CNN(Dense Net) CIFAR

May 7, 2021

0.0.1 Dense Net on CIFAR"

[2]:
```
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
from tensorflow.keras.preprocessing.image import ImageDataGenerator
import matplotlib.pyplot as plt
import numpy as np
from tensorflow.keras.callbacks import ModelCheckpoint,ReduceLROnPlateau
```

[3]:
```
import tensorflow as tf
```

[4]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id
=947318989803-6bn6qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleusercontent.com&redire
ct_uri=urn%3aietf%3awg%3aoauth%3a2.0%3aoob&response_type=code&scope=email%20http
s%3a%2f%2fwww.googleapis.com%2fauth%2fdocs.test%20https%3a%2f%2fwww.googleapis.c
om%2fauth%2fdrive%20https%3a%2f%2fwww.googleapis.com%2fauth%2fdrive.photos.reado
nly%20https%3a%2f%2fwww.googleapis.com%2fauth%2fpeopleapi.readonly

Enter your authorization code:
··········
Mounted at /content/drive
```

0.0.2 DATA

[5]:
```
# Load CIFAR10 Data
(X_train, y_train), (X_test, y_test) = tf.keras.datasets.cifar10.load_data()
img_height, img_width, channel = X_train.shape[1],X_train.shape[2],X_train.
↪shape[3]

# convert to one hot encoing
y_train = tf.keras.utils.to_categorical(y_train, 10)
y_test = tf.keras.utils.to_categorical(y_test, 10)
```

```
Downloading data from https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz
170500096/170498071 [==============================] - 6s 0us/step
```

[6]:
```
batch_size =50
num_filter = 35
dropout_rate = 0
num_classes = 10
l = 6
compression = 1.0
```

[7]:
```
# Dense Block
def denseblock(input, num_filter = 12 , dropout_rate = 0.0):
    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), (3,3),␣
 ↪use_bias=False ,padding='same')(relu)
        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
def transition(input, num_filter=12 , dropout_rate = 0.0):
    global compression
    BatchNorm = layers.BatchNormalization()(input)
    relu = layers.Activation('relu')(BatchNorm)
    Conv2D_BottleNeck = layers.Conv2D(int(num_filter*compression), (1,1),␣
 ↪use_bias=False ,padding='same')(relu)
    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.AveragePooling2D(pool_size=(2,2))(relu)
```

```
    output = layers.
↪Conv2D(filters=num_classes,kernel_size=(2,2),activation='softmax')(AvgPooling)

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

[8]:
```
dropout_rate=0
input = layers.Input(shape=(img_height, img_width, channel,))
First_Conv2D = layers.Conv2D(35, (3,3), use_bias=False ,padding='same')(input)

First_Block = denseblock(First_Conv2D, 35, dropout_rate)
First_Transition = transition(First_Block, 35, dropout_rate)

Second_Block = denseblock(First_Transition, 35, dropout_rate)
Second_Transition = transition(Second_Block, 35, dropout_rate)

Third_Block = denseblock(Second_Transition, 35, dropout_rate)
Third_Transition = transition(Third_Block, 35, dropout_rate)

Last_Block = denseblock(Third_Transition,  35, dropout_rate)
output = output_layer(Last_Block)
```

