```
# import keras
# from keras.datasets import cifar10
# from keras.models import Model, Sequential
# from keras.layers import Dense, Dropout, Flatten, Input, AveragePooling2D, merge, Activa
# 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 %te
```

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

from keras import backend as k

# Don't pre-allocate memory; allocate as-needed
# import tensorflow as tf
#tf.config.gpu.set_per_process_memory_fraction(0.75)
#tf.config.gpu.set_per_process_memory_growth(True)
config = tf.ConfigProto()
config.gpu_options.allow_growth = True

# Create a session with the above options specified.
k.tensorflow_backend.set_session(tf.Session(config=config))
```

```
Using TensorFlow backend.
```

```
# Hyperparameters
batch_size = 64
num_classes = 10
epochs = 300
l = 8
num_filter = 38
compression = 0.94
dropout_rate = 0.2
```

```
# 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, num_classes)
y_test = tf.keras.utils.to_categorical(y_test, num_classes)
```

```
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)
```

```
# 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), (3,3), use_bias=False ,pad
        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 = 0.2):
    global compression
    BatchNorm = layers.BatchNormalization()(input)
    relu = layers.Activation('relu')(BatchNorm)
    Conv2D_BottleNeck = layers.Conv2D(int(num_filter*compression), (1,1), use_bias=False ,
    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)
    conv = layers.Conv2D(num_classes, (3,3), padding='same')(AvgPooling)
    AvgPooling1 = layers.AveragePooling2D()(conv)
    flat = layers.Flatten()(AvgPooling1)
    output = layers.Activation('softmax')(flat)

    return output
```

```
num_filter = 20
dropout_rate = 0.15
```

```
dropout_rate = 0.15
l = 12
input = layers.Input(shape=(img_height, img_width, channel,))
First_Conv2D = layers.Conv2D(num_filter, (3,3), use_bias=False ,padding='same')(input)

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

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

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

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

```
#https://arxiv.org/pdf/1608.06993.pdf
from IPython.display import IFrame, YouTubeVideo
YouTubeVideo(id='-W6y8xnd--U', width=600)
```


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

```
Model: "model_3"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_4 (InputLayer)            [(None, 32, 32, 3)]  0
__________________________________________________________________________________________________
conv2d_159 (Conv2D)             (None, 32, 32, 20)   540         input_4[0][0]
__________________________________________________________________________________________________
batch_normalization_156 (BatchN (None, 32, 32, 20)   80          conv2d_159[0][0]
__________________________________________________________________________________________________
activation_159 (Activation)     (None, 32, 32, 20)   0           batch_normalization_
__________________________________________________________________________________________________
conv2d_160 (Conv2D)             (None, 32, 32, 18)   3240        activation_159[0][0]
__________________________________________________________________________________________________
dropout_153 (Dropout)           (None, 32, 32, 18)   0           conv2d_160[0][0]
__________________________________________________________________________________________________
concatenate_144 (Concatenate)   (None, 32, 32, 38)   0           conv2d_159[0][0]
                                                                 dropout_153[0][0]
__________________________________________________________________________________________________
batch_normalization_157 (BatchN (None, 32, 32, 38)   152         concatenate_144[0][0
__________________________________________________________________________________________________
activation_160 (Activation)     (None, 32, 32, 38)   0           batch_normalization_
__________________________________________________________________________________________________
conv2d_161 (Conv2D)             (None, 32, 32, 18)   6156        activation_160[0][0]
__________________________________________________________________________________________________
dropout_154 (Dropout)           (None, 32, 32, 18)   0           conv2d_161[0][0]
__________________________________________________________________________________________________
concatenate_145 (Concatenate)   (None, 32, 32, 56)   0           concatenate_144[0][0
                                                                 dropout_154[0][0]
__________________________________________________________________________________________________
batch_normalization_158 (BatchN (None, 32, 32, 56)   224         concatenate_145[0][0
__________________________________________________________________________________________________
activation_161 (Activation)     (None, 32, 32, 56)   0           batch_normalization_
__________________________________________________________________________________________________
conv2d_162 (Conv2D)             (None, 32, 32, 18)   9072        activation_161[0][0]
__________________________________________________________________________________________________
dropout_155 (Dropout)           (None, 32, 32, 18)   0           conv2d_162[0][0]
__________________________________________________________________________________________________
concatenate_146 (Concatenate)   (None, 32, 32, 74)   0           concatenate_145[0][0
                                                                 dropout_155[0][0]
__________________________________________________________________________________________________
batch_normalization_159 (BatchN (None, 32, 32, 74)   296         concatenate_146[0][0
__________________________________________________________________________________________________
activation_162 (Activation)     (None, 32, 32, 74)   0           batch_normalization_
__________________________________________________________________________________________________
conv2d_163 (Conv2D)             (None, 32, 32, 18)   11988       activation_162[0][0]
__________________________________________________________________________________________________
dropout_156 (Dropout)           (None, 32, 32, 18)   0           conv2d_163[0][0]
__________________________________________________________________________________________________
concatenate_147 (Concatenate)   (None, 32, 32, 92)   0           concatenate_146[0][0
                                                                 dropout_156[0][0]
__________________________________________________________________________________________________
batch_normalization_160 (BatchN (None, 32, 32, 92)   368         concatenate_147[0][0
__________________________________________________________________________________________________
activation_163 (Activation)     (None, 32, 32, 92)   0           batch_normalization_
__________________________________________________________________________________________________
conv2d_164 (Conv2D)             (None, 32, 32, 18)   14904       activation_163[0][0]
__________________________________________________________________________________________________
dropout_157 (Dropout)           (None, 32, 32, 18)   0           conv2d_164[0][0]
__________________________________________________________________________________________________
concatenate_148 (Concatenate)   (None, 32, 32, 110)  0           concatenate_147[0][0
```

```
                                                                 dropout_157[0][0]
__________________________________________________________________________________________________
batch_normalization_161 (BatchN (None, 32, 32, 110)  440         concatenate_148[0][0
__________________________________________________________________________________________________
activation_164 (Activation)     (None, 32, 32, 110)  0           batch_normalization_
__________________________________________________________________________________________________
conv2d_165 (Conv2D)             (None, 32, 32, 18)   17820       activation_164[0][0]
__________________________________________________________________________________________________
dropout_158 (Dropout)           (None, 32, 32, 18)   0           conv2d_165[0][0]
__________________________________________________________________________________________________
concatenate_149 (Concatenate)   (None, 32, 32, 128)  0           concatenate_148[0][0
                                                                 dropout_158[0][0]
__________________________________________________________________________________________________
batch_normalization_162 (BatchN (None, 32, 32, 128)  512         concatenate_149[0][0
__________________________________________________________________________________________________
activation_165 (Activation)     (None, 32, 32, 128)  0           batch_normalization_
__________________________________________________________________________________________________
conv2d_166 (Conv2D)             (None, 32, 32, 18)   20736       activation_165[0][0]
__________________________________________________________________________________________________
dropout_159 (Dropout)           (None, 32, 32, 18)   0           conv2d_166[0][0]
__________________________________________________________________________________________________
concatenate_150 (Concatenate)   (None, 32, 32, 146)  0           concatenate_149[0][0
                                                                 dropout_159[0][0]
__________________________________________________________________________________________________
batch_normalization_163 (BatchN (None, 32, 32, 146)  584         concatenate_150[0][0
__________________________________________________________________________________________________
activation_166 (Activation)     (None, 32, 32, 146)  0           batch_normalization_
__________________________________________________________________________________________________
conv2d_167 (Conv2D)             (None, 32, 32, 18)   23652       activation_166[0][0]
__________________________________________________________________________________________________
dropout_160 (Dropout)           (None, 32, 32, 18)   0           conv2d_167[0][0]
__________________________________________________________________________________________________
concatenate_151 (Concatenate)   (None, 32, 32, 164)  0           concatenate_150[0][0
                                                                 dropout_160[0][0]
__________________________________________________________________________________________________
batch_normalization_164 (BatchN (None, 32, 32, 164)  656         concatenate_151[0][0
__________________________________________________________________________________________________
activation_167 (Activation)     (None, 32, 32, 164)  0           batch_normalization_
__________________________________________________________________________________________________
conv2d_168 (Conv2D)             (None, 32, 32, 18)   26568       activation_167[0][0]
__________________________________________________________________________________________________
dropout_161 (Dropout)           (None, 32, 32, 18)   0           conv2d_168[0][0]
__________________________________________________________________________________________________
concatenate_152 (Concatenate)   (None, 32, 32, 182)  0           concatenate_151[0][0
                                                                 dropout_161[0][0]
__________________________________________________________________________________________________
batch_normalization_165 (BatchN (None, 32, 32, 182)  728         concatenate_152[0][0
__________________________________________________________________________________________________
activation_168 (Activation)     (None, 32, 32, 182)  0           batch_normalization_
__________________________________________________________________________________________________
conv2d_169 (Conv2D)             (None, 32, 32, 18)   29484       activation_168[0][0]
__________________________________________________________________________________________________
dropout_162 (Dropout)           (None, 32, 32, 18)   0           conv2d_169[0][0]
__________________________________________________________________________________________________
concatenate_153 (Concatenate)   (None, 32, 32, 200)  0           concatenate_152[0][0
                                                                 dropout_162[0][0]
__________________________________________________________________________________________________
batch_normalization_166 (BatchN (None, 32, 32, 200)  800         concatenate_153[0][0
__________________________________________________________________________________________________
activation_169 (Activation)     (None, 32, 32, 200)  0           batch_normalization_
__________________________________________________________________________________________________
conv2d_170 (Conv2D)             (None, 32, 32, 18)   32400       activation_169[0][0]
```

