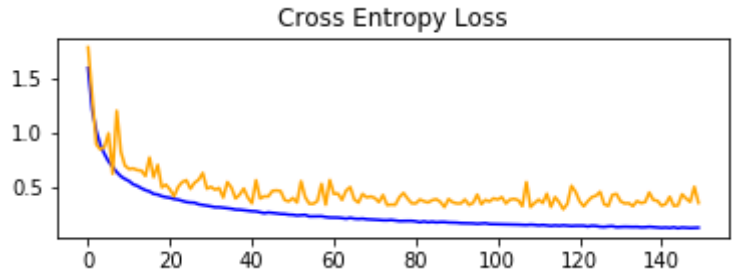
389/390 [============================>.] - ETA: 0s - loss: 0.1346 - acc: 0.95
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1348 - a
Epoch 140/150
389/390 [============================>.] - ETA: 0s - loss: 0.1321 - acc: 0.95
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1322 - a
Epoch 141/150
389/390 [============================>.] - ETA: 0s - loss: 0.1286 - acc: 0.95
10000/390 [==============================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1290 - a
Epoch 142/150
389/390 [============================>.] - ETA: 0s - loss: 0.1312 - acc: 0.95
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1315 - a
Epoch 143/150
389/390 [============================>.] - ETA: 0s - loss: 0.1276 - acc: 0.95
10000/390 [==============================================================================
390/390 [==============================] - 180s 463ms/step - loss: 0.1275 - a
Epoch 144/150
389/390 [============================>.] - ETA: 0s - loss: 0.1338 - acc: 0.95
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1339 - a
Epoch 145/150
389/390 [============================>.] - ETA: 0s - loss: 0.1252 - acc: 0.95
10000/390 [==============================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1250 - a
Epoch 146/150
389/390 [============================>.] - ETA: 0s - loss: 0.1316 - acc: 0.95
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1315 - a
Epoch 147/150
389/390 [============================>.] - ETA: 0s - loss: 0.1284 - acc: 0.95
10000/390 [==============================================================================
                                ==========] - 181s 463ms/step - loss: 0.1285 - a

                                ==========>.] - ETA: 0s - loss: 0.1269 - acc: 0.95
10000/390 [==============================================================================
390/390 [==============================] - 181s 464ms/step - loss: 0.1269 - a
Epoch 149/150
389/390 [============================>.] - ETA: 0s - loss: 0.1283 - acc: 0.95
10000/390 [==============================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1283 - a
Epoch 150/150
389/390 [============================>.] - ETA: 0s - loss: 0.1300 - acc: 0.95
10000/390 [==============================================================================
390/390 [==============================] - 181s 463ms/step - loss: 0.1299 - a
> 90.330
```



Saving...

```
from prettytable import PrettyTable
```

```
conclusion= PrettyTable()
conclusion.field_names = [ "Model","Optimizer", 'epochs','Train Loss','Test Loss',
conclusion.add_row(["CNN DenseNet",'SGD',150, 0.2162, 0.3828,0.9253,0.8840])
conclusion.add_row(["CNN DenseNet",'Adam',150, 0.1299, 0.3592,0.9537,0.9033])


print(conclusion)
```

```
+-------+-----------+--------+------------+-----------+----------------+-----
| Model | Optimizer | epochs | Train Loss | Test Loss | Train Accuracy | Test
+-------+-----------+--------+------------+-----------+----------------+-----
|  CNN  |    SGD    |  150   |   0.2162   |   0.3828  |     0.9253     |
|  CNN  |    Adam   |  150   |   0.1299   |   0.3592  |     0.9537     |
+-------+-----------+--------+------------+-----------+----------------+-----
```