[9]:
```
model = Model(inputs=[input], outputs=[output])
model.summary()
```

```
Model: "model"
__________________________________________________________________________________
__________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================
==================
input_1 (InputLayer)            [(None, 32, 32, 3)]  0
__________________________________________________________________________________
__________________
conv2d (Conv2D)                 (None, 32, 32, 35)   945         input_1[0][0]
__________________________________________________________________________________
__________________
batch_normalization (BatchNorma (None, 32, 32, 35)   140         conv2d[0][0]
__________________________________________________________________________________
__________________
activation (Activation)         (None, 32, 32, 35)   0
batch_normalization[0][0]
__________________________________________________________________________________
__________________
conv2d_1 (Conv2D)               (None, 32, 32, 35)   11025
activation[0][0]
__________________________________________________________________________________
```

```
__________________
concatenate (Concatenate)       (None, 32, 32, 70)   0           conv2d[0][0]
                                                                 conv2d_1[0][0]

____________________________________________________________________________________
__________________
batch_normalization_1 (BatchNor (None, 32, 32, 70)   280
concatenate[0][0]

____________________________________________________________________________________
__________________
activation_1 (Activation)       (None, 32, 32, 70)   0
batch_normalization_1[0][0]

____________________________________________________________________________________
__________________
conv2d_2 (Conv2D)               (None, 32, 32, 35)   22050
activation_1[0][0]

____________________________________________________________________________________
__________________
concatenate_1 (Concatenate)     (None, 32, 32, 105)  0
concatenate[0][0]
                                                                 conv2d_2[0][0]

____________________________________________________________________________________
__________________
batch_normalization_2 (BatchNor (None, 32, 32, 105)  420
concatenate_1[0][0]

____________________________________________________________________________________
__________________
activation_2 (Activation)       (None, 32, 32, 105)  0
batch_normalization_2[0][0]

____________________________________________________________________________________
__________________
conv2d_3 (Conv2D)               (None, 32, 32, 35)   33075
activation_2[0][0]

____________________________________________________________________________________
__________________
concatenate_2 (Concatenate)     (None, 32, 32, 140)  0
concatenate_1[0][0]
                                                                 conv2d_3[0][0]

____________________________________________________________________________________
__________________
batch_normalization_3 (BatchNor (None, 32, 32, 140)  560
concatenate_2[0][0]

____________________________________________________________________________________
__________________
activation_3 (Activation)       (None, 32, 32, 140)  0
batch_normalization_3[0][0]

____________________________________________________________________________________
__________________
conv2d_4 (Conv2D)               (None, 32, 32, 35)   44100
```

```
activation_3[0][0]
__________________________________________________________________________________
__________________
concatenate_3 (Concatenate)     (None, 32, 32, 175)  0
concatenate_2[0][0]
                                                                 conv2d_4[0][0]
__________________________________________________________________________________
__________________
batch_normalization_4 (BatchNor (None, 32, 32, 175)  700
concatenate_3[0][0]
__________________________________________________________________________________
__________________
activation_4 (Activation)       (None, 32, 32, 175)  0
batch_normalization_4[0][0]
__________________________________________________________________________________
__________________
conv2d_5 (Conv2D)               (None, 32, 32, 35)   55125
activation_4[0][0]
__________________________________________________________________________________
__________________
concatenate_4 (Concatenate)     (None, 32, 32, 210)  0
concatenate_3[0][0]
                                                                 conv2d_5[0][0]
__________________________________________________________________________________
__________________
batch_normalization_5 (BatchNor (None, 32, 32, 210)  840
concatenate_4[0][0]
__________________________________________________________________________________
__________________
activation_5 (Activation)       (None, 32, 32, 210)  0
batch_normalization_5[0][0]
__________________________________________________________________________________
__________________
conv2d_6 (Conv2D)               (None, 32, 32, 35)   66150
activation_5[0][0]
__________________________________________________________________________________
__________________
concatenate_5 (Concatenate)     (None, 32, 32, 245)  0
concatenate_4[0][0]
                                                                 conv2d_6[0][0]
__________________________________________________________________________________
__________________
batch_normalization_6 (BatchNor (None, 32, 32, 245)  980
concatenate_5[0][0]
__________________________________________________________________________________
__________________
activation_6 (Activation)       (None, 32, 32, 245)  0
batch_normalization_6[0][0]
```

```
____________________________________________________________________________
__________________
conv2d_7 (Conv2D)               (None, 32, 32, 35)   8575
activation_6[0][0]
____________________________________________________________________________
__________________
average_pooling2d (AveragePooli (None, 16, 16, 35)   0           conv2d_7[0][0]
____________________________________________________________________________
__________________
batch_normalization_7 (BatchNor (None, 16, 16, 35)   140
average_pooling2d[0][0]
____________________________________________________________________________
__________________
activation_7 (Activation)       (None, 16, 16, 35)   0
batch_normalization_7[0][0]
____________________________________________________________________________
__________________
conv2d_8 (Conv2D)               (None, 16, 16, 35)   11025
activation_7[0][0]
____________________________________________________________________________
__________________
concatenate_6 (Concatenate)     (None, 16, 16, 70)   0
average_pooling2d[0][0]
                                                     conv2d_8[0][0]
____________________________________________________________________________
__________________
batch_normalization_8 (BatchNor (None, 16, 16, 70)   280
concatenate_6[0][0]
____________________________________________________________________________
__________________
activation_8 (Activation)       (None, 16, 16, 70)   0
batch_normalization_8[0][0]
____________________________________________________________________________
__________________
conv2d_9 (Conv2D)               (None, 16, 16, 35)   22050
activation_8[0][0]
____________________________________________________________________________
__________________
concatenate_7 (Concatenate)     (None, 16, 16, 105)  0
concatenate_6[0][0]
                                                     conv2d_9[0][0]
____________________________________________________________________________
__________________
batch_normalization_9 (BatchNor (None, 16, 16, 105)  420