dropout_163 (Dropout)	(None, 32, 32, 18)	0	conv2d_170[0][0]
concatenate_154 (Concatenate)	(None, 32, 32, 218)	0	concatenate_153[0][0 dropout_163[0][0]
batch_normalization_167 (BatchN	(None, 32, 32, 218)	872	concatenate_154[0][0
activation_170 (Activation)	(None, 32, 32, 218)	0	batch_normalization_
conv2d_171 (Conv2D)	(None, 32, 32, 18)	35316	activation_170[0][0]
dropout_164 (Dropout)	(None, 32, 32, 18)	0	conv2d_171[0][0]
concatenate_155 (Concatenate)	(None, 32, 32, 236)	0	concatenate_154[0][0 dropout_164[0][0]
batch_normalization_168 (BatchN	(None, 32, 32, 236)	944	concatenate_155[0][0
activation_171 (Activation)	(None, 32, 32, 236)	0	batch_normalization_
conv2d_172 (Conv2D)	(None, 32, 32, 18)	4248	activation_171[0][0]
dropout_165 (Dropout)	(None, 32, 32, 18)	0	conv2d_172[0][0]
average_pooling2d_15 (AveragePo	(None, 16, 16, 18)	0	dropout_165[0][0]
batch_normalization_169 (BatchN	(None, 16, 16, 18)	72	average_pooling2d_15
activation_172 (Activation)	(None, 16, 16, 18)	0	batch_normalization_
conv2d_173 (Conv2D)	(None, 16, 16, 18)	2916	activation_172[0][0]
dropout_166 (Dropout)	(None, 16, 16, 18)	0	conv2d_173[0][0]
concatenate_156 (Concatenate)	(None, 16, 16, 36)	0	average_pooling2d_15 dropout_166[0][0]
batch_normalization_170 (BatchN	(None, 16, 16, 36)	144	concatenate_156[0][0
activation_173 (Activation)	(None, 16, 16, 36)	0	batch_normalization_
conv2d_174 (Conv2D)	(None, 16, 16, 18)	5832	activation_173[0][0]
dropout_167 (Dropout)	(None, 16, 16, 18)	0	conv2d_174[0][0]
concatenate_157 (Concatenate)	(None, 16, 16, 54)	0	concatenate_156[0][0 dropout_167[0][0]
batch_normalization_171 (BatchN	(None, 16, 16, 54)	216	concatenate_157[0][0
activation_174 (Activation)	(None, 16, 16, 54)	0	batch_normalization_
conv2d_175 (Conv2D)	(None, 16, 16, 18)	8748	activation_174[0][0]
dropout_168 (Dropout)	(None, 16, 16, 18)	0	conv2d_175[0][0]
concatenate_158 (Concatenate)	(None, 16, 16, 72)	0	concatenate_157[0][0 dropout_168[0][0]
batch_normalization_172 (BatchN	(None, 16, 16, 72)	288	concatenate_158[0][0

