```
import itertools
import os

import keras
from keras.applications.inception_v3 import InceptionV3
from keras.applications.inception_v3 import preprocess_input as
inception_v3_preprocessor
from keras.layers import Dense, GlobalAveragePooling2D, Input
from keras.preprocessing import image
from keras.preprocessing.image import ImageDataGenerator
from keras.utils import np_utils
import matplotlib.pyplot as plt
import numpy as np
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import train_test_split
from tqdm import tqdm
```

```
Using TensorFlow backend.
```

```
%matplotlib inline
```

```
INPUT_SIZE = 299
```

```
data_dir = '../data/crop/'
label_path = '../breeds_16.txt'

breeds = []
with open(label_path, 'r') as f:
    lines = f.readlines()
    for line in lines:
        breeds.append(line.replace('\n', ''))

print(len(breeds))
```

```
16
```

```
def load_img(img_path):
    """ Load a image with (INPUT_SIZE, INPUT_SIZE)
    Returns:
        RGB image as numpy array
    """
    img = image.load_img(img_path, target_size=(INPUT_SIZE, INPUT_SIZE))
    img = image.img_to_array(img)
    img /= 255

    return img
```

```
# Load all images and labels
X = []
y = []
for breed in breeds:
    print(breed)
    index = breeds.index(breed)
    imgs = os.listdir(data_dir + breed + '/')
    for img in imgs:
        img_path = data_dir + breed + '/' + img
        X.append(load_img(img_path))
        y.append(index)
```

```
beagle
border_collie
borzoi
chihuahua
doberman
french_bulldog
german_shepherd
golden_retriever
maltese_dog
pembroke
pomeranian
pug
shih-tzu
siberian_husky
toy_poodle
yorkshire_terrier
```

```
X = np.array(X)
y = np.array(y)
```

```
y = np_utils.to_categorical(y)
print(X.shape, y.shape)
```

```
(1360, 299, 299, 3) (1360, 16)
```

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3)
```

```
print(X_train.shape, y_train.shape, X_test.shape, y_test.shape)
```

```
(952, 299, 299, 3) (952, 16) (408, 299, 299, 3) (408, 16)
```

```
# Data augmentation
train_datagen = ImageDataGenerator(rotation_range=30,
                                   zoom_range = 0.1,
                                   width_shift_range=0.2,
                                   height_shift_range=0.2,
                                   horizontal_flip = True)
train_generator = train_datagen.flow(X_train, y_train, shuffle=False, batch_size=10,
seed=10)
```

```
base_model = InceptionV3(weights='imagenet', include_top=False, input_shape=(299, 299,
3))
```

```
""" Transfer learning """
x = base_model.output
x = GlobalAveragePooling2D()(x)
x = Dense(512, activation='relu')(x)
prediction = Dense(len(breeds), activation='softmax')(x)
model = keras.models.Model(inputs=base_model.input, outputs=prediction)

for layer in base_model.layers:
    layer.trainable=False
```

```
model.compile(optimizer=keras.optimizers.Adam(lr=0.0001),
              loss='categorical_crossentropy',
              metrics=['accuracy'])
```

```
model.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         (None, 299, 299, 3)       0
```

```
____________________________________________________________________________________________
conv2d_1 (Conv2D)               (None, 149, 149, 32) 864         input_1[0][0]

____________________________________________________________________________________________
batch_normalization_1 (BatchNor (None, 149, 149, 32) 96          conv2d_1[0][0]

____________________________________________________________________________________________
activation_1 (Activation)       (None, 149, 149, 32) 0
batch_normalization_1[0][0]
____________________________________________________________________________________________
conv2d_2 (Conv2D)               (None, 147, 147, 32) 9216        activation_1[0][0]

____________________________________________________________________________________________
batch_normalization_2 (BatchNor (None, 147, 147, 32) 96          conv2d_2[0][0]

____________________________________________________________________________________________
activation_2 (Activation)       (None, 147, 147, 32) 0
batch_normalization_2[0][0]
____________________________________________________________________________________________
conv2d_3 (Conv2D)               (None, 147, 147, 64) 18432       activation_2[0][0]

____________________________________________________________________________________________
batch_normalization_3 (BatchNor (None, 147, 147, 64) 192         conv2d_3[0][0]

____________________________________________________________________________________________
activation_3 (Activation)       (None, 147, 147, 64) 0
batch_normalization_3[0][0]
____________________________________________________________________________________________
max_pooling2d_1 (MaxPooling2D)  (None, 73, 73, 64)   0           activation_3[0][0]

____________________________________________________________________________________________
conv2d_4 (Conv2D)               (None, 73, 73, 80)   5120        max_pooling2d_1[0][0]

____________________________________________________________________________________________
batch_normalization_4 (BatchNor (None, 73, 73, 80)   240         conv2d_4[0][0]

____________________________________________________________________________________________
activation_4 (Activation)       (None, 73, 73, 80)   0
batch_normalization_4[0][0]
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____________________________________________________________________________________________
____________
conv2d_5 (Conv2D)               (None, 71, 71, 192)  138240      activation_4[0][0]

____________________________________________________________________________________________
____________
batch_normalization_5 (BatchNor (None, 71, 71, 192)  576         conv2d_5[0][0]

____________________________________________________________________________________________
____________
activation_5 (Activation)       (None, 71, 71, 192)  0
batch_normalization_5[0][0]
____________________________________________________________________________________________
____________
max_pooling2d_2 (MaxPooling2D)  (None, 35, 35, 192)  0           activation_5[0][0]

____________________________________________________________________________________________
____________
conv2d_9 (Conv2D)               (None, 35, 35, 64)   12288       max_pooling2d_2[0][0]

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____________
batch_normalization_9 (BatchNor (None, 35, 35, 64)   192         conv2d_9[0][0]

____________________________________________________________________________________________
____________
activation_9 (Activation)       (None, 35, 35, 64)   0
batch_normalization_9[0][0]
____________________________________________________________________________________________
____________
conv2d_7 (Conv2D)               (None, 35, 35, 48)   9216        max_pooling2d_2[0][0]

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____________
conv2d_10 (Conv2D)              (None, 35, 35, 96)   55296       activation_9[0][0]

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____________
batch_normalization_7 (BatchNor (None, 35, 35, 48)   144         conv2d_7[0][0]

____________________________________________________________________________________________
____________
batch_normalization_10 (BatchNo (None, 35, 35, 96)   288         conv2d_10[0][0]