concatenate_7[0][0]
____________________________________________________________________________
__________________
activation_9 (Activation)       (None, 16, 16, 105)  0
```

```
batch_normalization_9[0][0]
__________________________________________________________________________________________________
conv2d_10 (Conv2D)              (None, 16, 16, 35)   33075
activation_9[0][0]
__________________________________________________________________________________________________
concatenate_8 (Concatenate)     (None, 16, 16, 140)  0
concatenate_7[0][0]
                                                                 conv2d_10[0][0]
__________________________________________________________________________________________________
batch_normalization_10 (BatchNo (None, 16, 16, 140)  560
concatenate_8[0][0]
__________________________________________________________________________________________________
activation_10 (Activation)      (None, 16, 16, 140)  0
batch_normalization_10[0][0]
__________________________________________________________________________________________________
conv2d_11 (Conv2D)              (None, 16, 16, 35)   44100
activation_10[0][0]
__________________________________________________________________________________________________
concatenate_9 (Concatenate)     (None, 16, 16, 175)  0
concatenate_8[0][0]
                                                                 conv2d_11[0][0]
__________________________________________________________________________________________________
batch_normalization_11 (BatchNo (None, 16, 16, 175)  700
concatenate_9[0][0]
__________________________________________________________________________________________________
activation_11 (Activation)      (None, 16, 16, 175)  0
batch_normalization_11[0][0]
__________________________________________________________________________________________________
conv2d_12 (Conv2D)              (None, 16, 16, 35)   55125
activation_11[0][0]
__________________________________________________________________________________________________
concatenate_10 (Concatenate)    (None, 16, 16, 210)  0
concatenate_9[0][0]
                                                                 conv2d_12[0][0]
__________________________________________________________________________________________________
batch_normalization_12 (BatchNo (None, 16, 16, 210)  840
concatenate_10[0][0]
```

```
____________________________________________________________________________
__________________
activation_12 (Activation)      (None, 16, 16, 210)  0
batch_normalization_12[0][0]
____________________________________________________________________________
__________________
conv2d_13 (Conv2D)              (None, 16, 16, 35)   66150
activation_12[0][0]
____________________________________________________________________________
__________________
concatenate_11 (Concatenate)    (None, 16, 16, 245)  0
concatenate_10[0][0]
                                                                 conv2d_13[0][0]
____________________________________________________________________________
__________________
batch_normalization_13 (BatchNo (None, 16, 16, 245)  980
concatenate_11[0][0]
____________________________________________________________________________
__________________
activation_13 (Activation)      (None, 16, 16, 245)  0
batch_normalization_13[0][0]
____________________________________________________________________________
__________________
conv2d_14 (Conv2D)              (None, 16, 16, 35)   8575
activation_13[0][0]
____________________________________________________________________________
__________________
average_pooling2d_1 (AveragePoo (None, 8, 8, 35)     0           conv2d_14[0][0]
____________________________________________________________________________
__________________
batch_normalization_14 (BatchNo (None, 8, 8, 35)     140
average_pooling2d_1[0][0]
____________________________________________________________________________
__________________
activation_14 (Activation)      (None, 8, 8, 35)     0
batch_normalization_14[0][0]
____________________________________________________________________________
__________________
conv2d_15 (Conv2D)              (None, 8, 8, 35)     11025
activation_14[0][0]
____________________________________________________________________________
__________________
concatenate_12 (Concatenate)    (None, 8, 8, 70)     0
average_pooling2d_1[0][0]
                                                                 conv2d_15[0][0]
____________________________________________________________________________
__________________
batch_normalization_15 (BatchNo (None, 8, 8, 70)     280
```

```
concatenate_12[0][0]
__________________________________________________________________________________
__________________
activation_15 (Activation)      (None, 8, 8, 70)     0
batch_normalization_15[0][0]
__________________________________________________________________________________
__________________
conv2d_16 (Conv2D)              (None, 8, 8, 35)     22050
activation_15[0][0]
__________________________________________________________________________________
__________________
concatenate_13 (Concatenate)    (None, 8, 8, 105)    0
concatenate_12[0][0]
                                                                  conv2d_16[0][0]
__________________________________________________________________________________
__________________
batch_normalization_16 (BatchNo (None, 8, 8, 105)    420
concatenate_13[0][0]
__________________________________________________________________________________
__________________
activation_16 (Activation)      (None, 8, 8, 105)    0
batch_normalization_16[0][0]
__________________________________________________________________________________
__________________
conv2d_17 (Conv2D)              (None, 8, 8, 35)     33075
activation_16[0][0]
__________________________________________________________________________________
__________________
concatenate_14 (Concatenate)    (None, 8, 8, 140)    0
concatenate_13[0][0]
                                                                  conv2d_17[0][0]
__________________________________________________________________________________
__________________
batch_normalization_17 (BatchNo (None, 8, 8, 140)    560
concatenate_14[0][0]
__________________________________________________________________________________
__________________
activation_17 (Activation)      (None, 8, 8, 140)    0
batch_normalization_17[0][0]
__________________________________________________________________________________
__________________
conv2d_18 (Conv2D)              (None, 8, 8, 35)     44100
activation_17[0][0]
__________________________________________________________________________________
__________________
concatenate_15 (Concatenate)    (None, 8, 8, 175)    0
concatenate_14[0][0]
                                                                  conv2d_18[0][0]
```

```
__________________________________________________________________________________
__________________
batch_normalization_18 (BatchNo (None, 8, 8, 175)    700
concatenate_15[0][0]
__________________________________________________________________________________
__________________
activation_18 (Activation)      (None, 8, 8, 175)    0
batch_normalization_18[0][0]
__________________________________________________________________________________
__________________
conv2d_19 (Conv2D)              (None, 8, 8, 35)     55125
activation_18[0][0]
__________________________________________________________________________________
__________________
concatenate_16 (Concatenate)    (None, 8, 8, 210)    0