activation_175 (Activation)	(None, 16, 16, 72)	0	batch_normalization_
conv2d_176 (Conv2D)	(None, 16, 16, 18)	11664	activation_175[0][0]
dropout_169 (Dropout)	(None, 16, 16, 18)	0	conv2d_176[0][0]
concatenate_159 (Concatenate)	(None, 16, 16, 90)	0	concatenate_158[0][0 dropout_169[0][0]
batch_normalization_173 (BatchN	(None, 16, 16, 90)	360	concatenate_159[0][0
activation_176 (Activation)	(None, 16, 16, 90)	0	batch_normalization_
conv2d_177 (Conv2D)	(None, 16, 16, 18)	14580	activation_176[0][0]
dropout_170 (Dropout)	(None, 16, 16, 18)	0	conv2d_177[0][0]
concatenate_160 (Concatenate)	(None, 16, 16, 108)	0	concatenate_159[0][0 dropout_170[0][0]
batch_normalization_174 (BatchN	(None, 16, 16, 108)	432	concatenate_160[0][0
activation_177 (Activation)	(None, 16, 16, 108)	0	batch_normalization_
conv2d_178 (Conv2D)	(None, 16, 16, 18)	17496	activation_177[0][0]
dropout_171 (Dropout)	(None, 16, 16, 18)	0	conv2d_178[0][0]
concatenate_161 (Concatenate)	(None, 16, 16, 126)	0	concatenate_160[0][0 dropout_171[0][0]
batch_normalization_175 (BatchN	(None, 16, 16, 126)	504	concatenate_161[0][0
activation_178 (Activation)	(None, 16, 16, 126)	0	batch_normalization_
conv2d_179 (Conv2D)	(None, 16, 16, 18)	20412	activation_178[0][0]
dropout_172 (Dropout)	(None, 16, 16, 18)	0	conv2d_179[0][0]
concatenate_162 (Concatenate)	(None, 16, 16, 144)	0	concatenate_161[0][0 dropout_172[0][0]
batch_normalization_176 (BatchN	(None, 16, 16, 144)	576	concatenate_162[0][0
activation_179 (Activation)	(None, 16, 16, 144)	0	batch_normalization_
conv2d_180 (Conv2D)	(None, 16, 16, 18)	23328	activation_179[0][0]
dropout_173 (Dropout)	(None, 16, 16, 18)	0	conv2d_180[0][0]
concatenate_163 (Concatenate)	(None, 16, 16, 162)	0	concatenate_162[0][0 dropout_173[0][0]
batch_normalization_177 (BatchN	(None, 16, 16, 162)	648	concatenate_163[0][0
activation_180 (Activation)	(None, 16, 16, 162)	0	batch_normalization_
conv2d_181 (Conv2D)	(None, 16, 16, 18)	26244	activation_180[0][0]
dropout_174 (Dropout)	(None, 16, 16, 18)	0	conv2d_181[0][0]

concatenate_164 (Concatenate)	(None, 16, 16, 180)	0	concatenate_163[0][0] dropout_174[0][0]
batch_normalization_178 (BatchN	(None, 16, 16, 180)	720	concatenate_164[0][0
activation_181 (Activation)	(None, 16, 16, 180)	0	batch_normalization_
conv2d_182 (Conv2D)	(None, 16, 16, 18)	29160	activation_181[0][0]
dropout_175 (Dropout)	(None, 16, 16, 18)	0	conv2d_182[0][0]
concatenate_165 (Concatenate)	(None, 16, 16, 198)	0	concatenate_164[0][0] dropout_175[0][0]
batch_normalization_179 (BatchN	(None, 16, 16, 198)	792	concatenate_165[0][0
activation_182 (Activation)	(None, 16, 16, 198)	0	batch_normalization_
conv2d_183 (Conv2D)	(None, 16, 16, 18)	32076	activation_182[0][0]
dropout_176 (Dropout)	(None, 16, 16, 18)	0	conv2d_183[0][0]
concatenate_166 (Concatenate)	(None, 16, 16, 216)	0	concatenate_165[0][0] dropout_176[0][0]
batch_normalization_180 (BatchN	(None, 16, 16, 216)	864	concatenate_166[0][0
activation_183 (Activation)	(None, 16, 16, 216)	0	batch_normalization_
conv2d_184 (Conv2D)	(None, 16, 16, 18)	34992	activation_183[0][0]
dropout_177 (Dropout)	(None, 16, 16, 18)	0	conv2d_184[0][0]
concatenate_167 (Concatenate)	(None, 16, 16, 234)	0	concatenate_166[0][0] dropout_177[0][0]
batch_normalization_181 (BatchN	(None, 16, 16, 234)	936	concatenate_167[0][0
activation_184 (Activation)	(None, 16, 16, 234)	0	batch_normalization_
conv2d_185 (Conv2D)	(None, 16, 16, 18)	4212	activation_184[0][0]
dropout_178 (Dropout)	(None, 16, 16, 18)	0	conv2d_185[0][0]
average_pooling2d_16 (AveragePo	(None, 8, 8, 18)	0	dropout_178[0][0]
batch_normalization_182 (BatchN	(None, 8, 8, 18)	72	average_pooling2d_16
activation_185 (Activation)	(None, 8, 8, 18)	0	batch_normalization_
conv2d_186 (Conv2D)	(None, 8, 8, 18)	2916	activation_185[0][0]
dropout_179 (Dropout)	(None, 8, 8, 18)	0	conv2d_186[0][0]
concatenate_168 (Concatenate)	(None, 8, 8, 36)	0	average_pooling2d_16 dropout_179[0][0]
batch_normalization_183 (BatchN	(None, 8, 8, 36)	144	concatenate_168[0][0
activation_186 (Activation)	(None, 8, 8, 36)	0	batch_normalization_

conv2d_187 (Conv2D)	(None, 8, 8, 18)	5832	activation_186[0][0]
dropout_180 (Dropout)	(None, 8, 8, 18)	0	conv2d_187[0][0]
concatenate_169 (Concatenate)	(None, 8, 8, 54)	0	concatenate_168[0][0] dropout_180[0][0]
batch_normalization_184 (BatchN	(None, 8, 8, 54)	216	concatenate_169[0][0
activation_187 (Activation)	(None, 8, 8, 54)	0	batch_normalization_
conv2d_188 (Conv2D)	(None, 8, 8, 18)	8748	activation_187[0][0]
dropout_181 (Dropout)	(None, 8, 8, 18)	0	conv2d_188[0][0]
concatenate_170 (Concatenate)	(None, 8, 8, 72)	0	concatenate_169[0][0] dropout_181[0][0]
batch_normalization_185 (BatchN	(None, 8, 8, 72)	288	concatenate_170[0][0
activation_188 (Activation)	(None, 8, 8, 72)	0	batch_normalization_
conv2d_189 (Conv2D)	(None, 8, 8, 18)	11664	activation_188[0][0]
dropout_182 (Dropout)	(None, 8, 8, 18)	0	conv2d_189[0][0]
concatenate_171 (Concatenate)	(None, 8, 8, 90)	0	concatenate_170[0][0] dropout_182[0][0]
batch_normalization_186 (BatchN	(None, 8, 8, 90)	360	concatenate_171[0][0
activation_189 (Activation)	(None, 8, 8, 90)	0	batch_normalization_
conv2d_190 (Conv2D)	(None, 8, 8, 18)	14580	activation_189[0][0]
dropout_183 (Dropout)	(None, 8, 8, 18)	0	conv2d_190[0][0]
concatenate_172 (Concatenate)	(None, 8, 8, 108)	0	concatenate_171[0][0] dropout_183[0][0]
batch_normalization_187 (BatchN	(None, 8, 8, 108)	432	concatenate_172[0][0
activation_190 (Activation)	(None, 8, 8, 108)	0	batch_normalization_
conv2d_191 (Conv2D)	(None, 8, 8, 18)	17496	activation_190[0][0]
dropout_184 (Dropout)	(None, 8, 8, 18)	0	conv2d_191[0][0]
concatenate_173 (Concatenate)	(None, 8, 8, 126)	0	concatenate_172[0][0] dropout_184[0][0]
batch_normalization_188 (BatchN	(None, 8, 8, 126)	504	concatenate_173[0][0
activation_191 (Activation)	(None, 8, 8, 126)	0	batch_normalization_
conv2d_192 (Conv2D)	(None, 8, 8, 18)	20412	activation_191[0][0]
dropout_185 (Dropout)	(None, 8, 8, 18)	0	conv2d_192[0][0]
concatenate_174 (Concatenate)	(None, 8, 8, 144)	0	concatenate_173[0][0] dropout_185[0][0]