____________________________________________________________________________________________
____________
activation_7 (Activation)       (None, 35, 35, 48)   0
batch_normalization_7[0][0]
____________________________________________________________________________________________
____________
activation_10 (Activation)      (None, 35, 35, 96)   0
batch_normalization_10[0][0]
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____________________________________________________________________________________________
____________
average_pooling2d_1 (AveragePoo (None, 35, 35, 192)  0           max_pooling2d_2[0][0]
____________________________________________________________________________________________
____________
conv2d_6 (Conv2D)               (None, 35, 35, 64)   12288       max_pooling2d_2[0][0]
____________________________________________________________________________________________
____________
conv2d_8 (Conv2D)               (None, 35, 35, 64)   76800       activation_7[0][0]
____________________________________________________________________________________________
____________
conv2d_11 (Conv2D)              (None, 35, 35, 96)   82944       activation_10[0][0]
____________________________________________________________________________________________
____________
conv2d_12 (Conv2D)              (None, 35, 35, 32)   6144        average_pooling2d_1[0]
[0]
____________________________________________________________________________________________
____________
batch_normalization_6 (BatchNor (None, 35, 35, 64)   192         conv2d_6[0][0]
____________________________________________________________________________________________
____________
batch_normalization_8 (BatchNor (None, 35, 35, 64)   192         conv2d_8[0][0]
____________________________________________________________________________________________
____________
batch_normalization_11 (BatchNo (None, 35, 35, 96)   288         conv2d_11[0][0]
____________________________________________________________________________________________
____________
batch_normalization_12 (BatchNo (None, 35, 35, 32)   96          conv2d_12[0][0]
____________________________________________________________________________________________
____________
activation_6 (Activation)       (None, 35, 35, 64)   0
batch_normalization_6[0][0]
____________________________________________________________________________________________
____________
activation_8 (Activation)       (None, 35, 35, 64)   0
batch_normalization_8[0][0]
____________________________________________________________________________________________
____________
activation_11 (Activation)      (None, 35, 35, 96)   0
batch_normalization_11[0][0]
____________________________________________________________________________________________
____________
activation_12 (Activation)      (None, 35, 35, 32)   0
batch_normalization_12[0][0]
```

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__________________________________________________________________________________________________
mixed0 (Concatenate)            (None, 35, 35, 256)  0           activation_6[0][0]
                                                                 activation_8[0][0]
                                                                 activation_11[0][0]
                                                                 activation_12[0][0]
__________________________________________________________________________________________________
conv2d_16 (Conv2D)              (None, 35, 35, 64)   16384       mixed0[0][0]
__________________________________________________________________________________________________
batch_normalization_16 (BatchNo (None, 35, 35, 64)   192         conv2d_16[0][0]
__________________________________________________________________________________________________
activation_16 (Activation)      (None, 35, 35, 64)   0
batch_normalization_16[0][0]
__________________________________________________________________________________________________
conv2d_14 (Conv2D)              (None, 35, 35, 48)   12288       mixed0[0][0]
__________________________________________________________________________________________________
conv2d_17 (Conv2D)              (None, 35, 35, 96)   55296       activation_16[0][0]
__________________________________________________________________________________________________
batch_normalization_14 (BatchNo (None, 35, 35, 48)   144         conv2d_14[0][0]
__________________________________________________________________________________________________
batch_normalization_17 (BatchNo (None, 35, 35, 96)   288         conv2d_17[0][0]
__________________________________________________________________________________________________
activation_14 (Activation)      (None, 35, 35, 48)   0
batch_normalization_14[0][0]
__________________________________________________________________________________________________
activation_17 (Activation)      (None, 35, 35, 96)   0
batch_normalization_17[0][0]
__________________________________________________________________________________________________
average_pooling2d_2 (AveragePoo (None, 35, 35, 256)  0           mixed0[0][0]
__________________________________________________________________________________________________
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conv2d_13 (Conv2D)              (None, 35, 35, 64)   16384       mixed0[0][0]
__________________________________________________________________________________________
conv2d_15 (Conv2D)              (None, 35, 35, 64)   76800       activation_14[0][0]
__________________________________________________________________________________________
conv2d_18 (Conv2D)              (None, 35, 35, 96)   82944       activation_17[0][0]
__________________________________________________________________________________________
conv2d_19 (Conv2D)              (None, 35, 35, 64)   16384       average_pooling2d_2[0]
[0]
__________________________________________________________________________________________
batch_normalization_13 (BatchNo (None, 35, 35, 64)   192         conv2d_13[0][0]
__________________________________________________________________________________________
batch_normalization_15 (BatchNo (None, 35, 35, 64)   192         conv2d_15[0][0]
__________________________________________________________________________________________
batch_normalization_18 (BatchNo (None, 35, 35, 96)   288         conv2d_18[0][0]
__________________________________________________________________________________________
batch_normalization_19 (BatchNo (None, 35, 35, 64)   192         conv2d_19[0][0]
__________________________________________________________________________________________
activation_13 (Activation)      (None, 35, 35, 64)   0
batch_normalization_13[0][0]
__________________________________________________________________________________________
activation_15 (Activation)      (None, 35, 35, 64)   0
batch_normalization_15[0][0]
__________________________________________________________________________________________
activation_18 (Activation)      (None, 35, 35, 96)   0
batch_normalization_18[0][0]
__________________________________________________________________________________________
activation_19 (Activation)      (None, 35, 35, 64)   0
batch_normalization_19[0][0]
__________________________________________________________________________________________
mixed1 (Concatenate)            (None, 35, 35, 288)  0           activation_13[0][0]
                                                                 activation_15[0][0]
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                                                                 activation_18[0][0]

                                                                 activation_19[0][0]

__________________________________________________________________________________________
__________
conv2d_23 (Conv2D)              (None, 35, 35, 64)   18432       mixed1[0][0]

__________________________________________________________________________________________
__________
batch_normalization_23 (BatchNo (None, 35, 35, 64)   192         conv2d_23[0][0]

__________________________________________________________________________________________
__________
activation_23 (Activation)      (None, 35, 35, 64)   0
batch_normalization_23[0][0]
__________________________________________________________________________________________
__________
conv2d_21 (Conv2D)              (None, 35, 35, 48)   13824       mixed1[0][0]

__________________________________________________________________________________________
__________
conv2d_24 (Conv2D)              (None, 35, 35, 96)   55296       activation_23[0][0]

__________________________________________________________________________________________
__________
batch_normalization_21 (BatchNo (None, 35, 35, 48)   144         conv2d_21[0][0]

__________________________________________________________________________________________
__________
batch_normalization_24 (BatchNo (None, 35, 35, 96)   288         conv2d_24[0][0]

__________________________________________________________________________________________
__________
activation_21 (Activation)      (None, 35, 35, 48)   0
batch_normalization_21[0][0]
__________________________________________________________________________________________
__________
activation_24 (Activation)      (None, 35, 35, 96)   0
batch_normalization_24[0][0]
__________________________________________________________________________________________
__________
average_pooling2d_3 (AveragePoo (None, 35, 35, 288)  0           mixed1[0][0]

__________________________________________________________________________________________
__________
conv2d_20 (Conv2D)              (None, 35, 35, 64)   18432       mixed1[0][0]

__________________________________________________________________________________________
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conv2d_22 (Conv2D)              (None, 35, 35, 64)   76800       activation_21[0][0]
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__________________________________________________________________________________________________
conv2d_25 (Conv2D)              (None, 35, 35, 96)   82944       activation_24[0][0]
__________________________________________________________________________________________________
conv2d_26 (Conv2D)              (None, 35, 35, 64)   18432       average_pooling2d_3[0]
[0]
__________________________________________________________________________________________________
batch_normalization_20 (BatchNo (None, 35, 35, 64)   192         conv2d_20[0][0]
__________________________________________________________________________________________________
batch_normalization_22 (BatchNo (None, 35, 35, 64)   192         conv2d_22[0][0]
__________________________________________________________________________________________________
batch_normalization_25 (BatchNo (None, 35, 35, 96)   288         conv2d_25[0][0]
__________________________________________________________________________________________________
batch_normalization_26 (BatchNo (None, 35, 35, 64)   192         conv2d_26[0][0]
__________________________________________________________________________________________________
activation_20 (Activation)      (None, 35, 35, 64)   0
batch_normalization_20[0][0]
__________________________________________________________________________________________________
activation_22 (Activation)      (None, 35, 35, 64)   0
batch_normalization_22[0][0]
__________________________________________________________________________________________________
activation_25 (Activation)      (None, 35, 35, 96)   0
batch_normalization_25[0][0]
__________________________________________________________________________________________________
activation_26 (Activation)      (None, 35, 35, 64)   0
batch_normalization_26[0][0]
__________________________________________________________________________________________________
mixed2 (Concatenate)            (None, 35, 35, 288)  0           activation_20[0][0]
                                                                 activation_22[0][0]
                                                                 activation_25[0][0]
                                                                 activation_26[0][0]
__________________________________________________________________________________________________
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conv2d_28 (Conv2D)              (None, 35, 35, 64)   18432       mixed2[0][0]

__________________________________________________________________________________________________
batch_normalization_28 (BatchNo (None, 35, 35, 64)   192         conv2d_28[0][0]

__________________________________________________________________________________________________
activation_28 (Activation)      (None, 35, 35, 64)   0
batch_normalization_28[0][0]
__________________________________________________________________________________________________
conv2d_29 (Conv2D)              (None, 35, 35, 96)   55296       activation_28[0][0]

__________________________________________________________________________________________________
batch_normalization_29 (BatchNo (None, 35, 35, 96)   288         conv2d_29[0][0]

__________________________________________________________________________________________________
activation_29 (Activation)      (None, 35, 35, 96)   0
batch_normalization_29[0][0]
__________________________________________________________________________________________________
conv2d_27 (Conv2D)              (None, 17, 17, 384)  995328      mixed2[0][0]