concatenate_15[0][0]
                                                                  conv2d_19[0][0]
__________________________________________________________________________________
__________________
batch_normalization_19 (BatchNo (None, 8, 8, 210)    840
concatenate_16[0][0]
__________________________________________________________________________________
__________________
activation_19 (Activation)      (None, 8, 8, 210)    0
batch_normalization_19[0][0]
__________________________________________________________________________________
__________________
conv2d_20 (Conv2D)              (None, 8, 8, 35)     66150
activation_19[0][0]
__________________________________________________________________________________
__________________
concatenate_17 (Concatenate)    (None, 8, 8, 245)    0
concatenate_16[0][0]
                                                                  conv2d_20[0][0]
__________________________________________________________________________________
__________________
batch_normalization_20 (BatchNo (None, 8, 8, 245)    980
concatenate_17[0][0]
__________________________________________________________________________________
__________________
activation_20 (Activation)      (None, 8, 8, 245)    0
batch_normalization_20[0][0]
__________________________________________________________________________________
__________________
conv2d_21 (Conv2D)              (None, 8, 8, 35)     8575
activation_20[0][0]
__________________________________________________________________________________
__________________
```

```
average_pooling2d_2 (AveragePoo (None, 4, 4, 35)     0           conv2d_21[0][0]
__________________________________________________________________________________________________
batch_normalization_21 (BatchNo (None, 4, 4, 35)     140
average_pooling2d_2[0][0]
__________________________________________________________________________________________________
activation_21 (Activation)      (None, 4, 4, 35)     0
batch_normalization_21[0][0]
__________________________________________________________________________________________________
conv2d_22 (Conv2D)              (None, 4, 4, 35)     11025
activation_21[0][0]
__________________________________________________________________________________________________
concatenate_18 (Concatenate)    (None, 4, 4, 70)     0
average_pooling2d_2[0][0]
                                                                 conv2d_22[0][0]
__________________________________________________________________________________________________
batch_normalization_22 (BatchNo (None, 4, 4, 70)     280
concatenate_18[0][0]
__________________________________________________________________________________________________
activation_22 (Activation)      (None, 4, 4, 70)     0
batch_normalization_22[0][0]
__________________________________________________________________________________________________
conv2d_23 (Conv2D)              (None, 4, 4, 35)     22050
activation_22[0][0]
__________________________________________________________________________________________________
concatenate_19 (Concatenate)    (None, 4, 4, 105)    0
concatenate_18[0][0]
                                                                 conv2d_23[0][0]
__________________________________________________________________________________________________
batch_normalization_23 (BatchNo (None, 4, 4, 105)    420
concatenate_19[0][0]
__________________________________________________________________________________________________
activation_23 (Activation)      (None, 4, 4, 105)    0
batch_normalization_23[0][0]
__________________________________________________________________________________________________
conv2d_24 (Conv2D)              (None, 4, 4, 35)     33075
activation_23[0][0]
__________________________________________________________________________________________________
```

```
__________________
concatenate_20 (Concatenate)    (None, 4, 4, 140)    0
concatenate_19[0][0]
                                                                  conv2d_24[0][0]
__________________________________________________________________________________
__________________
batch_normalization_24 (BatchNo (None, 4, 4, 140)    560
concatenate_20[0][0]
__________________________________________________________________________________
__________________
activation_24 (Activation)      (None, 4, 4, 140)    0
batch_normalization_24[0][0]
__________________________________________________________________________________
__________________
conv2d_25 (Conv2D)              (None, 4, 4, 35)     44100
activation_24[0][0]
__________________________________________________________________________________
__________________
concatenate_21 (Concatenate)    (None, 4, 4, 175)    0
concatenate_20[0][0]
                                                                  conv2d_25[0][0]
__________________________________________________________________________________
__________________
batch_normalization_25 (BatchNo (None, 4, 4, 175)    700
concatenate_21[0][0]
__________________________________________________________________________________
__________________
activation_25 (Activation)      (None, 4, 4, 175)    0
batch_normalization_25[0][0]
__________________________________________________________________________________
__________________
conv2d_26 (Conv2D)              (None, 4, 4, 35)     55125
activation_25[0][0]
__________________________________________________________________________________
__________________
concatenate_22 (Concatenate)    (None, 4, 4, 210)    0
concatenate_21[0][0]
                                                                  conv2d_26[0][0]
__________________________________________________________________________________
__________________
batch_normalization_26 (BatchNo (None, 4, 4, 210)    840
concatenate_22[0][0]
__________________________________________________________________________________
__________________
activation_26 (Activation)      (None, 4, 4, 210)    0
batch_normalization_26[0][0]
__________________________________________________________________________________
__________________
```

```
conv2d_27 (Conv2D)              (None, 4, 4, 35)     66150
activation_26[0][0]
__________________________________________________________________________________
__________________
concatenate_23 (Concatenate)    (None, 4, 4, 245)    0
concatenate_22[0][0]
                                                                 conv2d_27[0][0]
__________________________________________________________________________________
__________________
batch_normalization_27 (BatchNo (None, 4, 4, 245)    980
concatenate_23[0][0]
__________________________________________________________________________________
__________________
activation_27 (Activation)      (None, 4, 4, 245)    0
batch_normalization_27[0][0]
__________________________________________________________________________________
__________________
average_pooling2d_3 (AveragePoo (None, 2, 2, 245)    0
activation_27[0][0]
__________________________________________________________________________________
__________________
conv2d_28 (Conv2D)              (None, 1, 1, 10)     9810
average_pooling2d_3[0][0]
__________________________________________________________________________________
__________________
flatten (Flatten)               (None, 10)           0           conv2d_28[0][0]
==================================================================================
==================
Total params: 978,260
Trainable params: 970,420
Non-trainable params: 7,840
__________________________________________________________________________________
__________________
```