batch_normalization_189 (BatchN	(None, 8, 8, 144)	576	concatenate_174[0][0
activation_192 (Activation)	(None, 8, 8, 144)	0	batch_normalization_
conv2d_193 (Conv2D)	(None, 8, 8, 18)	23328	activation_192[0][0]
dropout_186 (Dropout)	(None, 8, 8, 18)	0	conv2d_193[0][0]
concatenate_175 (Concatenate)	(None, 8, 8, 162)	0	concatenate_174[0][0 dropout_186[0][0]
batch_normalization_190 (BatchN	(None, 8, 8, 162)	648	concatenate_175[0][0
activation_193 (Activation)	(None, 8, 8, 162)	0	batch_normalization_
conv2d_194 (Conv2D)	(None, 8, 8, 18)	26244	activation_193[0][0]
dropout_187 (Dropout)	(None, 8, 8, 18)	0	conv2d_194[0][0]
concatenate_176 (Concatenate)	(None, 8, 8, 180)	0	concatenate_175[0][0 dropout_187[0][0]
batch_normalization_191 (BatchN	(None, 8, 8, 180)	720	concatenate_176[0][0
activation_194 (Activation)	(None, 8, 8, 180)	0	batch_normalization_
conv2d_195 (Conv2D)	(None, 8, 8, 18)	29160	activation_194[0][0]
dropout_188 (Dropout)	(None, 8, 8, 18)	0	conv2d_195[0][0]
concatenate_177 (Concatenate)	(None, 8, 8, 198)	0	concatenate_176[0][0 dropout_188[0][0]
batch_normalization_192 (BatchN	(None, 8, 8, 198)	792	concatenate_177[0][0
activation_195 (Activation)	(None, 8, 8, 198)	0	batch_normalization_
conv2d_196 (Conv2D)	(None, 8, 8, 18)	32076	activation_195[0][0]
dropout_189 (Dropout)	(None, 8, 8, 18)	0	conv2d_196[0][0]
concatenate_178 (Concatenate)	(None, 8, 8, 216)	0	concatenate_177[0][0 dropout_189[0][0]
batch_normalization_193 (BatchN	(None, 8, 8, 216)	864	concatenate_178[0][0
activation_196 (Activation)	(None, 8, 8, 216)	0	batch_normalization_
conv2d_197 (Conv2D)	(None, 8, 8, 18)	34992	activation_196[0][0]
dropout_190 (Dropout)	(None, 8, 8, 18)	0	conv2d_197[0][0]
concatenate_179 (Concatenate)	(None, 8, 8, 234)	0	concatenate_178[0][0 dropout_190[0][0]
batch_normalization_194 (BatchN	(None, 8, 8, 234)	936	concatenate_179[0][0
activation_197 (Activation)	(None, 8, 8, 234)	0	batch_normalization_
conv2d_198 (Conv2D)	(None, 8, 8, 18)	4212	activation_197[0][0]

dropout_191 (Dropout)	(None, 8, 8, 18)	0	conv2d_198[0][0]
average_pooling2d_17 (AveragePo	(None, 4, 4, 18)	0	dropout_191[0][0]
batch_normalization_195 (BatchN	(None, 4, 4, 18)	72	average_pooling2d_17
activation_198 (Activation)	(None, 4, 4, 18)	0	batch_normalization_
conv2d_199 (Conv2D)	(None, 4, 4, 18)	2916	activation_198[0][0]
dropout_192 (Dropout)	(None, 4, 4, 18)	0	conv2d_199[0][0]
concatenate_180 (Concatenate)	(None, 4, 4, 36)	0	average_pooling2d_17 dropout_192[0][0]
batch_normalization_196 (BatchN	(None, 4, 4, 36)	144	concatenate_180[0][0
activation_199 (Activation)	(None, 4, 4, 36)	0	batch_normalization_
conv2d_200 (Conv2D)	(None, 4, 4, 18)	5832	activation_199[0][0]
dropout_193 (Dropout)	(None, 4, 4, 18)	0	conv2d_200[0][0]
concatenate_181 (Concatenate)	(None, 4, 4, 54)	0	concatenate_180[0][0 dropout_193[0][0]
batch_normalization_197 (BatchN	(None, 4, 4, 54)	216	concatenate_181[0][0
activation_200 (Activation)	(None, 4, 4, 54)	0	batch_normalization_
conv2d_201 (Conv2D)	(None, 4, 4, 18)	8748	activation_200[0][0]
dropout_194 (Dropout)	(None, 4, 4, 18)	0	conv2d_201[0][0]
concatenate_182 (Concatenate)	(None, 4, 4, 72)	0	concatenate_181[0][0 dropout_194[0][0]
batch_normalization_198 (BatchN	(None, 4, 4, 72)	288	concatenate_182[0][0
activation_201 (Activation)	(None, 4, 4, 72)	0	batch_normalization_
conv2d_202 (Conv2D)	(None, 4, 4, 18)	11664	activation_201[0][0]
dropout_195 (Dropout)	(None, 4, 4, 18)	0	conv2d_202[0][0]
concatenate_183 (Concatenate)	(None, 4, 4, 90)	0	concatenate_182[0][0 dropout_195[0][0]
batch_normalization_199 (BatchN	(None, 4, 4, 90)	360	concatenate_183[0][0
activation_202 (Activation)	(None, 4, 4, 90)	0	batch_normalization_
conv2d_203 (Conv2D)	(None, 4, 4, 18)	14580	activation_202[0][0]
dropout_196 (Dropout)	(None, 4, 4, 18)	0	conv2d_203[0][0]
concatenate_184 (Concatenate)	(None, 4, 4, 108)	0	concatenate_183[0][0 dropout_196[0][0]
batch_normalization_200 (BatchN	(None, 4, 4, 108)	432	concatenate_184[0][0
activation_203 (Activation)	(None, 4, 4, 108)	0	batch_normalization