__________________________________________________________________________________________________
conv2d_30 (Conv2D)              (None, 17, 17, 96)   82944       activation_29[0][0]

__________________________________________________________________________________________________
batch_normalization_27 (BatchNo (None, 17, 17, 384)  1152        conv2d_27[0][0]

__________________________________________________________________________________________________
batch_normalization_30 (BatchNo (None, 17, 17, 96)   288         conv2d_30[0][0]

__________________________________________________________________________________________________
activation_27 (Activation)      (None, 17, 17, 384)  0
batch_normalization_27[0][0]
__________________________________________________________________________________________________
activation_30 (Activation)      (None, 17, 17, 96)   0
batch_normalization_30[0][0]
__________________________________________________________________________________________________
max_pooling2d_3 (MaxPooling2D)  (None, 17, 17, 288)  0           mixed2[0][0]

__________________________________________________________________________________________________
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mixed3 (Concatenate)            (None, 17, 17, 768)  0           activation_27[0][0]
                                                                 activation_30[0][0]
                                                                 max_pooling2d_3[0][0]
__________________________________________________________________________________________
conv2d_35 (Conv2D)              (None, 17, 17, 128)  98304       mixed3[0][0]
__________________________________________________________________________________________
batch_normalization_35 (BatchNo (None, 17, 17, 128)  384         conv2d_35[0][0]
__________________________________________________________________________________________
activation_35 (Activation)      (None, 17, 17, 128)  0
batch_normalization_35[0][0]
__________________________________________________________________________________________
conv2d_36 (Conv2D)              (None, 17, 17, 128)  114688      activation_35[0][0]
__________________________________________________________________________________________
batch_normalization_36 (BatchNo (None, 17, 17, 128)  384         conv2d_36[0][0]
__________________________________________________________________________________________
activation_36 (Activation)      (None, 17, 17, 128)  0
batch_normalization_36[0][0]
__________________________________________________________________________________________
conv2d_32 (Conv2D)              (None, 17, 17, 128)  98304       mixed3[0][0]
__________________________________________________________________________________________
conv2d_37 (Conv2D)              (None, 17, 17, 128)  114688      activation_36[0][0]
__________________________________________________________________________________________
batch_normalization_32 (BatchNo (None, 17, 17, 128)  384         conv2d_32[0][0]
__________________________________________________________________________________________
batch_normalization_37 (BatchNo (None, 17, 17, 128)  384         conv2d_37[0][0]
__________________________________________________________________________________________
activation_32 (Activation)      (None, 17, 17, 128)  0
batch_normalization_32[0][0]
__________________________________________________________________________________________
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activation_37 (Activation)      (None, 17, 17, 128)  0
batch_normalization_37[0][0]
__________________________________________________________________________________________________
conv2d_33 (Conv2D)              (None, 17, 17, 128)  114688      activation_32[0][0]
__________________________________________________________________________________________________
conv2d_38 (Conv2D)              (None, 17, 17, 128)  114688      activation_37[0][0]
__________________________________________________________________________________________________
batch_normalization_33 (BatchNo (None, 17, 17, 128)  384         conv2d_33[0][0]
__________________________________________________________________________________________________
batch_normalization_38 (BatchNo (None, 17, 17, 128)  384         conv2d_38[0][0]
__________________________________________________________________________________________________
activation_33 (Activation)      (None, 17, 17, 128)  0
batch_normalization_33[0][0]
__________________________________________________________________________________________________
activation_38 (Activation)      (None, 17, 17, 128)  0
batch_normalization_38[0][0]
__________________________________________________________________________________________________
average_pooling2d_4 (AveragePoo (None, 17, 17, 768)  0           mixed3[0][0]
__________________________________________________________________________________________________
conv2d_31 (Conv2D)              (None, 17, 17, 192)  147456      mixed3[0][0]
__________________________________________________________________________________________________
conv2d_34 (Conv2D)              (None, 17, 17, 192)  172032      activation_33[0][0]
__________________________________________________________________________________________________
conv2d_39 (Conv2D)              (None, 17, 17, 192)  172032      activation_38[0][0]
__________________________________________________________________________________________________
conv2d_40 (Conv2D)              (None, 17, 17, 192)  147456      average_pooling2d_4[0]
[0]
__________________________________________________________________________________________________
batch_normalization_31 (BatchNo (None, 17, 17, 192)  576         conv2d_31[0][0]
__________________________________________________________________________________________________
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batch_normalization_34 (BatchNo (None, 17, 17, 192)  576         conv2d_34[0][0]
__________________________________________________________________________________________________
batch_normalization_39 (BatchNo (None, 17, 17, 192)  576         conv2d_39[0][0]
__________________________________________________________________________________________________
batch_normalization_40 (BatchNo (None, 17, 17, 192)  576         conv2d_40[0][0]
__________________________________________________________________________________________________
activation_31 (Activation)      (None, 17, 17, 192)  0
batch_normalization_31[0][0]
__________________________________________________________________________________________________
activation_34 (Activation)      (None, 17, 17, 192)  0
batch_normalization_34[0][0]
__________________________________________________________________________________________________
activation_39 (Activation)      (None, 17, 17, 192)  0
batch_normalization_39[0][0]
__________________________________________________________________________________________________
activation_40 (Activation)      (None, 17, 17, 192)  0
batch_normalization_40[0][0]
__________________________________________________________________________________________________
mixed4 (Concatenate)            (None, 17, 17, 768)  0           activation_31[0][0]
                                                                 activation_34[0][0]
                                                                 activation_39[0][0]
                                                                 activation_40[0][0]
__________________________________________________________________________________________________
conv2d_45 (Conv2D)              (None, 17, 17, 160)  122880      mixed4[0][0]
__________________________________________________________________________________________________
batch_normalization_45 (BatchNo (None, 17, 17, 160)  480         conv2d_45[0][0]
__________________________________________________________________________________________________
activation_45 (Activation)      (None, 17, 17, 160)  0
batch_normalization_45[0][0]
__________________________________________________________________________________________________
conv2d_46 (Conv2D)              (None, 17, 17, 160)  179200      activation_45[0][0]
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__________________________________________________________________________________________________
batch_normalization_46 (BatchNo (None, 17, 17, 160)  480         conv2d_46[0][0]
__________________________________________________________________________________________________
activation_46 (Activation)      (None, 17, 17, 160)  0
batch_normalization_46[0][0]
__________________________________________________________________________________________________
conv2d_42 (Conv2D)              (None, 17, 17, 160)  122880      mixed4[0][0]
__________________________________________________________________________________________________
conv2d_47 (Conv2D)              (None, 17, 17, 160)  179200      activation_46[0][0]
__________________________________________________________________________________________________
batch_normalization_42 (BatchNo (None, 17, 17, 160)  480         conv2d_42[0][0]
__________________________________________________________________________________________________
batch_normalization_47 (BatchNo (None, 17, 17, 160)  480         conv2d_47[0][0]
__________________________________________________________________________________________________
activation_42 (Activation)      (None, 17, 17, 160)  0
batch_normalization_42[0][0]
__________________________________________________________________________________________________
activation_47 (Activation)      (None, 17, 17, 160)  0
batch_normalization_47[0][0]
__________________________________________________________________________________________________
conv2d_43 (Conv2D)              (None, 17, 17, 160)  179200      activation_42[0][0]
__________________________________________________________________________________________________
conv2d_48 (Conv2D)              (None, 17, 17, 160)  179200      activation_47[0][0]
__________________________________________________________________________________________________
batch_normalization_43 (BatchNo (None, 17, 17, 160)  480         conv2d_43[0][0]
__________________________________________________________________________________________________
batch_normalization_48 (BatchNo (None, 17, 17, 160)  480         conv2d_48[0][0]
__________________________________________________________________________________________________
activation_43 (Activation)      (None, 17, 17, 160)  0
batch_normalization_43[0][0]
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__________________________________________________________________________________________________
activation_48 (Activation)      (None, 17, 17, 160)  0           batch_normalization_48[0][0]
__________________________________________________________________________________________________
average_pooling2d_5 (AveragePoo (None, 17, 17, 768)  0           mixed4[0][0]
__________________________________________________________________________________________________
conv2d_41 (Conv2D)              (None, 17, 17, 192)  147456      mixed4[0][0]
__________________________________________________________________________________________________
conv2d_44 (Conv2D)              (None, 17, 17, 192)  215040      activation_43[0][0]
__________________________________________________________________________________________________
conv2d_49 (Conv2D)              (None, 17, 17, 192)  215040      activation_48[0][0]
__________________________________________________________________________________________________
conv2d_50 (Conv2D)              (None, 17, 17, 192)  147456      average_pooling2d_5[0][0]
__________________________________________________________________________________________________
batch_normalization_41 (BatchNo (None, 17, 17, 192)  576         conv2d_41[0][0]
__________________________________________________________________________________________________
batch_normalization_44 (BatchNo (None, 17, 17, 192)  576         conv2d_44[0][0]
__________________________________________________________________________________________________
batch_normalization_49 (BatchNo (None, 17, 17, 192)  576         conv2d_49[0][0]
__________________________________________________________________________________________________
batch_normalization_50 (BatchNo (None, 17, 17, 192)  576         conv2d_50[0][0]
__________________________________________________________________________________________________
activation_41 (Activation)      (None, 17, 17, 192)  0           batch_normalization_41[0][0]
__________________________________________________________________________________________________
activation_44 (Activation)      (None, 17, 17, 192)  0           batch_normalization_44[0][0]
__________________________________________________________________________________________________
activation_49 (Activation)      (None, 17, 17, 192)  0           batch_normalization_49[0][0]
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__________________________________________________________________________________________________
activation_50 (Activation)      (None, 17, 17, 192)  0
batch_normalization_50[0][0]
__________________________________________________________________________________________________
mixed5 (Concatenate)            (None, 17, 17, 768)  0           activation_41[0][0]
                                                                 activation_44[0][0]
                                                                 activation_49[0][0]
                                                                 activation_50[0][0]
__________________________________________________________________________________________________
conv2d_55 (Conv2D)              (None, 17, 17, 160)  122880      mixed5[0][0]
__________________________________________________________________________________________________
batch_normalization_55 (BatchNo (None, 17, 17, 160)  480         conv2d_55[0][0]
__________________________________________________________________________________________________
activation_55 (Activation)      (None, 17, 17, 160)  0
batch_normalization_55[0][0]
__________________________________________________________________________________________________
conv2d_56 (Conv2D)              (None, 17, 17, 160)  179200      activation_55[0][0]
__________________________________________________________________________________________________
batch_normalization_56 (BatchNo (None, 17, 17, 160)  480         conv2d_56[0][0]
__________________________________________________________________________________________________
activation_56 (Activation)      (None, 17, 17, 160)  0
batch_normalization_56[0][0]
__________________________________________________________________________________________________
conv2d_52 (Conv2D)              (None, 17, 17, 160)  122880      mixed5[0][0]
__________________________________________________________________________________________________
conv2d_57 (Conv2D)              (None, 17, 17, 160)  179200      activation_56[0][0]
__________________________________________________________________________________________________
batch_normalization_52 (BatchNo (None, 17, 17, 160)  480         conv2d_52[0][0]
__________________________________________________________________________________________________
```

```
batch_normalization_57 (BatchNo (None, 17, 17, 160)  480         conv2d_57[0][0]

__________________________________________________________________________________________________
activation_52 (Activation)      (None, 17, 17, 160)  0
batch_normalization_52[0][0]
__________________________________________________________________________________________________
activation_57 (Activation)      (None, 17, 17, 160)  0
batch_normalization_57[0][0]
__________________________________________________________________________________________________
conv2d_53 (Conv2D)              (None, 17, 17, 160)  179200      activation_52[0][0]

__________________________________________________________________________________________________
conv2d_58 (Conv2D)              (None, 17, 17, 160)  179200      activation_57[0][0]

__________________________________________________________________________________________________
batch_normalization_53 (BatchNo (None, 17, 17, 160)  480         conv2d_53[0][0]

__________________________________________________________________________________________________
batch_normalization_58 (BatchNo (None, 17, 17, 160)  480         conv2d_58[0][0]

__________________________________________________________________________________________________
activation_53 (Activation)      (None, 17, 17, 160)  0
batch_normalization_53[0][0]
__________________________________________________________________________________________________
activation_58 (Activation)      (None, 17, 17, 160)  0
batch_normalization_58[0][0]
__________________________________________________________________________________________________
average_pooling2d_6 (AveragePoo (None, 17, 17, 768)  0           mixed5[0][0]

__________________________________________________________________________________________________
conv2d_51 (Conv2D)              (None, 17, 17, 192)  147456      mixed5[0][0]

__________________________________________________________________________________________________
conv2d_54 (Conv2D)              (None, 17, 17, 192)  215040      activation_53[0][0]

__________________________________________________________________________________________________
conv2d_59 (Conv2D)              (None, 17, 17, 192)  215040      activation_58[0][0]

__________________________________________________________________________________________________
```

```
conv2d_60 (Conv2D)              (None, 17, 17, 192)  147456      average_pooling2d_6[0]
[0]
__________________________________________________________________________________________
__________
batch_normalization_51 (BatchNo (None, 17, 17, 192)  576         conv2d_51[0][0]

__________________________________________________________________________________________
__________
batch_normalization_54 (BatchNo (None, 17, 17, 192)  576         conv2d_54[0][0]

__________________________________________________________________________________________
__________
batch_normalization_59 (BatchNo (None, 17, 17, 192)  576         conv2d_59[0][0]

__________________________________________________________________________________________
__________
batch_normalization_60 (BatchNo (None, 17, 17, 192)  576         conv2d_60[0][0]

__________________________________________________________________________________________
__________
activation_51 (Activation)      (None, 17, 17, 192)  0
batch_normalization_51[0][0]
__________________________________________________________________________________________
__________
activation_54 (Activation)      (None, 17, 17, 192)  0
batch_normalization_54[0][0]
__________________________________________________________________________________________
__________
activation_59 (Activation)      (None, 17, 17, 192)  0
batch_normalization_59[0][0]
__________________________________________________________________________________________
__________
activation_60 (Activation)      (None, 17, 17, 192)  0
batch_normalization_60[0][0]
__________________________________________________________________________________________
__________
mixed6 (Concatenate)            (None, 17, 17, 768)  0           activation_51[0][0]

                                                                    activation_54[0][0]

                                                                    activation_59[0][0]

                                                                    activation_60[0][0]

__________________________________________________________________________________________
__________
conv2d_65 (Conv2D)              (None, 17, 17, 192)  147456      mixed6[0][0]

__________________________________________________________________________________________
__________
batch_normalization_65 (BatchNo (None, 17, 17, 192)  576         conv2d_65[0][0]
```

```
__________________________________________________________________________________________________
activation_65 (Activation)      (None, 17, 17, 192)  0
batch_normalization_65[0][0]
__________________________________________________________________________________________________
conv2d_66 (Conv2D)              (None, 17, 17, 192)  258048      activation_65[0][0]
__________________________________________________________________________________________________
batch_normalization_66 (BatchNo (None, 17, 17, 192)  576         conv2d_66[0][0]
__________________________________________________________________________________________________
activation_66 (Activation)      (None, 17, 17, 192)  0
batch_normalization_66[0][0]
__________________________________________________________________________________________________
conv2d_62 (Conv2D)              (None, 17, 17, 192)  147456      mixed6[0][0]
__________________________________________________________________________________________________
conv2d_67 (Conv2D)              (None, 17, 17, 192)  258048      activation_66[0][0]
__________________________________________________________________________________________________
batch_normalization_62 (BatchNo (None, 17, 17, 192)  576         conv2d_62[0][0]
__________________________________________________________________________________________________
batch_normalization_67 (BatchNo (None, 17, 17, 192)  576         conv2d_67[0][0]
__________________________________________________________________________________________________
activation_62 (Activation)      (None, 17, 17, 192)  0
batch_normalization_62[0][0]
__________________________________________________________________________________________________
activation_67 (Activation)      (None, 17, 17, 192)  0
batch_normalization_67[0][0]
__________________________________________________________________________________________________
conv2d_63 (Conv2D)              (None, 17, 17, 192)  258048      activation_62[0][0]
__________________________________________________________________________________________________
conv2d_68 (Conv2D)              (None, 17, 17, 192)  258048      activation_67[0][0]
__________________________________________________________________________________________________
batch_normalization_63 (BatchNo (None, 17, 17, 192)  576         conv2d_63[0][0]
```

```
__________________________________________________________________________________________________
batch_normalization_68 (BatchNo (None, 17, 17, 192)  576         conv2d_68[0][0]
__________________________________________________________________________________________________
activation_63 (Activation)      (None, 17, 17, 192)  0           batch_normalization_63[0][0]
__________________________________________________________________________________________________
activation_68 (Activation)      (None, 17, 17, 192)  0           batch_normalization_68[0][0]
__________________________________________________________________________________________________
average_pooling2d_7 (AveragePoo (None, 17, 17, 768)  0           mixed6[0][0]
__________________________________________________________________________________________________
conv2d_61 (Conv2D)              (None, 17, 17, 192)  147456      mixed6[0][0]
__________________________________________________________________________________________________
conv2d_64 (Conv2D)              (None, 17, 17, 192)  258048      activation_63[0][0]
__________________________________________________________________________________________________
conv2d_69 (Conv2D)              (None, 17, 17, 192)  258048      activation_68[0][0]
__________________________________________________________________________________________________
conv2d_70 (Conv2D)              (None, 17, 17, 192)  147456      average_pooling2d_7[0][0]
__________________________________________________________________________________________________
batch_normalization_61 (BatchNo (None, 17, 17, 192)  576         conv2d_61[0][0]
__________________________________________________________________________________________________
batch_normalization_64 (BatchNo (None, 17, 17, 192)  576         conv2d_64[0][0]
__________________________________________________________________________________________________
batch_normalization_69 (BatchNo (None, 17, 17, 192)  576         conv2d_69[0][0]
__________________________________________________________________________________________________
batch_normalization_70 (BatchNo (None, 17, 17, 192)  576         conv2d_70[0][0]
__________________________________________________________________________________________________
activation_61 (Activation)      (None, 17, 17, 192)  0           batch_normalization_61[0][0]
```

```
__________________________________________________________________________________________________
activation_64 (Activation)      (None, 17, 17, 192)  0
batch_normalization_64[0][0]
__________________________________________________________________________________________________
activation_69 (Activation)      (None, 17, 17, 192)  0
batch_normalization_69[0][0]
__________________________________________________________________________________________________
activation_70 (Activation)      (None, 17, 17, 192)  0
batch_normalization_70[0][0]
__________________________________________________________________________________________________
mixed7 (Concatenate)            (None, 17, 17, 768)  0           activation_61[0][0]
                                                                 activation_64[0][0]
                                                                 activation_69[0][0]
                                                                 activation_70[0][0]
__________________________________________________________________________________________________
conv2d_73 (Conv2D)              (None, 17, 17, 192)  147456      mixed7[0][0]
__________________________________________________________________________________________________
batch_normalization_73 (BatchNo (None, 17, 17, 192)  576         conv2d_73[0][0]
__________________________________________________________________________________________________
activation_73 (Activation)      (None, 17, 17, 192)  0
batch_normalization_73[0][0]
__________________________________________________________________________________________________
conv2d_74 (Conv2D)              (None, 17, 17, 192)  258048      activation_73[0][0]
__________________________________________________________________________________________________
batch_normalization_74 (BatchNo (None, 17, 17, 192)  576         conv2d_74[0][0]
__________________________________________________________________________________________________
activation_74 (Activation)      (None, 17, 17, 192)  0
batch_normalization_74[0][0]
__________________________________________________________________________________________________
conv2d_71 (Conv2D)              (None, 17, 17, 192)  147456      mixed7[0][0]
__________________________________________________________________________________________________
```

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conv2d_75 (Conv2D)              (None, 17, 17, 192)  258048      activation_74[0][0]

__________________________________________________________________________________________
____________
batch_normalization_71 (BatchNo (None, 17, 17, 192)  576         conv2d_71[0][0]

__________________________________________________________________________________________
____________
batch_normalization_75 (BatchNo (None, 17, 17, 192)  576         conv2d_75[0][0]

__________________________________________________________________________________________
____________
activation_71 (Activation)      (None, 17, 17, 192)  0
batch_normalization_71[0][0]
__________________________________________________________________________________________
____________
activation_75 (Activation)      (None, 17, 17, 192)  0
batch_normalization_75[0][0]
__________________________________________________________________________________________
____________
conv2d_72 (Conv2D)              (None, 8, 8, 320)    552960      activation_71[0][0]

__________________________________________________________________________________________
____________
conv2d_76 (Conv2D)              (None, 8, 8, 192)    331776      activation_75[0][0]

__________________________________________________________________________________________
____________
batch_normalization_72 (BatchNo (None, 8, 8, 320)    960         conv2d_72[0][0]

__________________________________________________________________________________________
____________
batch_normalization_76 (BatchNo (None, 8, 8, 192)    576         conv2d_76[0][0]

__________________________________________________________________________________________
____________
activation_72 (Activation)      (None, 8, 8, 320)    0
batch_normalization_72[0][0]
__________________________________________________________________________________________
____________
activation_76 (Activation)      (None, 8, 8, 192)    0
batch_normalization_76[0][0]
__________________________________________________________________________________________
____________
max_pooling2d_4 (MaxPooling2D)  (None, 8, 8, 768)    0           mixed7[0][0]

__________________________________________________________________________________________
____________
mixed8 (Concatenate)            (None, 8, 8, 1280)   0           activation_72[0][0]

                                                                 activation_76[0][0]
```

```
                                                                 max_pooling2d_4[0][0]
__________________________________________________________________________________________________
conv2d_81 (Conv2D)              (None, 8, 8, 448)    573440      mixed8[0][0]
__________________________________________________________________________________________________
batch_normalization_81 (BatchNo (None, 8, 8, 448)    1344        conv2d_81[0][0]
__________________________________________________________________________________________________
activation_81 (Activation)      (None, 8, 8, 448)    0
batch_normalization_81[0][0]
__________________________________________________________________________________________________
conv2d_78 (Conv2D)              (None, 8, 8, 384)    491520      mixed8[0][0]
__________________________________________________________________________________________________
conv2d_82 (Conv2D)              (None, 8, 8, 384)    1548288     activation_81[0][0]
__________________________________________________________________________________________________
batch_normalization_78 (BatchNo (None, 8, 8, 384)    1152        conv2d_78[0][0]
__________________________________________________________________________________________________
batch_normalization_82 (BatchNo (None, 8, 8, 384)    1152        conv2d_82[0][0]
__________________________________________________________________________________________________
activation_78 (Activation)      (None, 8, 8, 384)    0
batch_normalization_78[0][0]
__________________________________________________________________________________________________
activation_82 (Activation)      (None, 8, 8, 384)    0
batch_normalization_82[0][0]
__________________________________________________________________________________________________
conv2d_79 (Conv2D)              (None, 8, 8, 384)    442368      activation_78[0][0]
__________________________________________________________________________________________________
conv2d_80 (Conv2D)              (None, 8, 8, 384)    442368      activation_78[0][0]
__________________________________________________________________________________________________
conv2d_83 (Conv2D)              (None, 8, 8, 384)    442368      activation_82[0][0]
__________________________________________________________________________________________________
```

```
conv2d_84 (Conv2D)              (None, 8, 8, 384)    442368      activation_82[0][0]
__________________________________________________________________________________________
__________
average_pooling2d_8 (AveragePoo (None, 8, 8, 1280)   0           mixed8[0][0]
__________________________________________________________________________________________
__________
conv2d_77 (Conv2D)              (None, 8, 8, 320)    409600      mixed8[0][0]
__________________________________________________________________________________________
__________
batch_normalization_79 (BatchNo (None, 8, 8, 384)    1152        conv2d_79[0][0]
__________________________________________________________________________________________
__________
batch_normalization_80 (BatchNo (None, 8, 8, 384)    1152        conv2d_80[0][0]
__________________________________________________________________________________________
__________
batch_normalization_83 (BatchNo (None, 8, 8, 384)    1152        conv2d_83[0][0]
__________________________________________________________________________________________
__________
batch_normalization_84 (BatchNo (None, 8, 8, 384)    1152        conv2d_84[0][0]
__________________________________________________________________________________________
__________
conv2d_85 (Conv2D)              (None, 8, 8, 192)    245760      average_pooling2d_8[0]
[0]
__________________________________________________________________________________________
__________
batch_normalization_77 (BatchNo (None, 8, 8, 320)    960         conv2d_77[0][0]
__________________________________________________________________________________________
__________
activation_79 (Activation)      (None, 8, 8, 384)    0
batch_normalization_79[0][0]
__________________________________________________________________________________________
__________
activation_80 (Activation)      (None, 8, 8, 384)    0
batch_normalization_80[0][0]
__________________________________________________________________________________________
__________
activation_83 (Activation)      (None, 8, 8, 384)    0
batch_normalization_83[0][0]
__________________________________________________________________________________________
__________
activation_84 (Activation)      (None, 8, 8, 384)    0
batch_normalization_84[0][0]
__________________________________________________________________________________________
__________
```

```
batch_normalization_85 (BatchNo (None, 8, 8, 192)    576         conv2d_85[0][0]
__________________________________________________________________________________________________
activation_77 (Activation)      (None, 8, 8, 320)    0
batch_normalization_77[0][0]
__________________________________________________________________________________________________
mixed9_0 (Concatenate)          (None, 8, 8, 768)    0           activation_79[0][0]
                                                                 activation_80[0][0]
__________________________________________________________________________________________________
concatenate_1 (Concatenate)     (None, 8, 8, 768)    0           activation_83[0][0]
                                                                 activation_84[0][0]
__________________________________________________________________________________________________
activation_85 (Activation)      (None, 8, 8, 192)    0
batch_normalization_85[0][0]
__________________________________________________________________________________________________
mixed9 (Concatenate)            (None, 8, 8, 2048)   0           activation_77[0][0]
                                                                 mixed9_0[0][0]
                                                                 concatenate_1[0][0]
                                                                 activation_85[0][0]
__________________________________________________________________________________________________
conv2d_90 (Conv2D)              (None, 8, 8, 448)    917504      mixed9[0][0]
__________________________________________________________________________________________________
batch_normalization_90 (BatchNo (None, 8, 8, 448)    1344        conv2d_90[0][0]
__________________________________________________________________________________________________
activation_90 (Activation)      (None, 8, 8, 448)    0
batch_normalization_90[0][0]
__________________________________________________________________________________________________
conv2d_87 (Conv2D)              (None, 8, 8, 384)    786432      mixed9[0][0]
__________________________________________________________________________________________________
conv2d_91 (Conv2D)              (None, 8, 8, 384)    1548288     activation_90[0][0]
```

```
__________________________________________________________________________________________________
batch_normalization_87 (BatchNo (None, 8, 8, 384)    1152        conv2d_87[0][0]
__________________________________________________________________________________________________
batch_normalization_91 (BatchNo (None, 8, 8, 384)    1152        conv2d_91[0][0]
__________________________________________________________________________________________________
activation_87 (Activation)      (None, 8, 8, 384)    0
batch_normalization_87[0][0]
__________________________________________________________________________________________________
activation_91 (Activation)      (None, 8, 8, 384)    0
batch_normalization_91[0][0]
__________________________________________________________________________________________________
conv2d_88 (Conv2D)              (None, 8, 8, 384)    442368      activation_87[0][0]
__________________________________________________________________________________________________
conv2d_89 (Conv2D)              (None, 8, 8, 384)    442368      activation_87[0][0]
__________________________________________________________________________________________________
conv2d_92 (Conv2D)              (None, 8, 8, 384)    442368      activation_91[0][0]
__________________________________________________________________________________________________
conv2d_93 (Conv2D)              (None, 8, 8, 384)    442368      activation_91[0][0]
__________________________________________________________________________________________________
average_pooling2d_9 (AveragePoo (None, 8, 8, 2048)   0           mixed9[0][0]
__________________________________________________________________________________________________
conv2d_86 (Conv2D)              (None, 8, 8, 320)    655360      mixed9[0][0]
__________________________________________________________________________________________________
batch_normalization_88 (BatchNo (None, 8, 8, 384)    1152        conv2d_88[0][0]
__________________________________________________________________________________________________
batch_normalization_89 (BatchNo (None, 8, 8, 384)    1152        conv2d_89[0][0]
__________________________________________________________________________________________________
batch_normalization_92 (BatchNo (None, 8, 8, 384)    1152        conv2d_92[0][0]
```

```
__________________________________________________________________________________________________
batch_normalization_93 (BatchNo (None, 8, 8, 384)    1152        conv2d_93[0][0]
__________________________________________________________________________________________________
conv2d_94 (Conv2D)              (None, 8, 8, 192)    393216      average_pooling2d_9[0]
[0]
__________________________________________________________________________________________________
batch_normalization_86 (BatchNo (None, 8, 8, 320)    960         conv2d_86[0][0]
__________________________________________________________________________________________________
activation_88 (Activation)      (None, 8, 8, 384)    0
batch_normalization_88[0][0]
__________________________________________________________________________________________________
activation_89 (Activation)      (None, 8, 8, 384)    0
batch_normalization_89[0][0]
__________________________________________________________________________________________________
activation_92 (Activation)      (None, 8, 8, 384)    0
batch_normalization_92[0][0]
__________________________________________________________________________________________________
activation_93 (Activation)      (None, 8, 8, 384)    0
batch_normalization_93[0][0]
__________________________________________________________________________________________________
batch_normalization_94 (BatchNo (None, 8, 8, 192)    576         conv2d_94[0][0]
__________________________________________________________________________________________________
activation_86 (Activation)      (None, 8, 8, 320)    0
batch_normalization_86[0][0]
__________________________________________________________________________________________________
mixed9_1 (Concatenate)          (None, 8, 8, 768)    0           activation_88[0][0]
                                                                 activation_89[0][0]
__________________________________________________________________________________________________
concatenate_2 (Concatenate)     (None, 8, 8, 768)    0           activation_92[0][0]
                                                                 activation_93[0][0]
__________________________________________________________________________________________________
activation_94 (Activation)      (None, 8, 8, 192)    0
batch_normalization_94[0][0]
```

```
__________________________________________________________________________________________________
__________
mixed10 (Concatenate)           (None, 8, 8, 2048)   0           activation_86[0][0]

                                                                 mixed9_1[0][0]

                                                                 concatenate_2[0][0]

                                                                 activation_94[0][0]

__________________________________________________________________________________________________
__________
global_average_pooling2d_1 (Glo (None, 2048)         0           mixed10[0][0]

__________________________________________________________________________________________________
__________
dense_1 (Dense)                 (None, 512)          1049088
global_average_pooling2d_1[0][0]
__________________________________________________________________________________________________
__________
dense_2 (Dense)                 (None, 16)           8208        dense_1[0][0]

==================================================================================================
===========
Total params: 22,860,080
Trainable params: 1,057,296
Non-trainable params: 21,802,784
__________________________________________________________________________________________________
__________
```

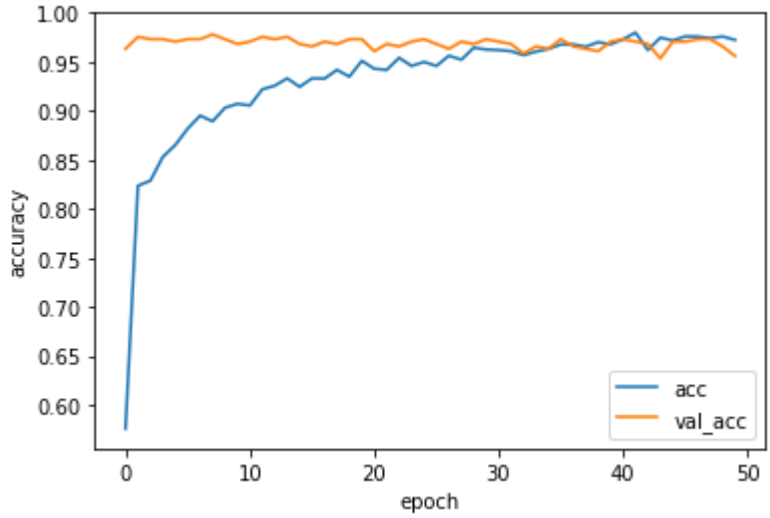
```
history = model.fit_generator(train_generator,
                              steps_per_epoch=175,
                              validation_data=(X_test, y_test),
                              validation_steps=44,
                              epochs=50,
                              verbose=2)
```

```
Epoch 1/50
 - 39s - loss: 1.6997 - acc: 0.5754 - val_loss: 0.4074 - val_acc: 0.9632
Epoch 2/50
 - 34s - loss: 0.7656 - acc: 0.8229 - val_loss: 0.1433 - val_acc: 0.9755
Epoch 3/50
 - 33s - loss: 0.6031 - acc: 0.8257 - val_loss: 0.1204 - val_acc: 0.9730
Epoch 4/50
 - 33s - loss: 0.5218 - acc: 0.8543 - val_loss: 0.1181 - val_acc: 0.9730
Epoch 5/50
 - 33s - loss: 0.4749 - acc: 0.8663 - val_loss: 0.1043 - val_acc: 0.9706
Epoch 6/50
 - 33s - loss: 0.4203 - acc: 0.8823 - val_loss: 0.0980 - val_acc: 0.9730
Epoch 7/50
```

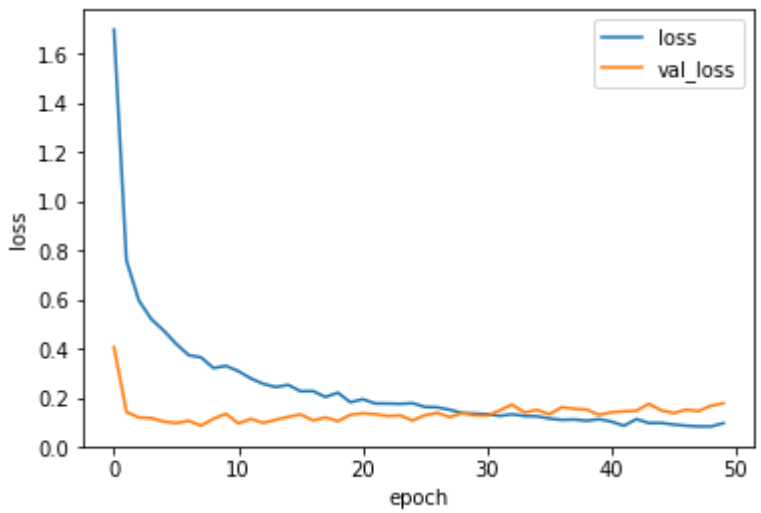
```
 - 33s - loss: 0.3769 - acc: 0.8960 - val_loss: 0.1073 - val_acc: 0.9730
Epoch 8/50
 - 33s - loss: 0.3645 - acc: 0.8903 - val_loss: 0.0876 - val_acc: 0.9779
Epoch 9/50
 - 32s - loss: 0.3208 - acc: 0.9040 - val_loss: 0.1158 - val_acc: 0.9730
Epoch 10/50
 - 32s - loss: 0.3314 - acc: 0.9080 - val_loss: 0.1357 - val_acc: 0.9681
Epoch 11/50
 - 32s - loss: 0.3078 - acc: 0.9063 - val_loss: 0.0965 - val_acc: 0.9706
Epoch 12/50
 - 32s - loss: 0.2801 - acc: 0.9223 - val_loss: 0.1151 - val_acc: 0.9755
Epoch 13/50
 - 32s - loss: 0.2574 - acc: 0.9263 - val_loss: 0.0987 - val_acc: 0.9730
Epoch 14/50
 - 32s - loss: 0.2439 - acc: 0.9337 - val_loss: 0.1115 - val_acc: 0.9755
Epoch 15/50
 - 32s - loss: 0.2537 - acc: 0.9251 - val_loss: 0.1231 - val_acc: 0.9681
Epoch 16/50
 - 32s - loss: 0.2262 - acc: 0.9337 - val_loss: 0.1333 - val_acc: 0.9657
Epoch 17/50
 - 32s - loss: 0.2281 - acc: 0.9331 - val_loss: 0.1087 - val_acc: 0.9706
Epoch 18/50
 - 32s - loss: 0.2047 - acc: 0.9423 - val_loss: 0.1209 - val_acc: 0.9681
Epoch 19/50
 - 32s - loss: 0.2206 - acc: 0.9354 - val_loss: 0.1060 - val_acc: 0.9730
Epoch 20/50
 - 33s - loss: 0.1826 - acc: 0.9514 - val_loss: 0.1315 - val_acc: 0.9730
Epoch 21/50
 - 34s - loss: 0.1942 - acc: 0.9434 - val_loss: 0.1375 - val_acc: 0.9608
Epoch 22/50
 - 32s - loss: 0.1767 - acc: 0.9423 - val_loss: 0.1343 - val_acc: 0.9681
Epoch 23/50
 - 32s - loss: 0.1769 - acc: 0.9543 - val_loss: 0.1268 - val_acc: 0.9657
Epoch 24/50
 - 32s - loss: 0.1750 - acc: 0.9463 - val_loss: 0.1292 - val_acc: 0.9706
Epoch 25/50
 - 32s - loss: 0.1777 - acc: 0.9503 - val_loss: 0.1086 - val_acc: 0.9730
Epoch 26/50
 - 32s - loss: 0.1630 - acc: 0.9463 - val_loss: 0.1297 - val_acc: 0.9681
Epoch 27/50
 - 33s - loss: 0.1614 - acc: 0.9566 - val_loss: 0.1394 - val_acc: 0.9632
Epoch 28/50
 - 31s - loss: 0.1515 - acc: 0.9526 - val_loss: 0.1221 - val_acc: 0.9706
Epoch 29/50
 - 31s - loss: 0.1386 - acc: 0.9646 - val_loss: 0.1387 - val_acc: 0.9681
Epoch 30/50
 - 31s - loss: 0.1369 - acc: 0.9629 - val_loss: 0.1295 - val_acc: 0.9730
Epoch 31/50
 - 31s - loss: 0.1341 - acc: 0.9623 - val_loss: 0.1286 - val_acc: 0.9706
Epoch 32/50
 - 31s - loss: 0.1268 - acc: 0.9611 - val_loss: 0.1489 - val_acc: 0.9681
Epoch 33/50
 - 31s - loss: 0.1329 - acc: 0.9571 - val_loss: 0.1732 - val_acc: 0.9583
```

```
Epoch 34/50
 - 31s - loss: 0.1268 - acc: 0.9606 - val_loss: 0.1412 - val_acc: 0.9657
Epoch 35/50
 - 31s - loss: 0.1249 - acc: 0.9634 - val_loss: 0.1515 - val_acc: 0.9632
Epoch 36/50
 - 31s - loss: 0.1162 - acc: 0.9680 - val_loss: 0.1339 - val_acc: 0.9730
Epoch 37/50
 - 32s - loss: 0.1106 - acc: 0.9680 - val_loss: 0.1624 - val_acc: 0.9657
Epoch 38/50
 - 32s - loss: 0.1118 - acc: 0.9657 - val_loss: 0.1561 - val_acc: 0.9632
Epoch 39/50
 - 32s - loss: 0.1071 - acc: 0.9703 - val_loss: 0.1529 - val_acc: 0.9608
Epoch 40/50
 - 31s - loss: 0.1135 - acc: 0.9680 - val_loss: 0.1315 - val_acc: 0.9706
Epoch 41/50
 - 32s - loss: 0.1033 - acc: 0.9731 - val_loss: 0.1418 - val_acc: 0.9730
Epoch 42/50
 - 33s - loss: 0.0868 - acc: 0.9800 - val_loss: 0.1460 - val_acc: 0.9706
Epoch 43/50
 - 33s - loss: 0.1137 - acc: 0.9623 - val_loss: 0.1483 - val_acc: 0.9681
Epoch 44/50
 - 32s - loss: 0.0982 - acc: 0.9749 - val_loss: 0.1763 - val_acc: 0.9534
Epoch 45/50
 - 31s - loss: 0.0980 - acc: 0.9720 - val_loss: 0.1496 - val_acc: 0.9706
Epoch 46/50
 - 33s - loss: 0.0917 - acc: 0.9760 - val_loss: 0.1386 - val_acc: 0.9706
Epoch 47/50
 - 32s - loss: 0.0874 - acc: 0.9760 - val_loss: 0.1525 - val_acc: 0.9730
Epoch 48/50
 - 32s - loss: 0.0838 - acc: 0.9743 - val_loss: 0.1467 - val_acc: 0.9730
Epoch 49/50
 - 32s - loss: 0.0839 - acc: 0.9760 - val_loss: 0.1689 - val_acc: 0.9657
Epoch 50/50
 - 32s - loss: 0.0982 - acc: 0.9726 - val_loss: 0.1786 - val_acc: 0.9559
```

```
plt.plot(history.history['acc'], label='acc')
plt.plot(history.history['val_acc'], label='val_acc')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(loc='best')
plt.show()
```




```
plt.plot(history.history['loss'], label='loss')
plt.plot(history.history['val_loss'], label='val_loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(loc='best')
plt.show()
```




```
score = model.evaluate(X_test, y_test, batch_size=32)
list(zip(model.metrics_names, score))
```

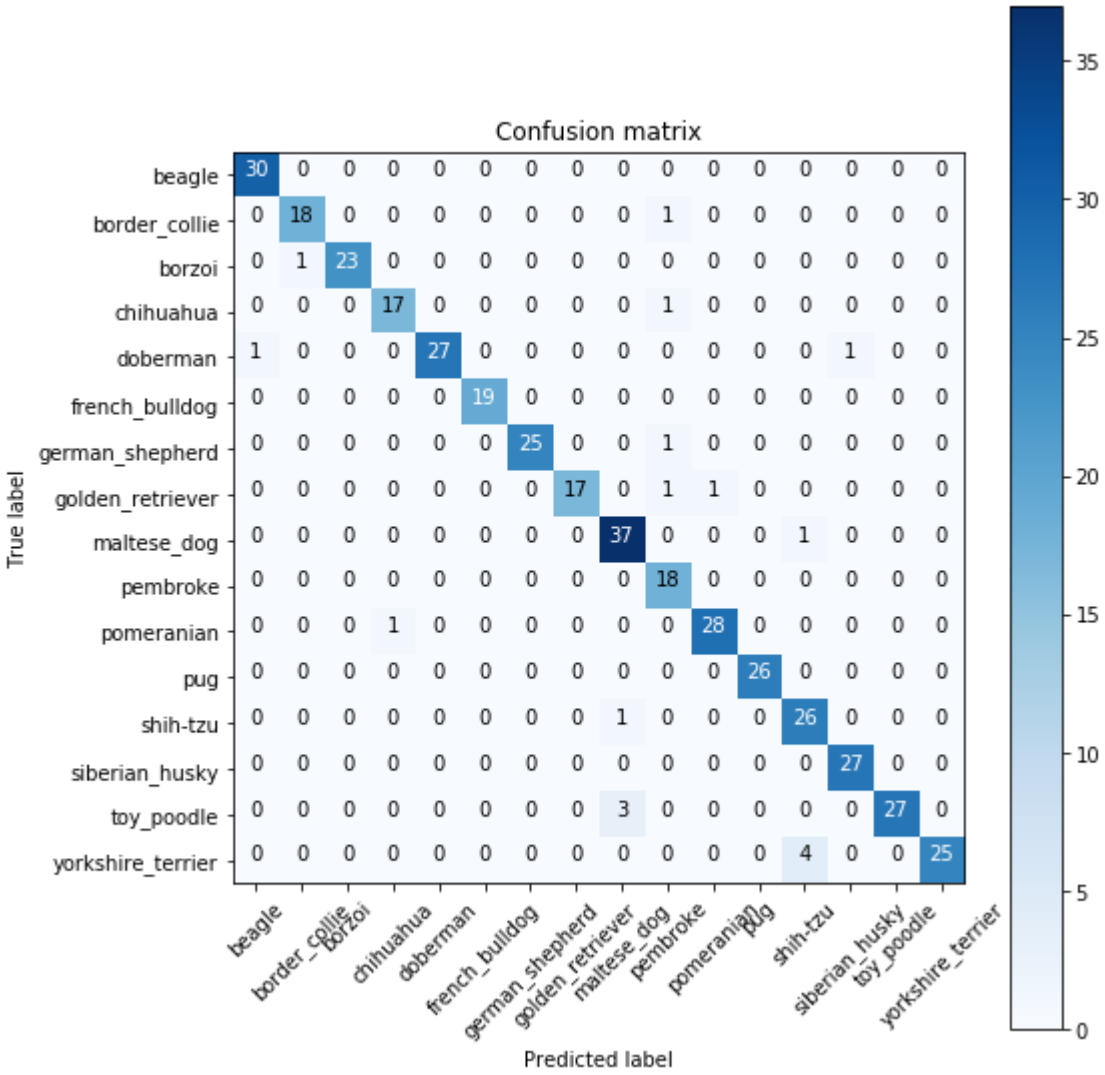
```
408/408 [==============================] - ETA: 10 - ETA: 5 - ETA:  - ETA:  - ETA:  -
ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - 3s 8ms/step
```

```
[('loss', 0.17864525814851126), ('acc', 0.955882351772458)]
```

```
from pylab import rcParams
rcParams['figure.figsize'] = (8, 8)

def plot_confusion_matrix(cm, breeds, normalize=False, title='Confusion matrix',
    cmap=plt.cm.Blues):
    """
    This function prints and plots the confusion matrix.
    Normalization can be applied by setting `normalize=True`.
    """

    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
        print("Normalized confusion matrix")
    else:
        print('Confusion matrix, without normalization')

    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(breeds))
    plt.xticks(tick_marks, breeds, rotation=45)
    plt.yticks(tick_marks, breeds)
    fmt = '.2f' if normalize else 'd'
    thresh = cm.max() / 2.
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        plt.text(j, i, format(cm[i, j], fmt),
                 horizontalalignment="center",
                 color="white" if cm[i, j] > thresh else "black")
    plt.tight_layout()
    plt.xlabel('Predicted label')
    plt.ylabel('True label')
    plt.show()
```

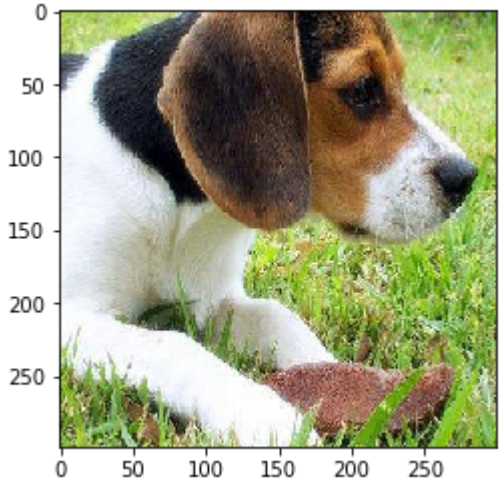
```
y_pred = model.predict(X_test)
y_pred = np.argmax(y_pred, axis=1)
y_true = np.argmax(y_test, axis=1)
confusion_mtx = confusion_matrix(y_true, y_pred)
plot_confusion_matrix(confusion_mtx, breeds)
```

```
Confusion matrix, without normalization
```



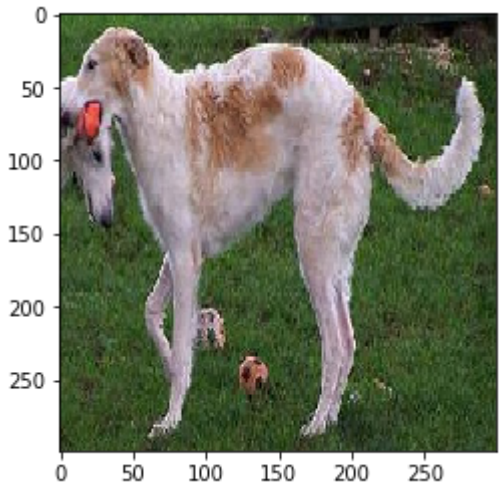

```
test_index = 10
rcParams['figure.figsize'] = (4, 4)

plt.imshow(X[test_index, :, :, :])
test_img = np.reshape(X[test_index, :, :, :], (1, INPUT_SIZE, INPUT_SIZE, 3))

predict = model.predict(test_img)
print(breeds[np.argmax(predict)])
```

```
beagle
```




```
test_index = 200
rcParams['figure.figsize'] = (4, 4)

plt.imshow(X[test_index, :, :, :])
test_img = np.reshape(X[test_index, :, :, :], (1, INPUT_SIZE, INPUT_SIZE, 3))

predict = model.predict(test_img)
print(breeds[np.argmax(predict)])
```

```
borzoi
```




```
model.save('model_16.h5')
```