[10]:
```
def conv_pixel(train, test):

        train_norm = train.astype('float32')
        test_norm = test.astype('float32')
        train_norm = train_norm / 255.0
        test_norm = test_norm / 255.0
        return train_norm, test_norm

X_train,X_test = conv_pixel(X_train,X_test)
```

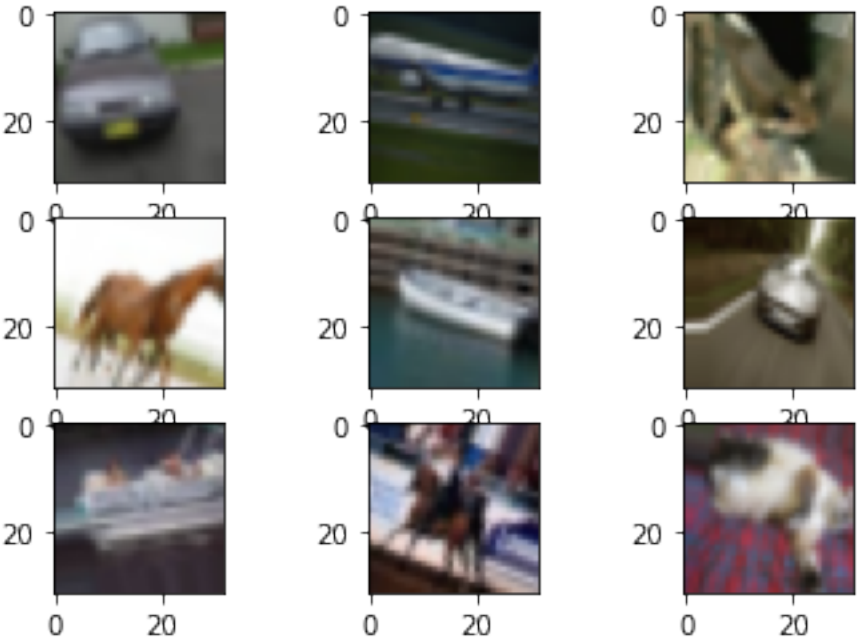
0.0.3 Data Augmentation

[11]:
```
data_gen = ImageDataGenerator(
    rotation_range=22,
    width_shift_range=0.125,
    height_shift_range=0.125,
    horizontal_flip=True,
    fill_mode = 'nearest',
    zoom_range=0.01)
data_gen.fit(X_train)
```

[12]:
```
X_train.shape
```

[12]:
```
(50000, 32, 32, 3)
```

[13]:
```
for X_batch, y_batch in data_gen.flow(X_train, y_train, batch_size=9):
    for i in range(0, 9):
        plt.subplot(330 + 1 + i)
        plt.imshow(X_batch[i], cmap=plt.get_cmap())
    plt.show()
    break
```