conv2d_204 (Conv2D)	(None, 4, 4, 18)	17496	activation_203[0][0]
dropout_197 (Dropout)	(None, 4, 4, 18)	0	conv2d_204[0][0]
concatenate_185 (Concatenate)	(None, 4, 4, 126)	0	concatenate_184[0][0 dropout_197[0][0]
batch_normalization_201 (BatchN	(None, 4, 4, 126)	504	concatenate_185[0][0
activation_204 (Activation)	(None, 4, 4, 126)	0	batch_normalization_
conv2d_205 (Conv2D)	(None, 4, 4, 18)	20412	activation_204[0][0]
dropout_198 (Dropout)	(None, 4, 4, 18)	0	conv2d_205[0][0]
concatenate_186 (Concatenate)	(None, 4, 4, 144)	0	concatenate_185[0][0 dropout_198[0][0]
batch_normalization_202 (BatchN	(None, 4, 4, 144)	576	concatenate_186[0][0
activation_205 (Activation)	(None, 4, 4, 144)	0	batch_normalization_
conv2d_206 (Conv2D)	(None, 4, 4, 18)	23328	activation_205[0][0]
dropout_199 (Dropout)	(None, 4, 4, 18)	0	conv2d_206[0][0]
concatenate_187 (Concatenate)	(None, 4, 4, 162)	0	concatenate_186[0][0 dropout_199[0][0]
batch_normalization_203 (BatchN	(None, 4, 4, 162)	648	concatenate_187[0][0
activation_206 (Activation)	(None, 4, 4, 162)	0	batch_normalization_
conv2d_207 (Conv2D)	(None, 4, 4, 18)	26244	activation_206[0][0]
dropout_200 (Dropout)	(None, 4, 4, 18)	0	conv2d_207[0][0]
concatenate_188 (Concatenate)	(None, 4, 4, 180)	0	concatenate_187[0][0 dropout_200[0][0]
batch_normalization_204 (BatchN	(None, 4, 4, 180)	720	concatenate_188[0][0
activation_207 (Activation)	(None, 4, 4, 180)	0	batch_normalization_
conv2d_208 (Conv2D)	(None, 4, 4, 18)	29160	activation_207[0][0]
dropout_201 (Dropout)	(None, 4, 4, 18)	0	conv2d_208[0][0]
concatenate_189 (Concatenate)	(None, 4, 4, 198)	0	concatenate_188[0][0 dropout_201[0][0]
batch_normalization_205 (BatchN	(None, 4, 4, 198)	792	concatenate_189[0][0
activation_208 (Activation)	(None, 4, 4, 198)	0	batch_normalization_
conv2d_209 (Conv2D)	(None, 4, 4, 18)	32076	activation_208[0][0]
dropout_202 (Dropout)	(None, 4, 4, 18)	0	conv2d_209[0][0]
concatenate_190 (Concatenate)	(None, 4, 4, 216)	0	concatenate_189[0][0

```
                                                                 dropout_202[0][0]
__________________________________________________________________________________________________
batch_normalization_206 (BatchN (None, 4, 4, 216)    864         concatenate_190[0][0
__________________________________________________________________________________________________
activation_209 (Activation)     (None, 4, 4, 216)    0           batch_normalization_
__________________________________________________________________________________________________
conv2d_210 (Conv2D)             (None, 4, 4, 18)     34992       activation_209[0][0]
__________________________________________________________________________________________________
dropout_203 (Dropout)           (None, 4, 4, 18)     0           conv2d_210[0][0]
__________________________________________________________________________________________________
concatenate_191 (Concatenate)   (None, 4, 4, 234)    0           concatenate_190[0][0
                                                                 dropout_203[0][0]
__________________________________________________________________________________________________
batch_normalization_207 (BatchN (None, 4, 4, 234)    936         concatenate_191[0][0
__________________________________________________________________________________________________
activation_210 (Activation)     (None, 4, 4, 234)    0           batch_normalization_
__________________________________________________________________________________________________
average_pooling2d_18 (AveragePo (None, 2, 2, 234)    0           activation_210[0][0]
__________________________________________________________________________________________________
conv2d_211 (Conv2D)             (None, 2, 2, 10)     21070       average_pooling2d_18
__________________________________________________________________________________________________
average_pooling2d_19 (AveragePo (None, 1, 1, 10)     0           conv2d_211[0][0]
__________________________________________________________________________________________________
flatten_3 (Flatten)             (None, 10)           0           average_pooling2d_19
__________________________________________________________________________________________________
activation_211 (Activation)     (None, 10)           0           flatten_3[0][0]
==================================================================================================
Total params: 974,274
Trainable params: 961,118
Non-trainable params: 13,156
__________________________________________________________________________________________________
```

```
from time import time
from datetime import datetime
from tensorflow.python.keras.callbacks import TensorBoard
#https://keras.rstudio.com/reference/callback_model_checkpoint.html
#https://machinelearningmastery.com/check-point-deep-learning-models-keras/
filepath = "weights.{epoch:02d}-{val_loss:.2f}.hdf5"
history = tf.keras.callbacks.History()

# https://docs.w3cub.com/tensorflow~python/tf/keras/callbacks/reducelronplateau/
tensorboard = TensorBoard(log_dir="model_logs/{}".format(time()))

filepath = "weights.{epoch:02d}-{val_loss:.2f}.hdf5"
learning_rate_reduction = tf.keras.callbacks.ReduceLROnPlateau(monitor='val_acc',
                                            patience=3,
                                            verbose=1,
                                            factor=0.5,
                                            min_lr=0.0001)
checkpoint_save = tf.keras.callbacks.ModelCheckpoint(filepath, monitor='val_acc', verbose=

callbacks_list = [checkpoint_save,learning_rate_reduction,history,tensorboard]
```

```
#https://keras.io/preprocessing/image/
#Data agumentation
from keras.preprocessing.image import ImageDataGenerator
```

```
datagen = ImageDataGenerator(
    #featurewise_center=True, This was overfitting so commented this out
    #featurewise_std_normalization=True,
    rotation_range=20,
    width_shift_range=0.2,
    height_shift_range=0.2,
    horizontal_flip=True,
    fill_mode='nearest',
    zoom_range=0.10)
datagen.fit(X_train)
```

```
# determine Loss function and Optimizer
# Tried with different optimizer Adam was giving best results
model.compile(loss='categorical_crossentropy',
              optimizer=Adam(),
              metrics=['accuracy'])
```

```
history = model.fit_generator(datagen.flow(X_train, y_train,
                        batch_size=batch_size),callbacks= callbacks_list,
                        epochs=epochs,verbose=0,
                        validation_data=(X_test, y_test))
```

```
Epoch 00001: val_acc improved from -inf to 0.40600, saving model to weights.01-2.26.h

Epoch 00002: val_acc improved from 0.40600 to 0.41820, saving model to weights.02-2.8

Epoch 00003: val_acc improved from 0.41820 to 0.51420, saving model to weights.03-2.0

Epoch 00004: val_acc improved from 0.51420 to 0.67160, saving model to weights.04-1.0

Epoch 00005: val_acc improved from 0.67160 to 0.70430, saving model to weights.05-0.9

Epoch 00006: val_acc did not improve from 0.70430

Epoch 00007: val_acc improved from 0.70430 to 0.71130, saving model to weights.07-0.9

Epoch 00008: val_acc did not improve from 0.71130

Epoch 00009: val_acc did not improve from 0.71130

Epoch 00010: val_acc improved from 0.71130 to 0.76760, saving model to weights.10-0.7

Epoch 00011: val_acc did not improve from 0.76760

Epoch 00012: val_acc improved from 0.76760 to 0.78900, saving model to weights.12-0.6

Epoch 00013: val_acc improved from 0.78900 to 0.79880, saving model to weights.13-0.6

Epoch 00014: val_acc did not improve from 0.79880

Epoch 00015: val_acc improved from 0.79880 to 0.80750, saving model to weights.15-0.6

Epoch 00016: val_acc did not improve from 0.80750

Epoch 00017: val_acc improved from 0.80750 to 0.82660, saving model to weights.17-0.5

Epoch 00018: val_acc did not improve from 0.82660

Epoch 00019: val_acc did not improve from 0.82660

Epoch 00020: val_acc did not improve from 0.82660

Epoch 00020: ReduceLROnPlateau reducing learning rate to 0.0005000000237487257.

Epoch 00021: val_acc improved from 0.82660 to 0.84220, saving model to weights.21-0.5

Epoch 00022: val_acc improved from 0.84220 to 0.85140, saving model to weights.22-0.4

Epoch 00023: val_acc improved from 0.85140 to 0.85190, saving model to weights.23-0.5

Epoch 00024: val_acc improved from 0.85190 to 0.86120, saving model to weights.24-0.4

Epoch 00025: val_acc did not improve from 0.86120

Epoch 00026: val_acc improved from 0.86120 to 0.86300, saving model to weights.26-0.4

Epoch 00027: val_acc did not improve from 0.86300

Epoch 00028: val_acc did not improve from 0.86300

Epoch 00029: val_acc did not improve from 0.86300
```

```
Epoch 00029: ReduceLROnPlateau reducing learning rate to 0.0002500000118743628.

Epoch 00030: val_acc improved from 0.86300 to 0.87940, saving model to weights.30-0.3

Epoch 00031: val_acc improved from 0.87940 to 0.88260, saving model to weights.31-0.3

Epoch 00032: val_acc improved from 0.88260 to 0.88310, saving model to weights.32-0.3

Epoch 00033: val_acc did not improve from 0.88310

Epoch 00034: val_acc did not improve from 0.88310

Epoch 00035: val_acc did not improve from 0.88310

Epoch 00035: ReduceLROnPlateau reducing learning rate to 0.0001250000059371814.

Epoch 00036: val_acc improved from 0.88310 to 0.88540, saving model to weights.36-0.3

Epoch 00037: val_acc improved from 0.88540 to 0.88880, saving model to weights.37-0.3

Epoch 00038: val_acc did not improve from 0.88880

Epoch 00039: val_acc improved from 0.88880 to 0.89180, saving model to weights.39-0.3

Epoch 00040: val_acc improved from 0.89180 to 0.89220, saving model to weights.40-0.3

Epoch 00041: val_acc improved from 0.89220 to 0.89570, saving model to weights.41-0.3

Epoch 00042: val_acc did not improve from 0.89570

Epoch 00043: val_acc did not improve from 0.89570

Epoch 00044: val_acc did not improve from 0.89570

Epoch 00044: ReduceLROnPlateau reducing learning rate to 0.0001.

Epoch 00045: val_acc did not improve from 0.89570

Epoch 00046: val_acc did not improve from 0.89570

Epoch 00047: val_acc did not improve from 0.89570

Epoch 00048: val_acc did not improve from 0.89570

Epoch 00049: val_acc improved from 0.89570 to 0.89820, saving model to weights.49-0.3

Epoch 00050: val_acc did not improve from 0.89820

Epoch 00051: val_acc did not improve from 0.89820

Epoch 00052: val_acc did not improve from 0.89820

Epoch 00053: val_acc did not improve from 0.89820

Epoch 00054: val_acc did not improve from 0.89820

Epoch 00055: val_acc improved from 0.89820 to 0.89850, saving model to weights.55-0.3

Epoch 00056: val_acc did not improve from 0.89850

Epoch 00057: val_acc did not improve from 0.89850
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Epoch 00058: val_acc did not improve from 0.89850

Epoch 00059: val_acc did not improve from 0.89850

Epoch 00060: val_acc did not improve from 0.89850

Epoch 00061: val_acc did not improve from 0.89850

Epoch 00062: val_acc did not improve from 0.89850

Epoch 00063: val_acc did not improve from 0.89850

Epoch 00064: val_acc did not improve from 0.89850

Epoch 00065: val_acc did not improve from 0.89850

Epoch 00066: val_acc did not improve from 0.89850

Epoch 00067: val_acc did not improve from 0.89850

Epoch 00068: val_acc did not improve from 0.89850

Epoch 00069: val_acc did not improve from 0.89850

Epoch 00070: val_acc did not improve from 0.89850

Epoch 00071: val_acc did not improve from 0.89850

Epoch 00072: val_acc did not improve from 0.89850

Epoch 00073: val_acc did not improve from 0.89850

Epoch 00074: val_acc did not improve from 0.89850

Epoch 00075: val_acc did not improve from 0.89850

Epoch 00076: val_acc improved from 0.89850 to 0.89920, saving model to weights.76-0.3

Epoch 00077: val_acc did not improve from 0.89920

Epoch 00078: val_acc did not improve from 0.89920

Epoch 00079: val_acc did not improve from 0.89920

Epoch 00080: val_acc did not improve from 0.89920

Epoch 00081: val_acc improved from 0.89920 to 0.89960, saving model to weights.81-0.3

Epoch 00082: val_acc did not improve from 0.89960

Epoch 00083: val_acc did not improve from 0.89960

Epoch 00084: val_acc improved from 0.89960 to 0.90100, saving model to weights.84-0.3

Epoch 00085: val_acc did not improve from 0.90100

Epoch 00086: val_acc did not improve from 0.90100

Epoch 00087: val_acc did not improve from 0.90100

Epoch 00088: val_acc did not improve from 0.90100
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Epoch 00089: val_acc improved from 0.90100 to 0.90170, saving model to weights.89-0.3

Epoch 00090: val_acc did not improve from 0.90170

Epoch 00091: val_acc did not improve from 0.90170

Epoch 00092: val_acc did not improve from 0.90170

Epoch 00093: val_acc did not improve from 0.90170

Epoch 00094: val_acc did not improve from 0.90170

Epoch 00095: val_acc did not improve from 0.90170

Epoch 00096: val_acc did not improve from 0.90170

Epoch 00097: val_acc did not improve from 0.90170

Epoch 00098: val_acc did not improve from 0.90170

Epoch 00099: val_acc did not improve from 0.90170

Epoch 00100: val_acc did not improve from 0.90170

Epoch 00101: val_acc improved from 0.90170 to 0.90240, saving model to weights.101-0.

Epoch 00102: val_acc did not improve from 0.90240

Epoch 00103: val_acc improved from 0.90240 to 0.90260, saving model to weights.103-0.

Epoch 00104: val_acc improved from 0.90260 to 0.90270, saving model to weights.104-0.

Epoch 00105: val_acc did not improve from 0.90270

Epoch 00106: val_acc did not improve from 0.90270

Epoch 00107: val_acc did not improve from 0.90270

Epoch 00108: val_acc did not improve from 0.90270

Epoch 00109: val_acc improved from 0.90270 to 0.90510, saving model to weights.109-0.

Epoch 00110: val_acc did not improve from 0.90510

Epoch 00111: val_acc did not improve from 0.90510

Epoch 00112: val_acc did not improve from 0.90510

Epoch 00113: val_acc did not improve from 0.90510

Epoch 00114: val_acc did not improve from 0.90510

Epoch 00115: val_acc did not improve from 0.90510

Epoch 00116: val_acc did not improve from 0.90510

Epoch 00117: val_acc improved from 0.90510 to 0.90710, saving model to weights.117-0.

Epoch 00118: val_acc did not improve from 0.90710

Epoch 00119: val_acc did not improve from 0.90710
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Epoch 00120: val_acc did not improve from 0.90710

Epoch 00121: val_acc did not improve from 0.90710

Epoch 00122: val_acc did not improve from 0.90710

Epoch 00123: val_acc did not improve from 0.90710

Epoch 00124: val_acc did not improve from 0.90710

Epoch 00125: val_acc did not improve from 0.90710

Epoch 00126: val_acc did not improve from 0.90710

Epoch 00127: val_acc did not improve from 0.90710

Epoch 00128: val_acc did not improve from 0.90710

Epoch 00129: val_acc did not improve from 0.90710

Epoch 00130: val_acc did not improve from 0.90710

Epoch 00131: val_acc did not improve from 0.90710

Epoch 00132: val_acc did not improve from 0.90710

Epoch 00133: val_acc did not improve from 0.90710

Epoch 00134: val_acc did not improve from 0.90710

Epoch 00135: val_acc did not improve from 0.90710

Epoch 00136: val_acc did not improve from 0.90710

Epoch 00137: val_acc did not improve from 0.90710

Epoch 00138: val_acc improved from 0.90710 to 0.90720, saving model to weights.138-0.

Epoch 00139: val_acc did not improve from 0.90720

Epoch 00140: val_acc did not improve from 0.90720

Epoch 00141: val_acc did not improve from 0.90720

Epoch 00142: val_acc did not improve from 0.90720

Epoch 00143: val_acc did not improve from 0.90720

Epoch 00144: val_acc did not improve from 0.90720

Epoch 00145: val_acc did not improve from 0.90720

Epoch 00146: val_acc did not improve from 0.90720

Epoch 00147: val_acc did not improve from 0.90720

Epoch 00148: val_acc did not improve from 0.90720

Epoch 00149: val_acc did not improve from 0.90720
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Epoch 00150: val_acc did not improve from 0.90720

Epoch 00151: val_acc did not improve from 0.90720

Epoch 00152: val_acc did not improve from 0.90720

Epoch 00153: val_acc did not improve from 0.90720

Epoch 00154: val_acc did not improve from 0.90720

Epoch 00155: val_acc did not improve from 0.90720

Epoch 00156: val_acc did not improve from 0.90720

Epoch 00157: val_acc did not improve from 0.90720

Epoch 00158: val_acc did not improve from 0.90720

Epoch 00159: val_acc did not improve from 0.90720

Epoch 00160: val_acc improved from 0.90720 to 0.90800, saving model to weights.160-0.

Epoch 00161: val_acc did not improve from 0.90800

Epoch 00162: val_acc did not improve from 0.90800

Epoch 00163: val_acc did not improve from 0.90800

Epoch 00164: val_acc did not improve from 0.90800

Epoch 00165: val_acc did not improve from 0.90800

Epoch 00166: val_acc did not improve from 0.90800

Epoch 00167: val_acc did not improve from 0.90800

Epoch 00168: val_acc did not improve from 0.90800

Epoch 00169: val_acc did not improve from 0.90800

Epoch 00170: val_acc did not improve from 0.90800

Epoch 00171: val_acc did not improve from 0.90800

Epoch 00172: val_acc did not improve from 0.90800

Epoch 00173: val_acc did not improve from 0.90800

Epoch 00174: val_acc did not improve from 0.90800

Epoch 00175: val_acc did not improve from 0.90800

Epoch 00176: val_acc improved from 0.90800 to 0.90820, saving model to weights.176-0.

Epoch 00177: val_acc did not improve from 0.90820

Epoch 00178: val_acc improved from 0.90820 to 0.90870, saving model to weights.178-0.

Epoch 00179: val_acc did not improve from 0.90870

Epoch 00180: val_acc did not improve from 0.90870
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Epoch 00181: val_acc did not improve from 0.90870

Epoch 00182: val_acc did not improve from 0.90870

Epoch 00183: val_acc did not improve from 0.90870

Epoch 00184: val_acc did not improve from 0.90870

Epoch 00185: val_acc did not improve from 0.90870

Epoch 00186: val_acc did not improve from 0.90870

Epoch 00187: val_acc did not improve from 0.90870

Epoch 00188: val_acc did not improve from 0.90870

Epoch 00189: val_acc did not improve from 0.90870

Epoch 00190: val_acc did not improve from 0.90870

Epoch 00191: val_acc did not improve from 0.90870

Epoch 00192: val_acc did not improve from 0.90870

Epoch 00193: val_acc did not improve from 0.90870

Epoch 00194: val_acc improved from 0.90870 to 0.91050, saving model to weights.194-0.

Epoch 00195: val_acc improved from 0.91050 to 0.91100, saving model to weights.195-0.

Epoch 00196: val_acc did not improve from 0.91100

Epoch 00197: val_acc did not improve from 0.91100

Epoch 00198: val_acc did not improve from 0.91100

Epoch 00199: val_acc did not improve from 0.91100

Epoch 00200: val_acc did not improve from 0.91100

Epoch 00201: val_acc did not improve from 0.91100

Epoch 00202: val_acc did not improve from 0.91100

Epoch 00203: val_acc did not improve from 0.91100

Epoch 00204: val_acc did not improve from 0.91100

Epoch 00205: val_acc did not improve from 0.91100

Epoch 00206: val_acc improved from 0.91100 to 0.91120, saving model to weights.206-0.

Epoch 00207: val_acc did not improve from 0.91120

Epoch 00208: val_acc improved from 0.91120 to 0.91180, saving model to weights.208-0.

Epoch 00209: val_acc did not improve from 0.91180

Epoch 00210: val_acc did not improve from 0.91180

Epoch 00211: val_acc did not improve from 0.91180
```