[14]:
```
ls
```

```
drive/  sample_data/
```

[15]:
```
model.compile(loss='categorical_crossentropy',optimizer=Adam(),␣
↪metrics=['accuracy'])
```

[16]:
```
reduce_lr = ReduceLROnPlateau(monitor='val_loss',factor=0.1,patience= 5,
                              min_lr=0.000001)
filepath = "drive/My Drive/best_model.hdf5"
checkpoint = ModelCheckpoint(filepath, monitor='val_loss', verbose=1,␣
↪save_best_only=True, mode='max')

callbacks = [checkpoint, reduce_lr]
```

[17]:
```
history=model.fit_generator(data_gen.flow(X_train, y_train, batch_size=50),
                    steps_per_epoch = (len(X_train) /50), epochs=50,␣
↪validation_data=(X_test, y_test),callbacks=callbacks)
```

```
WARNING:tensorflow:From <ipython-input-17-516e8d78b8f2>:2: Model.fit_generator
(from tensorflow.python.keras.engine.training) is deprecated and will be removed
in a future version.
Instructions for updating:
Please use Model.fit, which supports generators.
Epoch 1/50
1000/1000 [==============================] - ETA: 0s - loss: 1.4667 - accuracy:
0.4679
Epoch 00001: val_loss improved from -inf to 1.62575, saving model to drive/My
Drive/best_model.hdf5
1000/1000 [==============================] - 65s 65ms/step - loss: 1.4667 -
accuracy: 0.4679 - val_loss: 1.6258 - val_accuracy: 0.4306 - lr: 0.0010
Epoch 2/50
1000/1000 [==============================] - ETA: 0s - loss: 1.0271 - accuracy:
0.6341
Epoch 00002: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 1.0271 -
accuracy: 0.6341 - val_loss: 1.1933 - val_accuracy: 0.6039 - lr: 0.0010
Epoch 3/50
1000/1000 [==============================] - ETA: 0s - loss: 0.8457 - accuracy:
0.7010
Epoch 00003: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.8457 -
accuracy: 0.7010 - val_loss: 0.8319 - val_accuracy: 0.7154 - lr: 0.0010
Epoch 4/50
1000/1000 [==============================] - ETA: 0s - loss: 0.7349 - accuracy:
0.7442
Epoch 00004: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.7349 -
accuracy: 0.7442 - val_loss: 0.6837 - val_accuracy: 0.7613 - lr: 0.0010
Epoch 5/50
1000/1000 [==============================] - ETA: 0s - loss: 0.6655 - accuracy:
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0.7676
Epoch 00005: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.6655 -
accuracy: 0.7676 - val_loss: 0.7177 - val_accuracy: 0.7538 - lr: 0.0010
Epoch 6/50
1000/1000 [==============================] - ETA: 0s - loss: 0.6068 - accuracy:
0.7883
Epoch 00006: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.6068 -
accuracy: 0.7883 - val_loss: 0.9050 - val_accuracy: 0.7316 - lr: 0.0010
Epoch 7/50
1000/1000 [==============================] - ETA: 0s - loss: 0.5591 - accuracy:
0.8050
Epoch 00007: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.5591 -
accuracy: 0.8050 - val_loss: 0.6049 - val_accuracy: 0.7985 - lr: 0.0010
Epoch 8/50
1000/1000 [==============================] - ETA: 0s - loss: 0.5222 - accuracy:
0.8198
Epoch 00008: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.5222 -
accuracy: 0.8198 - val_loss: 0.6428 - val_accuracy: 0.7976 - lr: 0.0010
Epoch 9/50
1000/1000 [==============================] - ETA: 0s - loss: 0.4918 - accuracy:
0.8292
Epoch 00009: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.4918 -
accuracy: 0.8292 - val_loss: 0.5549 - val_accuracy: 0.8087 - lr: 0.0010
Epoch 10/50
1000/1000 [==============================] - ETA: 0s - loss: 0.4681 - accuracy:
0.8367
Epoch 00010: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.4681 -
accuracy: 0.8367 - val_loss: 0.5687 - val_accuracy: 0.8111 - lr: 0.0010
Epoch 11/50
1000/1000 [==============================] - ETA: 0s - loss: 0.4399 - accuracy:
0.8478
Epoch 00011: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.4399 -
accuracy: 0.8478 - val_loss: 0.5621 - val_accuracy: 0.8129 - lr: 0.0010
Epoch 12/50
1000/1000 [==============================] - ETA: 0s - loss: 0.4226 - accuracy:
0.8532
Epoch 00012: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.4226 -
accuracy: 0.8532 - val_loss: 0.5773 - val_accuracy: 0.8046 - lr: 0.0010
Epoch 13/50
1000/1000 [==============================] - ETA: 0s - loss: 0.4011 - accuracy:
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0.8601
Epoch 00013: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.4011 -
accuracy: 0.8601 - val_loss: 0.4529 - val_accuracy: 0.8510 - lr: 0.0010
Epoch 14/50
1000/1000 [==============================] - ETA: 0s - loss: 0.3872 - accuracy:
0.8665
Epoch 00014: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.3872 -
accuracy: 0.8665 - val_loss: 0.4723 - val_accuracy: 0.8447 - lr: 0.0010
Epoch 15/50