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Epoch 00212: val_acc did not improve from 0.91180

Epoch 00213: val_acc did not improve from 0.91180

Epoch 00214: val_acc did not improve from 0.91180

Epoch 00215: val_acc did not improve from 0.91180

Epoch 00216: val_acc did not improve from 0.91180

Epoch 00217: val_acc did not improve from 0.91180

Epoch 00218: val_acc did not improve from 0.91180

Epoch 00219: val_acc did not improve from 0.91180

Epoch 00220: val_acc improved from 0.91180 to 0.91290, saving model to weights.220-0.

Epoch 00221: val_acc did not improve from 0.91290

Epoch 00222: val_acc did not improve from 0.91290

Epoch 00223: val_acc did not improve from 0.91290

Epoch 00224: val_acc did not improve from 0.91290

Epoch 00225: val_acc did not improve from 0.91290

Epoch 00226: val_acc did not improve from 0.91290

Epoch 00227: val_acc did not improve from 0.91290

Epoch 00228: val_acc did not improve from 0.91290

Epoch 00229: val_acc did not improve from 0.91290

Epoch 00230: val_acc did not improve from 0.91290

Epoch 00231: val_acc did not improve from 0.91290

Epoch 00232: val_acc did not improve from 0.91290

Epoch 00233: val_acc did not improve from 0.91290

Epoch 00234: val_acc did not improve from 0.91290

Epoch 00235: val_acc did not improve from 0.91290

Epoch 00236: val_acc did not improve from 0.91290

Epoch 00237: val_acc improved from 0.91290 to 0.91410, saving model to weights.237-0.

Epoch 00238: val_acc did not improve from 0.91410

Epoch 00239: val_acc did not improve from 0.91410

Epoch 00240: val_acc did not improve from 0.91410

Epoch 00241: val_acc did not improve from 0.91410

Epoch 00242: val_acc did not improve from 0.91410
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Epoch 00243: val_acc did not improve from 0.91410

Epoch 00244: val_acc did not improve from 0.91410

Epoch 00245: val_acc did not improve from 0.91410

Epoch 00246: val_acc did not improve from 0.91410

Epoch 00247: val_acc did not improve from 0.91410

Epoch 00248: val_acc did not improve from 0.91410

Epoch 00249: val_acc did not improve from 0.91410

Epoch 00250: val_acc did not improve from 0.91410

Epoch 00251: val_acc did not improve from 0.91410

Epoch 00252: val_acc did not improve from 0.91410

Epoch 00253: val_acc did not improve from 0.91410

Epoch 00254: val_acc did not improve from 0.91410

Epoch 00255: val_acc did not improve from 0.91410

Epoch 00256: val_acc did not improve from 0.91410

Epoch 00257: val_acc did not improve from 0.91410

Epoch 00258: val_acc did not improve from 0.91410

Epoch 00259: val_acc did not improve from 0.91410

Epoch 00260: val_acc did not improve from 0.91410

Epoch 00261: val_acc did not improve from 0.91410

Epoch 00262: val_acc did not improve from 0.91410

Epoch 00263: val_acc did not improve from 0.91410

Epoch 00264: val_acc did not improve from 0.91410

Epoch 00265: val_acc did not improve from 0.91410

Epoch 00266: val_acc did not improve from 0.91410

Epoch 00267: val_acc did not improve from 0.91410

Epoch 00268: val_acc did not improve from 0.91410

Epoch 00269: val_acc did not improve from 0.91410

Epoch 00270: val_acc did not improve from 0.91410

Epoch 00271: val_acc did not improve from 0.91410

Epoch 00272: val_acc did not improve from 0.91410
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Epoch 00273: val_acc did not improve from 0.91410

Epoch 00274: val_acc did not improve from 0.91410

Epoch 00275: val_acc did not improve from 0.91410

Epoch 00276: val_acc did not improve from 0.91410

Epoch 00277: val_acc did not improve from 0.91410

Epoch 00278: val_acc did not improve from 0.91410

Epoch 00279: val_acc did not improve from 0.91410

Epoch 00280: val_acc did not improve from 0.91410

Epoch 00281: val_acc did not improve from 0.91410

Epoch 00282: val_acc did not improve from 0.91410

Epoch 00283: val_acc did not improve from 0.91410

Epoch 00284: val_acc did not improve from 0.91410

Epoch 00285: val_acc did not improve from 0.91410

Epoch 00286: val_acc did not improve from 0.91410

Epoch 00287: val_acc did not improve from 0.91410

Epoch 00288: val_acc did not improve from 0.91410

Epoch 00289: val_acc did not improve from 0.91410

Epoch 00290: val_acc did not improve from 0.91410

Epoch 00291: val_acc did not improve from 0.91410

Epoch 00292: val_acc improved from 0.91410 to 0.91480, saving model to weights.292-0.

Epoch 00293: val_acc did not improve from 0.91480

Epoch 00294: val_acc improved from 0.91480 to 0.91810, saving model to weights.294-0.

Epoch 00295: val_acc did not improve from 0.91810

Epoch 00296: val_acc did not improve from 0.91810

Epoch 00297: val_acc did not improve from 0.91810

Epoch 00298: val_acc did not improve from 0.91810

Epoch 00299: val_acc did not improve from 0.91810

Epoch 00300: val_acc did not improve from 0.91810
```

```
# Save the trained weights in to .h5 format weights.294-0.31.hdf5
model.load_weights("/content/weights.294-0.31.hdf5")
```

```
# Test the model
score = model.evaluate(X_test, y_test, verbose=1)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

```
10000/10000 [==============================] - 5s 461us/sample - loss: 0.3064 - acc:
Test loss: 0.3063799827516079
Test accuracy: 0.9181
```

```
import matplotlib.pyplot as plt
import seaborn as sns
sns.set()
plt.plot(history.history['acc'], 'r')
plt.plot(history.history['val_acc'], 'b')
plt.legend({'Train Accuracy': 'r', 'Test Accuracy':'b'})
plt.xlabel('Epoch')
plt.show()
```