1000/1000 [==============================] - ETA: 0s - loss: 0.3690 - accuracy:
0.8707
Epoch 00015: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.3690 -
accuracy: 0.8707 - val_loss: 0.4254 - val_accuracy: 0.8568 - lr: 0.0010
Epoch 16/50
1000/1000 [==============================] - ETA: 0s - loss: 0.3604 - accuracy:
0.8742
Epoch 00016: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.3604 -
accuracy: 0.8742 - val_loss: 0.4475 - val_accuracy: 0.8504 - lr: 0.0010
Epoch 17/50
1000/1000 [==============================] - ETA: 0s - loss: 0.3441 - accuracy:
0.8818
Epoch 00017: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.3441 -
accuracy: 0.8818 - val_loss: 0.6499 - val_accuracy: 0.8091 - lr: 0.0010
Epoch 18/50
1000/1000 [==============================] - ETA: 0s - loss: 0.3340 - accuracy:
0.8835
Epoch 00018: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.3340 -
accuracy: 0.8835 - val_loss: 0.4438 - val_accuracy: 0.8564 - lr: 0.0010
Epoch 19/50
1000/1000 [==============================] - ETA: 0s - loss: 0.3197 - accuracy:
0.8888
Epoch 00019: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.3197 -
accuracy: 0.8888 - val_loss: 0.5516 - val_accuracy: 0.8288 - lr: 0.0010
Epoch 20/50
1000/1000 [==============================] - ETA: 0s - loss: 0.3101 - accuracy:
0.8905
Epoch 00020: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.3101 -
accuracy: 0.8905 - val_loss: 0.5998 - val_accuracy: 0.8202 - lr: 0.0010
Epoch 21/50
1000/1000 [==============================] - ETA: 0s - loss: 0.2401 - accuracy:
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0.9154
Epoch 00021: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.2401 -
accuracy: 0.9154 - val_loss: 0.3210 - val_accuracy: 0.8929 - lr: 1.0000e-04
Epoch 22/50
1000/1000 [==============================] - ETA: 0s - loss: 0.2170 - accuracy:
0.9245
Epoch 00022: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.2170 -
accuracy: 0.9245 - val_loss: 0.3114 - val_accuracy: 0.8985 - lr: 1.0000e-04
Epoch 23/50
1000/1000 [==============================] - ETA: 0s - loss: 0.2091 - accuracy:
0.9266
Epoch 00023: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.2091 -
accuracy: 0.9266 - val_loss: 0.3216 - val_accuracy: 0.8963 - lr: 1.0000e-04
Epoch 24/50
1000/1000 [==============================] - ETA: 0s - loss: 0.2013 - accuracy:
0.9298
Epoch 00024: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.2013 -
accuracy: 0.9298 - val_loss: 0.3001 - val_accuracy: 0.9019 - lr: 1.0000e-04
Epoch 25/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1980 - accuracy:
0.9306
Epoch 00025: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1980 -
accuracy: 0.9306 - val_loss: 0.3060 - val_accuracy: 0.9021 - lr: 1.0000e-04
Epoch 26/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1916 - accuracy:
0.9349
Epoch 00026: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1916 -
accuracy: 0.9349 - val_loss: 0.3103 - val_accuracy: 0.9017 - lr: 1.0000e-04
Epoch 27/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1868 - accuracy:
0.9353
Epoch 00027: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1868 -
accuracy: 0.9353 - val_loss: 0.3157 - val_accuracy: 0.8984 - lr: 1.0000e-04
Epoch 28/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1846 - accuracy:
0.9364
Epoch 00028: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1846 -
accuracy: 0.9364 - val_loss: 0.3158 - val_accuracy: 0.9008 - lr: 1.0000e-04
Epoch 29/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1826 - accuracy:
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0.9354
Epoch 00029: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1826 -
accuracy: 0.9354 - val_loss: 0.3154 - val_accuracy: 0.9015 - lr: 1.0000e-04
Epoch 30/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1751 - accuracy:
0.9381
Epoch 00030: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1751 -
accuracy: 0.9381 - val_loss: 0.3073 - val_accuracy: 0.9015 - lr: 1.0000e-05
Epoch 31/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1717 - accuracy:
0.9395
Epoch 00031: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1717 -
accuracy: 0.9395 - val_loss: 0.3041 - val_accuracy: 0.9034 - lr: 1.0000e-05
Epoch 32/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1742 - accuracy:
0.9380
Epoch 00032: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1742 -
accuracy: 0.9380 - val_loss: 0.3077 - val_accuracy: 0.9036 - lr: 1.0000e-05
Epoch 33/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1717 - accuracy:
0.9390
Epoch 00033: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1717 -
accuracy: 0.9390 - val_loss: 0.3051 - val_accuracy: 0.9034 - lr: 1.0000e-05
Epoch 34/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1737 - accuracy:
0.9398
Epoch 00034: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1737 -
accuracy: 0.9398 - val_loss: 0.3061 - val_accuracy: 0.9031 - lr: 1.0000e-05
Epoch 35/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1722 - accuracy:
0.9401
Epoch 00035: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1722 -
accuracy: 0.9401 - val_loss: 0.3059 - val_accuracy: 0.9028 - lr: 1.0000e-06
Epoch 36/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1708 - accuracy:
0.9398
Epoch 00036: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1708 -
accuracy: 0.9398 - val_loss: 0.3060 - val_accuracy: 0.9034 - lr: 1.0000e-06
Epoch 37/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1703 - accuracy:
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0.9406
Epoch 00037: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1703 -
accuracy: 0.9406 - val_loss: 0.3076 - val_accuracy: 0.9030 - lr: 1.0000e-06
Epoch 38/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1685 - accuracy:
0.9421
Epoch 00038: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1685 -
accuracy: 0.9421 - val_loss: 0.3063 - val_accuracy: 0.9038 - lr: 1.0000e-06
Epoch 39/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1712 - accuracy:
0.9401
Epoch 00039: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1712 -
accuracy: 0.9401 - val_loss: 0.3062 - val_accuracy: 0.9040 - lr: 1.0000e-06
Epoch 40/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1699 - accuracy:
0.9394
Epoch 00040: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1699 -
accuracy: 0.9394 - val_loss: 0.3037 - val_accuracy: 0.9044 - lr: 1.0000e-06
Epoch 41/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1711 - accuracy:
0.9397
Epoch 00041: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1711 -
accuracy: 0.9397 - val_loss: 0.3053 - val_accuracy: 0.9035 - lr: 1.0000e-06
Epoch 42/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1690 - accuracy:
0.9422
Epoch 00042: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1690 -
accuracy: 0.9422 - val_loss: 0.3044 - val_accuracy: 0.9046 - lr: 1.0000e-06
Epoch 43/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1702 - accuracy:
0.9402
Epoch 00043: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1702 -
accuracy: 0.9402 - val_loss: 0.3027 - val_accuracy: 0.9044 - lr: 1.0000e-06
Epoch 44/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1691 - accuracy:
0.9412
Epoch 00044: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1691 -
accuracy: 0.9412 - val_loss: 0.3049 - val_accuracy: 0.9043 - lr: 1.0000e-06
Epoch 45/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1702 - accuracy:
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0.9414
Epoch 00045: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1702 -
accuracy: 0.9414 - val_loss: 0.3049 - val_accuracy: 0.9047 - lr: 1.0000e-06
Epoch 46/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1654 - accuracy:
0.9422
Epoch 00046: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1654 -
accuracy: 0.9422 - val_loss: 0.3059 - val_accuracy: 0.9037 - lr: 1.0000e-06
Epoch 47/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1699 - accuracy:
0.9403
Epoch 00047: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1699 -
accuracy: 0.9403 - val_loss: 0.3062 - val_accuracy: 0.9037 - lr: 1.0000e-06
Epoch 48/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1699 - accuracy:
0.9410
Epoch 00048: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1699 -
accuracy: 0.9410 - val_loss: 0.3034 - val_accuracy: 0.9041 - lr: 1.0000e-06
Epoch 49/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1716 - accuracy:
0.9400
Epoch 00049: val_loss did not improve from 1.62575
1000/1000 [==============================] - 63s 63ms/step - loss: 0.1716 -
accuracy: 0.9400 - val_loss: 0.3054 - val_accuracy: 0.9037 - lr: 1.0000e-06
Epoch 50/50
1000/1000 [==============================] - ETA: 0s - loss: 0.1682 - accuracy:
0.9421
Epoch 00050: val_loss did not improve from 1.62575
1000/1000 [==============================] - 64s 64ms/step - loss: 0.1682 -
accuracy: 0.9421 - val_loss: 0.3058 - val_accuracy: 0.9032 - lr: 1.0000e-06
```

0.1 Observation

1) Here i tried with variation of different values of number filters and conclusion was that the number of filters should be small.

2)I got accuracy as 94.21% and validation accuracy as 90.32 % after 50 epochs

3) Reduce lr on plateau helped to reach the convergence in less number of epochs

4) Data augmention helped to improve the results

[ ]: