In [1]:
```
# set tf 1.x for colab
%tensorflow_version 1.x
```

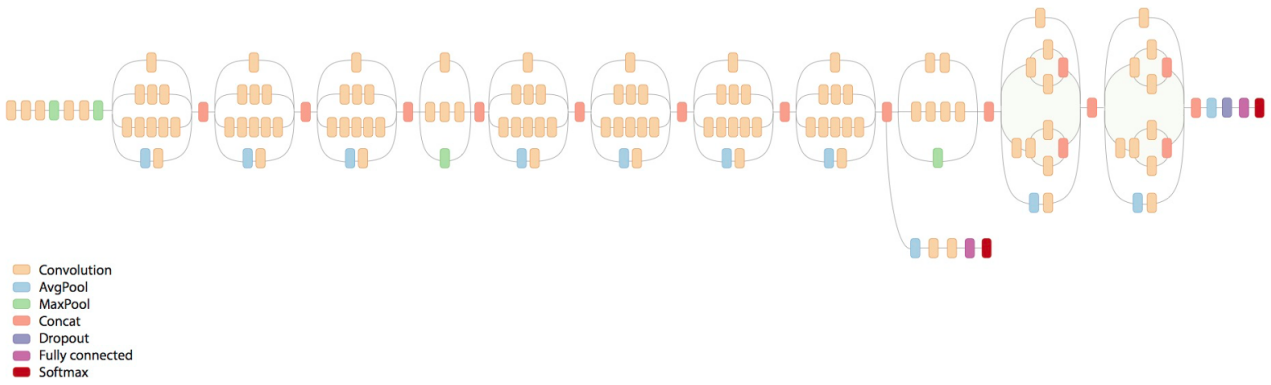
```
UsageError: Line magic function `%tensorflow_version` not found.
```

In [2]:
```
import warnings
warnings.filterwarnings('ignore', category=DeprecationWarning)
warnings.filterwarnings('ignore', category=FutureWarning)
```

Fine-tuning InceptionV3 for flowers classification

In this task you will fine-tune InceptionV3 architecture for flowers classification task.

InceptionV3 architecture (https://research.googleblog.com/2016/03/train-your-own-image-classifier-with.html (https://research.googleblog.com/2016/03/train-your-own-image-classifier-with.html)):



Flowers classification dataset (http://www.robots.ox.ac.uk/~vgg/data/flowers/102/index.html (http://www.robots.ox.ac.uk/~vgg/data/flowers/102/index.html)) consists of 102 flower categories commonly occurring in the United Kingdom. Each class contains between 40 and 258 images:

Import stuff

In [3]:
```
import sys
sys.path.append("..")
import grading
import download_utils
```

In [4]:
```
# !!! remember to clear session/graph if you rebuild your graph to avoid out-of-memory errors !!!
```

In [5]:
```
download_utils.link_all_keras_resources()
```

In [6]:
```
import tensorflow as tf
import keras
from keras import backend as K
import numpy as np
%matplotlib inline
import matplotlib.pyplot as plt
print(tf.__version__)
print(keras.__version__)
import cv2  # for image processing
from sklearn.model_selection import train_test_split
import scipy.io
import os
import tarfile
import keras_utils
from keras_utils import reset_tf_session
```

```
Using TensorFlow backend.

1.14.0
2.3.1
```

Fill in your Coursera token and email

To successfully submit your answers to our grader, please fill in your Coursera submission token and email

In [7]:
```
grader = grading.Grader(assignment_key="2v-uxpD7EeeMxQ6FWsz5LA",
                        all_parts=["wuwwC", "a4FK1", "qRsZ1"])
```

In [8]:
```
# token expires every 30 min
COURSERA_TOKEN = "IcfYrqfw78BHHOHV"
COURSERA_EMAIL = "lxwvictor@gmail.com"
```

Load dataset

Dataset was downloaded for you, it takes 12 min and 400mb. Relevant links (just in case):

- http://www.robots.ox.ac.uk/~vgg/data/flowers/102/index.html (http://www.robots.ox.ac.uk/~vgg/data/flowers/102/index.html)
- http://www.robots.ox.ac.uk/~vgg/data/flowers/102/102flowers.tgz (http://www.robots.ox.ac.uk/~vgg/data/flowers/102/102flowers.tgz)
- http://www.robots.ox.ac.uk/~vgg/data/flowers/102/imagelabels.mat (http://www.robots.ox.ac.uk/~vgg/data/flowers/102/imagelabels.mat)

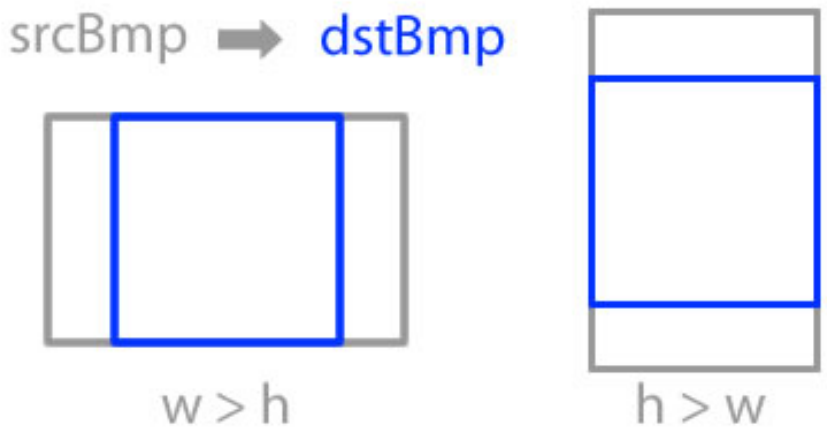
In [9]:
```
# we downloaded them for you, just link them here
download_utils.link_week_3_resources()
```

Prepare images for model

In [10]:
```
# we will crop and resize input images to IMG_SIZE x IMG_SIZE
IMG_SIZE = 250
```

In [11]:
```
def decode_image_from_raw_bytes(raw_bytes):
    img = cv2.imdecode(np.asarray(bytearray(raw_bytes), dtype=np.uint8), 1)
    img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
    return img
```

We will take a center crop from each image like this:



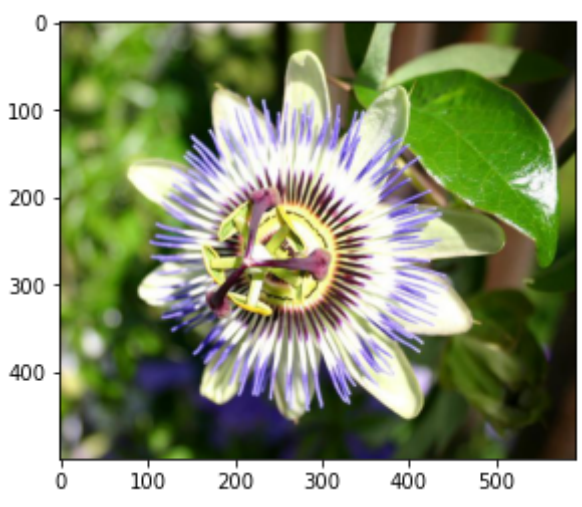
In [12]:
```python
def image_center_crop(img):
    """
    Makes a square center crop of an img, which is a [h, w, 3] numpy array.
    Returns [min(h, w), min(h, w), 3] output with same width and height.
    For cropping use numpy slicing.
    """

    ### YOUR CODE HERE
    h, w, c = img.shape

    if w > h:
        w_start = (w-h)//2
        w_end = w_start + h
        cropped_img = img[:, w_start:w_end, :]
    else:
        h_start = (h-w)//2
        h_end = h_start + w
        cropped_img = img[h_start:h_end, :, :]

    # checks for errors
#     h, w, c = img.shape
    assert cropped_img.shape == (min(h, w), min(h, w), c), "error in image_center_crop!"

    return cropped_img
```

In [13]:
```python
def prepare_raw_bytes_for_model(raw_bytes, normalize_for_model=True):
    img = decode_image_from_raw_bytes(raw_bytes)  # decode image raw bytes to matrix
    img = image_center_crop(img)  # take squared center crop
    img = cv2.resize(img, (IMG_SIZE, IMG_SIZE))  # resize for our model
    if normalize_for_model:
        img = img.astype("float32")  # prepare for normalization
        img = keras.applications.inception_v3.preprocess_input(img)  # normalize for model
    return img
```

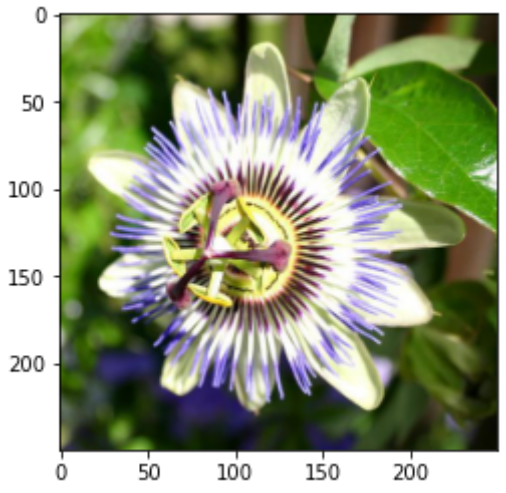
In [14]:
```python
# reads bytes directly from tar by filename (slow, but ok for testing, takes ~6 sec)
def read_raw_from_tar(tar_fn, fn):
    with tarfile.open(tar_fn) as f:
        m = f.getmember(fn)
        return f.extractfile(m).read()
```

In [15]:
```
# test cropping
raw_bytes = read_raw_from_tar("102flowers.tgz", "jpg/image_00001.jpg")

img = decode_image_from_raw_bytes(raw_bytes)
print(img.shape)
plt.imshow(img)
plt.show()

img = prepare_raw_bytes_for_model(raw_bytes, normalize_for_model=False)
print(img.shape)
plt.imshow(img)
plt.show()
```

```
(500, 591, 3)
```




```
(250, 250, 3)
```



In [16]:
```
## GRADED PART, DO NOT CHANGE!
# Test image preparation for model
prepared_img = prepare_raw_bytes_for_model(read_raw_from_tar("102flowers.tgz", "jpg/image_00001.jpg"))
grader.set_answer("qRsZ1", list(prepared_img.shape) + [np.mean(prepared_img), np.std(prepared_img)])
```

In [17]:
```
# you can make submission with answers so far to check yourself at this stage
grader.submit(COURSERA_EMAIL, COURSERA_TOKEN)
```

```
You used an invalid email or your token may have expired. Please make sure you have entered all fields correctly. Try g
enerating a new token if the issue still persists.
```

Prepare for training

In [18]:
```
# read all filenames and labels for them

# read filenames firectly from tar
def get_all_filenames(tar_fn):
    with tarfile.open(tar_fn) as f:
        return [m.name for m in f.getmembers() if m.isfile()]

all_files = sorted(get_all_filenames("102flowers.tgz"))  # list all files in tar sorted by name
all_labels = scipy.io.loadmat('imagelabels.mat')['labels'][0] - 1  # read class labels (0, 1, 2, ...)
# all_files and all_labels are aligned now
N_CLASSES = len(np.unique(all_labels))
print(N_CLASSES)
```

```
102
```

In [19]:
```
# split into train/test
tr_files, te_files, tr_labels, te_labels = \
    train_test_split(all_files, all_labels, test_size=0.2, random_state=42, stratify=all_labels)
```

In [20]:
```
# will yield raw image bytes from tar with corresponding label
def raw_generator_with_label_from_tar(tar_fn, files, labels):
    label_by_fn = dict(zip(files, labels))
    with tarfile.open(tar_fn) as f:
        while True:
            m = f.next()
            if m is None:
                break
            if m.name in label_by_fn:
                yield f.extractfile(m).read(), label_by_fn[m.name]
```

In [21]:
```
# batch generator
BATCH_SIZE = 32

def batch_generator(items, batch_size):
    """
    Implement batch generator that yields items in batches of size batch_size.
    There's no need to shuffle input items, just chop them into batches.
    Remember about the last batch that can be smaller than batch_size!
    Input: any iterable (list, generator, ...). You should do `for item in items: ...`
        In case of generator you can pass through your items only once!
    Output: In output yield each batch as a list of items.
    """

    ### YOUR CODE HERE
    count = 0
    batch = []
    for item in items:
        batch.append(item)
        count += 1
        if count == batch_size:
            yield batch
            count = 0
            batch = []

    yield batch
```

In [22]:
```
## GRADED PART, DO NOT CHANGE!
# Test batch generator
def _test_items_generator():
    for i in range(10):
        yield i

grader.set_answer("a4FK1", list(map(lambda x: len(x), batch_generator(_test_items_generator(), 3))))
```

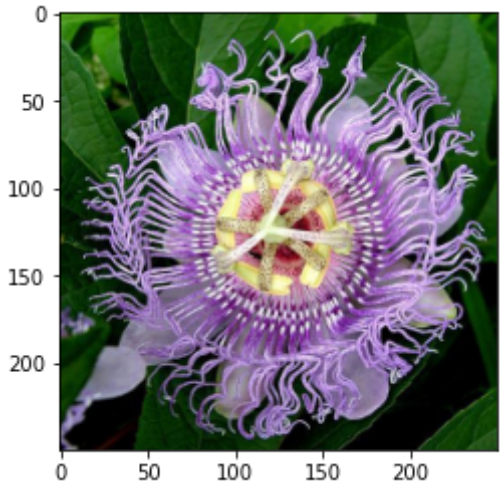
In [23]:
```
# you can make submission with answers so far to check yourself at this stage
grader.submit(COURSERA_EMAIL, COURSERA_TOKEN)
```

```
You used an invalid email or your token may have expired. Please make sure you have entered all fields correctly. Try g
enerating a new token if the issue still persists.
```

In [24]:
```
def train_generator(files, labels):
    while True:  # so that Keras can loop through this as long as it wants
        for batch in batch_generator(raw_generator_with_label_from_tar(
                "102flowers.tgz", files, labels), BATCH_SIZE):
            # prepare batch images
            batch_imgs = []
            batch_targets = []
            for raw, label in batch:
                img = prepare_raw_bytes_for_model(raw)
                batch_imgs.append(img)
                batch_targets.append(label)
            # stack images into 4D tensor [batch_size, img_size, img_size, 3]
            batch_imgs = np.stack(batch_imgs, axis=0)
            # convert targets into 2D tensor [batch_size, num_classes]
            batch_targets = keras.utils.np_utils.to_categorical(batch_targets, N_CLASSES)
            yield batch_imgs, batch_targets
```

In [25]:
```
# test training generator
for _ in train_generator(tr_files, tr_labels):
    print(_[0].shape, _[1].shape)
    plt.imshow(np.clip(_[0][0] / 2. + 0.5, 0, 1))
    break
```

```
(32, 250, 250, 3) (32, 102)
```



Training

You cannot train such a huge architecture from scratch with such a small dataset.

But using fine-tuning of last layers of pre-trained network you can get a pretty good classifier very quickly.

In [26]:
```
# remember to clear session if you start building graph from scratch!
s = reset_tf_session()
# don't call K.set_learning_phase() !!! (otherwise will enable dropout in train/test simultaneously)
```

```
WARNING:tensorflow:From ..\keras_utils.py:68: The name tf.get_default_session is deprecated. Please use tf.compat.v1.ge
t_default_session instead.

WARNING:tensorflow:From ..\keras_utils.py:75: The name tf.ConfigProto is deprecated. Please use tf.compat.v1.ConfigProt
o instead.

WARNING:tensorflow:From ..\keras_utils.py:77: The name tf.InteractiveSession is deprecated. Please use tf.compat.v1.Int
eractiveSession instead.
```

In [27]:
```
def inception(use_imagenet=True):
    # load pre-trained model graph, don't add final layer
    model = keras.applications.InceptionV3(include_top=False, input_shape=(IMG_SIZE, IMG_SIZE, 3),
                                           weights='imagenet' if use_imagenet else None)
    # add global pooling just like in InceptionV3
    new_output = keras.layers.GlobalAveragePooling2D()(model.output)
    # add new dense layer for our labels
    new_output = keras.layers.Dense(N_CLASSES, activation='softmax')(new_output)
    model = keras.engine.training.Model(model.inputs, new_output)
    return model
```

In [28]:
```
model = inception()
```

```
WARNING:tensorflow:From C:\Users\Xiaowei\Anaconda3\envs\tfspark\lib\site-packages\keras\backend\tensorflow_backend.py:4
070: The name tf.nn.max_pool is deprecated. Please use tf.nn.max_pool2d instead.

WARNING:tensorflow:From C:\Users\Xiaowei\Anaconda3\envs\tfspark\lib\site-packages\keras\backend\tensorflow_backend.py:4
074: The name tf.nn.avg_pool is deprecated. Please use tf.nn.avg_pool2d instead.
```

In [29]:
```
1 model.summary()
```

```
Model: "model_1"
```

Layer (type)	Output Shape	Param #	Connected to
input_1 (InputLayer)	(None, 250, 250, 3)	0	
conv2d_1 (Conv2D)	(None, 124, 124, 32)	864	input_1[0][0]
batch_normalization_1 (BatchNor	(None, 124, 124, 32)	96	conv2d_1[0][0]
activation_1 (Activation)	(None, 124, 124, 32)	0	batch_normalization_1[0][0]
conv2d_2 (Conv2D)	(None, 122, 122, 32)	9216	activation_1[0][0]
batch_normalization_2 (BatchNor	(None, 122, 122, 32)	96	conv2d_2[0][0]
activation_2 (Activation)	(None, 122, 122, 32)	0	batch_normalization_2[0][0]
conv2d_3 (Conv2D)	(None, 122, 122, 64)	18432	activation_2[0][0]
batch_normalization_3 (BatchNor	(None, 122, 122, 64)	192	conv2d_3[0][0]
activation_3 (Activation)	(None, 122, 122, 64)	0	batch_normalization_3[0][0]
max_pooling2d_1 (MaxPooling2D)	(None, 60, 60, 64)	0	activation_3[0][0]
conv2d_4 (Conv2D)	(None, 60, 60, 80)	5120	max_pooling2d_1[0][0]
batch_normalization_4 (BatchNor	(None, 60, 60, 80)	240	conv2d_4[0][0]
activation_4 (Activation)	(None, 60, 60, 80)	0	batch_normalization_4[0][0]
conv2d_5 (Conv2D)	(None, 58, 58, 192)	138240	activation_4[0][0]
batch_normalization_5 (BatchNor	(None, 58, 58, 192)	576	conv2d_5[0][0]
activation_5 (Activation)	(None, 58, 58, 192)	0	batch_normalization_5[0][0]
max_pooling2d_2 (MaxPooling2D)	(None, 28, 28, 192)	0	activation_5[0][0]
conv2d_9 (Conv2D)	(None, 28, 28, 64)	12288	max_pooling2d_2[0][0]
batch_normalization_9 (BatchNor	(None, 28, 28, 64)	192	conv2d_9[0][0]
activation_9 (Activation)	(None, 28, 28, 64)	0	batch_normalization_9[0][0]
conv2d_7 (Conv2D)	(None, 28, 28, 48)	9216	max_pooling2d_2[0][0]
conv2d_10 (Conv2D)	(None, 28, 28, 96)	55296	activation_9[0][0]
batch_normalization_7 (BatchNor	(None, 28, 28, 48)	144	conv2d_7[0][0]
batch_normalization_10 (BatchNo	(None, 28, 28, 96)	288	conv2d_10[0][0]
activation_7 (Activation)	(None, 28, 28, 48)	0	batch_normalization_7[0][0]
activation_10 (Activation)	(None, 28, 28, 96)	0	batch_normalization_10[0][0]
average_pooling2d_1 (AveragePoo	(None, 28, 28, 192)	0	max_pooling2d_2[0][0]
conv2d_6 (Conv2D)	(None, 28, 28, 64)	12288	max_pooling2d_2[0][0]
conv2d_8 (Conv2D)	(None, 28, 28, 64)	76800	activation_7[0][0]
conv2d_11 (Conv2D)	(None, 28, 28, 96)	82944	activation_10[0][0]
conv2d_12 (Conv2D)	(None, 28, 28, 32)	6144	average_pooling2d_1[0][0]
batch_normalization_6 (BatchNor	(None, 28, 28, 64)	192	conv2d_6[0][0]
batch_normalization_8 (BatchNor	(None, 28, 28, 64)	192	conv2d_8[0][0]
batch_normalization_11 (BatchNo	(None, 28, 28, 96)	288	conv2d_11[0][0]
batch_normalization_12 (BatchNo	(None, 28, 28, 32)	96	conv2d_12[0][0]
activation_6 (Activation)	(None, 28, 28, 64)	0	batch_normalization_6[0][0]
activation_8 (Activation)	(None, 28, 28, 64)	0	batch_normalization_8[0][0]
activation_11 (Activation)	(None, 28, 28, 96)	0	batch_normalization_11[0][0]
activation_12 (Activation)	(None, 28, 28, 32)	0	batch_normalization_12[0][0]
mixed0 (Concatenate)	(None, 28, 28, 256)	0	activation_6[0][0]

			activation_8[0][0] activation_11[0][0] activation_12[0][0]
conv2d_16 (Conv2D)	(None, 28, 28, 64)	16384	mixed0[0][0]
batch_normalization_16 (BatchNo	(None, 28, 28, 64)	192	conv2d_16[0][0]
activation_16 (Activation)	(None, 28, 28, 64)	0	batch_normalization_16[0][0]
conv2d_14 (Conv2D)	(None, 28, 28, 48)	12288	mixed0[0][0]
conv2d_17 (Conv2D)	(None, 28, 28, 96)	55296	activation_16[0][0]
batch_normalization_14 (BatchNo	(None, 28, 28, 48)	144	conv2d_14[0][0]
batch_normalization_17 (BatchNo	(None, 28, 28, 96)	288	conv2d_17[0][0]
activation_14 (Activation)	(None, 28, 28, 48)	0	batch_normalization_14[0][0]
activation_17 (Activation)	(None, 28, 28, 96)	0	batch_normalization_17[0][0]
average_pooling2d_2 (AveragePoo	(None, 28, 28, 256)	0	mixed0[0][0]
conv2d_13 (Conv2D)	(None, 28, 28, 64)	16384	mixed0[0][0]
conv2d_15 (Conv2D)	(None, 28, 28, 64)	76800	activation_14[0][0]
conv2d_18 (Conv2D)	(None, 28, 28, 96)	82944	activation_17[0][0]
conv2d_19 (Conv2D)	(None, 28, 28, 64)	16384	average_pooling2d_2[0][0]
batch_normalization_13 (BatchNo	(None, 28, 28, 64)	192	conv2d_13[0][0]
batch_normalization_15 (BatchNo	(None, 28, 28, 64)	192	conv2d_15[0][0]
batch_normalization_18 (BatchNo	(None, 28, 28, 96)	288	conv2d_18[0][0]
batch_normalization_19 (BatchNo	(None, 28, 28, 64)	192	conv2d_19[0][0]
activation_13 (Activation)	(None, 28, 28, 64)	0	batch_normalization_13[0][0]
activation_15 (Activation)	(None, 28, 28, 64)	0	batch_normalization_15[0][0]
activation_18 (Activation)	(None, 28, 28, 96)	0	batch_normalization_18[0][0]
activation_19 (Activation)	(None, 28, 28, 64)	0	batch_normalization_19[0][0]
mixed1 (Concatenate)	(None, 28, 28, 288)	0	activation_13[0][0] activation_15[0][0] activation_18[0][0] activation_19[0][0]
conv2d_23 (Conv2D)	(None, 28, 28, 64)	18432	mixed1[0][0]
batch_normalization_23 (BatchNo	(None, 28, 28, 64)	192	conv2d_23[0][0]
activation_23 (Activation)	(None, 28, 28, 64)	0	batch_normalization_23[0][0]
conv2d_21 (Conv2D)	(None, 28, 28, 48)	13824	mixed1[0][0]
conv2d_24 (Conv2D)	(None, 28, 28, 96)	55296	activation_23[0][0]
batch_normalization_21 (BatchNo	(None, 28, 28, 48)	144	conv2d_21[0][0]
batch_normalization_24 (BatchNo	(None, 28, 28, 96)	288	conv2d_24[0][0]
activation_21 (Activation)	(None, 28, 28, 48)	0	batch_normalization_21[0][0]
activation_24 (Activation)	(None, 28, 28, 96)	0	batch_normalization_24[0][0]
average_pooling2d_3 (AveragePoo	(None, 28, 28, 288)	0	mixed1[0][0]
conv2d_20 (Conv2D)	(None, 28, 28, 64)	18432	mixed1[0][0]
conv2d_22 (Conv2D)	(None, 28, 28, 64)	76800	activation_21[0][0]
conv2d_25 (Conv2D)	(None, 28, 28, 96)	82944	activation_24[0][0]
conv2d_26 (Conv2D)	(None, 28, 28, 64)	18432	average_pooling2d_3[0][0]
batch_normalization_20 (BatchNo	(None, 28, 28, 64)	192	conv2d_20[0][0]
batch_normalization_22 (BatchNo	(None, 28, 28, 64)	192	conv2d_22[0][0]
batch_normalization_25 (BatchNo	(None, 28, 28, 96)	288	conv2d_25[0][0]
batch_normalization_26 (BatchNo	(None, 28, 28, 64)	192	conv2d_26[0][0]

activation_20 (Activation)	(None, 28, 28, 64)	0	batch_normalization_20[0][0]
activation_22 (Activation)	(None, 28, 28, 64)	0	batch_normalization_22[0][0]
activation_25 (Activation)	(None, 28, 28, 96)	0	batch_normalization_25[0][0]
activation_26 (Activation)	(None, 28, 28, 64)	0	batch_normalization_26[0][0]
mixed2 (Concatenate)	(None, 28, 28, 288)	0	activation_20[0][0] activation_22[0][0] activation_25[0][0] activation_26[0][0]
conv2d_28 (Conv2D)	(None, 28, 28, 64)	18432	mixed2[0][0]
batch_normalization_28 (BatchNo	(None, 28, 28, 64)	192	conv2d_28[0][0]
activation_28 (Activation)	(None, 28, 28, 64)	0	batch_normalization_28[0][0]
conv2d_29 (Conv2D)	(None, 28, 28, 96)	55296	activation_28[0][0]
batch_normalization_29 (BatchNo	(None, 28, 28, 96)	288	conv2d_29[0][0]
activation_29 (Activation)	(None, 28, 28, 96)	0	batch_normalization_29[0][0]
conv2d_27 (Conv2D)	(None, 13, 13, 384)	995328	mixed2[0][0]
conv2d_30 (Conv2D)	(None, 13, 13, 96)	82944	activation_29[0][0]
batch_normalization_27 (BatchNo	(None, 13, 13, 384)	1152	conv2d_27[0][0]
batch_normalization_30 (BatchNo	(None, 13, 13, 96)	288	conv2d_30[0][0]
activation_27 (Activation)	(None, 13, 13, 384)	0	batch_normalization_27[0][0]
activation_30 (Activation)	(None, 13, 13, 96)	0	batch_normalization_30[0][0]
max_pooling2d_3 (MaxPooling2D)	(None, 13, 13, 288)	0	mixed2[0][0]
mixed3 (Concatenate)	(None, 13, 13, 768)	0	activation_27[0][0] activation_30[0][0] max_pooling2d_3[0][0]
conv2d_35 (Conv2D)	(None, 13, 13, 128)	98304	mixed3[0][0]
batch_normalization_35 (BatchNo	(None, 13, 13, 128)	384	conv2d_35[0][0]
activation_35 (Activation)	(None, 13, 13, 128)	0	batch_normalization_35[0][0]
conv2d_36 (Conv2D)	(None, 13, 13, 128)	114688	activation_35[0][0]
batch_normalization_36 (BatchNo	(None, 13, 13, 128)	384	conv2d_36[0][0]
activation_36 (Activation)	(None, 13, 13, 128)	0	batch_normalization_36[0][0]
conv2d_32 (Conv2D)	(None, 13, 13, 128)	98304	mixed3[0][0]
conv2d_37 (Conv2D)	(None, 13, 13, 128)	114688	activation_36[0][0]
batch_normalization_32 (BatchNo	(None, 13, 13, 128)	384	conv2d_32[0][0]
batch_normalization_37 (BatchNo	(None, 13, 13, 128)	384	conv2d_37[0][0]
activation_32 (Activation)	(None, 13, 13, 128)	0	batch_normalization_32[0][0]
activation_37 (Activation)	(None, 13, 13, 128)	0	batch_normalization_37[0][0]
conv2d_33 (Conv2D)	(None, 13, 13, 128)	114688	activation_32[0][0]
conv2d_38 (Conv2D)	(None, 13, 13, 128)	114688	activation_37[0][0]
batch_normalization_33 (BatchNo	(None, 13, 13, 128)	384	conv2d_33[0][0]
batch_normalization_38 (BatchNo	(None, 13, 13, 128)	384	conv2d_38[0][0]
activation_33 (Activation)	(None, 13, 13, 128)	0	batch_normalization_33[0][0]
activation_38 (Activation)	(None, 13, 13, 128)	0	batch_normalization_38[0][0]
average_pooling2d_4 (AveragePoo	(None, 13, 13, 768)	0	mixed3[0][0]
conv2d_31 (Conv2D)	(None, 13, 13, 192)	147456	mixed3[0][0]
conv2d_34 (Conv2D)	(None, 13, 13, 192)	172032	activation_33[0][0]
conv2d_39 (Conv2D)	(None, 13, 13, 192)	172032	activation_38[0][0]

conv2d_40 (Conv2D)	(None, 13, 13, 192)	147456	average_pooling2d_4[0][0]
batch_normalization_31 (BatchNo	(None, 13, 13, 192)	576	conv2d_31[0][0]
batch_normalization_34 (BatchNo	(None, 13, 13, 192)	576	conv2d_34[0][0]
batch_normalization_39 (BatchNo	(None, 13, 13, 192)	576	conv2d_39[0][0]
batch_normalization_40 (BatchNo	(None, 13, 13, 192)	576	conv2d_40[0][0]
activation_31 (Activation)	(None, 13, 13, 192)	0	batch_normalization_31[0][0]
activation_34 (Activation)	(None, 13, 13, 192)	0	batch_normalization_34[0][0]
activation_39 (Activation)	(None, 13, 13, 192)	0	batch_normalization_39[0][0]
activation_40 (Activation)	(None, 13, 13, 192)	0	batch_normalization_40[0][0]
mixed4 (Concatenate)	(None, 13, 13, 768)	0	activation_31[0][0] activation_34[0][0] activation_39[0][0] activation_40[0][0]
conv2d_45 (Conv2D)	(None, 13, 13, 160)	122880	mixed4[0][0]
batch_normalization_45 (BatchNo	(None, 13, 13, 160)	480	conv2d_45[0][0]
activation_45 (Activation)	(None, 13, 13, 160)	0	batch_normalization_45[0][0]
conv2d_46 (Conv2D)	(None, 13, 13, 160)	179200	activation_45[0][0]
batch_normalization_46 (BatchNo	(None, 13, 13, 160)	480	conv2d_46[0][0]
activation_46 (Activation)	(None, 13, 13, 160)	0	batch_normalization_46[0][0]
conv2d_42 (Conv2D)	(None, 13, 13, 160)	122880	mixed4[0][0]
conv2d_47 (Conv2D)	(None, 13, 13, 160)	179200	activation_46[0][0]
batch_normalization_42 (BatchNo	(None, 13, 13, 160)	480	conv2d_42[0][0]
batch_normalization_47 (BatchNo	(None, 13, 13, 160)	480	conv2d_47[0][0]
activation_42 (Activation)	(None, 13, 13, 160)	0	batch_normalization_42[0][0]
activation_47 (Activation)	(None, 13, 13, 160)	0	batch_normalization_47[0][0]
conv2d_43 (Conv2D)	(None, 13, 13, 160)	179200	activation_42[0][0]
conv2d_48 (Conv2D)	(None, 13, 13, 160)	179200	activation_47[0][0]
batch_normalization_43 (BatchNo	(None, 13, 13, 160)	480	conv2d_43[0][0]
batch_normalization_48 (BatchNo	(None, 13, 13, 160)	480	conv2d_48[0][0]
activation_43 (Activation)	(None, 13, 13, 160)	0	batch_normalization_43[0][0]
activation_48 (Activation)	(None, 13, 13, 160)	0	batch_normalization_48[0][0]
average_pooling2d_5 (AveragePoo	(None, 13, 13, 768)	0	mixed4[0][0]
conv2d_41 (Conv2D)	(None, 13, 13, 192)	147456	mixed4[0][0]
conv2d_44 (Conv2D)	(None, 13, 13, 192)	215040	activation_43[0][0]
conv2d_49 (Conv2D)	(None, 13, 13, 192)	215040	activation_48[0][0]
conv2d_50 (Conv2D)	(None, 13, 13, 192)	147456	average_pooling2d_5[0][0]
batch_normalization_41 (BatchNo	(None, 13, 13, 192)	576	conv2d_41[0][0]
batch_normalization_44 (BatchNo	(None, 13, 13, 192)	576	conv2d_44[0][0]
batch_normalization_49 (BatchNo	(None, 13, 13, 192)	576	conv2d_49[0][0]
batch_normalization_50 (BatchNo	(None, 13, 13, 192)	576	conv2d_50[0][0]
activation_41 (Activation)	(None, 13, 13, 192)	0	batch_normalization_41[0][0]
activation_44 (Activation)	(None, 13, 13, 192)	0	batch_normalization_44[0][0]
activation_49 (Activation)	(None, 13, 13, 192)	0	batch_normalization_49[0][0]
activation_50 (Activation)	(None, 13, 13, 192)	0	batch_normalization_50[0][0]
mixed5 (Concatenate)	(None, 13, 13, 768)	0	activation_41[0][0] activation_44[0][0] activation_49[0][0]

			activation_50[0][0]
conv2d_55 (Conv2D)	(None, 13, 13, 160)	122880	mixed5[0][0]
batch_normalization_55 (BatchNo	(None, 13, 13, 160)	480	conv2d_55[0][0]
activation_55 (Activation)	(None, 13, 13, 160)	0	batch_normalization_55[0][0]
conv2d_56 (Conv2D)	(None, 13, 13, 160)	179200	activation_55[0][0]
batch_normalization_56 (BatchNo	(None, 13, 13, 160)	480	conv2d_56[0][0]
activation_56 (Activation)	(None, 13, 13, 160)	0	batch_normalization_56[0][0]
conv2d_52 (Conv2D)	(None, 13, 13, 160)	122880	mixed5[0][0]
conv2d_57 (Conv2D)	(None, 13, 13, 160)	179200	activation_56[0][0]
batch_normalization_52 (BatchNo	(None, 13, 13, 160)	480	conv2d_52[0][0]
batch_normalization_57 (BatchNo	(None, 13, 13, 160)	480	conv2d_57[0][0]
activation_52 (Activation)	(None, 13, 13, 160)	0	batch_normalization_52[0][0]
activation_57 (Activation)	(None, 13, 13, 160)	0	batch_normalization_57[0][0]
conv2d_53 (Conv2D)	(None, 13, 13, 160)	179200	activation_52[0][0]
conv2d_58 (Conv2D)	(None, 13, 13, 160)	179200	activation_57[0][0]
batch_normalization_53 (BatchNo	(None, 13, 13, 160)	480	conv2d_53[0][0]
batch_normalization_58 (BatchNo	(None, 13, 13, 160)	480	conv2d_58[0][0]
activation_53 (Activation)	(None, 13, 13, 160)	0	batch_normalization_53[0][0]
activation_58 (Activation)	(None, 13, 13, 160)	0	batch_normalization_58[0][0]
average_pooling2d_6 (AveragePoo	(None, 13, 13, 768)	0	mixed5[0][0]
conv2d_51 (Conv2D)	(None, 13, 13, 192)	147456	mixed5[0][0]
conv2d_54 (Conv2D)	(None, 13, 13, 192)	215040	activation_53[0][0]
conv2d_59 (Conv2D)	(None, 13, 13, 192)	215040	activation_58[0][0]
conv2d_60 (Conv2D)	(None, 13, 13, 192)	147456	average_pooling2d_6[0][0]
batch_normalization_51 (BatchNo	(None, 13, 13, 192)	576	conv2d_51[0][0]
batch_normalization_54 (BatchNo	(None, 13, 13, 192)	576	conv2d_54[0][0]
batch_normalization_59 (BatchNo	(None, 13, 13, 192)	576	conv2d_59[0][0]
batch_normalization_60 (BatchNo	(None, 13, 13, 192)	576	conv2d_60[0][0]
activation_51 (Activation)	(None, 13, 13, 192)	0	batch_normalization_51[0][0]
activation_54 (Activation)	(None, 13, 13, 192)	0	batch_normalization_54[0][0]
activation_59 (Activation)	(None, 13, 13, 192)	0	batch_normalization_59[0][0]
activation_60 (Activation)	(None, 13, 13, 192)	0	batch_normalization_60[0][0]
mixed6 (Concatenate)	(None, 13, 13, 768)	0	activation_51[0][0] activation_54[0][0] activation_59[0][0] activation_60[0][0]
conv2d_65 (Conv2D)	(None, 13, 13, 192)	147456	mixed6[0][0]
batch_normalization_65 (BatchNo	(None, 13, 13, 192)	576	conv2d_65[0][0]
activation_65 (Activation)	(None, 13, 13, 192)	0	batch_normalization_65[0][0]
conv2d_66 (Conv2D)	(None, 13, 13, 192)	258048	activation_65[0][0]
batch_normalization_66 (BatchNo	(None, 13, 13, 192)	576	conv2d_66[0][0]
activation_66 (Activation)	(None, 13, 13, 192)	0	batch_normalization_66[0][0]
conv2d_62 (Conv2D)	(None, 13, 13, 192)	147456	mixed6[0][0]
conv2d_67 (Conv2D)	(None, 13, 13, 192)	258048	activation_66[0][0]
batch_normalization_62 (BatchNo	(None, 13, 13, 192)	576	conv2d_62[0][0]
batch_normalization_67 (BatchNo	(None, 13, 13, 192)	576	conv2d_67[0][0]

activation_62 (Activation)	(None, 13, 13, 192)	0	batch_normalization_62[0][0]
activation_67 (Activation)	(None, 13, 13, 192)	0	batch_normalization_67[0][0]
conv2d_63 (Conv2D)	(None, 13, 13, 192)	258048	activation_62[0][0]
conv2d_68 (Conv2D)	(None, 13, 13, 192)	258048	activation_67[0][0]
batch_normalization_63 (BatchNo	(None, 13, 13, 192)	576	conv2d_63[0][0]
batch_normalization_68 (BatchNo	(None, 13, 13, 192)	576	conv2d_68[0][0]
activation_63 (Activation)	(None, 13, 13, 192)	0	batch_normalization_63[0][0]
activation_68 (Activation)	(None, 13, 13, 192)	0	batch_normalization_68[0][0]
average_pooling2d_7 (AveragePoo	(None, 13, 13, 768)	0	mixed6[0][0]
conv2d_61 (Conv2D)	(None, 13, 13, 192)	147456	mixed6[0][0]
conv2d_64 (Conv2D)	(None, 13, 13, 192)	258048	activation_63[0][0]
conv2d_69 (Conv2D)	(None, 13, 13, 192)	258048	activation_68[0][0]
conv2d_70 (Conv2D)	(None, 13, 13, 192)	147456	average_pooling2d_7[0][0]
batch_normalization_61 (BatchNo	(None, 13, 13, 192)	576	conv2d_61[0][0]
batch_normalization_64 (BatchNo	(None, 13, 13, 192)	576	conv2d_64[0][0]
batch_normalization_69 (BatchNo	(None, 13, 13, 192)	576	conv2d_69[0][0]
batch_normalization_70 (BatchNo	(None, 13, 13, 192)	576	conv2d_70[0][0]
activation_61 (Activation)	(None, 13, 13, 192)	0	batch_normalization_61[0][0]
activation_64 (Activation)	(None, 13, 13, 192)	0	batch_normalization_64[0][0]
activation_69 (Activation)	(None, 13, 13, 192)	0	batch_normalization_69[0][0]
activation_70 (Activation)	(None, 13, 13, 192)	0	batch_normalization_70[0][0]
mixed7 (Concatenate)	(None, 13, 13, 768)	0	activation_61[0][0] activation_64[0][0] activation_69[0][0] activation_70[0][0]
conv2d_73 (Conv2D)	(None, 13, 13, 192)	147456	mixed7[0][0]
batch_normalization_73 (BatchNo	(None, 13, 13, 192)	576	conv2d_73[0][0]
activation_73 (Activation)	(None, 13, 13, 192)	0	batch_normalization_73[0][0]
conv2d_74 (Conv2D)	(None, 13, 13, 192)	258048	activation_73[0][0]
batch_normalization_74 (BatchNo	(None, 13, 13, 192)	576	conv2d_74[0][0]
activation_74 (Activation)	(None, 13, 13, 192)	0	batch_normalization_74[0][0]
conv2d_71 (Conv2D)	(None, 13, 13, 192)	147456	mixed7[0][0]
conv2d_75 (Conv2D)	(None, 13, 13, 192)	258048	activation_74[0][0]
batch_normalization_71 (BatchNo	(None, 13, 13, 192)	576	conv2d_71[0][0]
batch_normalization_75 (BatchNo	(None, 13, 13, 192)	576	conv2d_75[0][0]
activation_71 (Activation)	(None, 13, 13, 192)	0	batch_normalization_71[0][0]
activation_75 (Activation)	(None, 13, 13, 192)	0	batch_normalization_75[0][0]
conv2d_72 (Conv2D)	(None, 6, 6, 320)	552960	activation_71[0][0]
conv2d_76 (Conv2D)	(None, 6, 6, 192)	331776	activation_75[0][0]
batch_normalization_72 (BatchNo	(None, 6, 6, 320)	960	conv2d_72[0][0]
batch_normalization_76 (BatchNo	(None, 6, 6, 192)	576	conv2d_76[0][0]
activation_72 (Activation)	(None, 6, 6, 320)	0	batch_normalization_72[0][0]
activation_76 (Activation)	(None, 6, 6, 192)	0	batch_normalization_76[0][0]
max_pooling2d_4 (MaxPooling2D)	(None, 6, 6, 768)	0	mixed7[0][0]
mixed8 (Concatenate)	(None, 6, 6, 1280)	0	activation_72[0][0] activation_76[0][0]

			max_pooling2d_4[0][0]
conv2d_81 (Conv2D)	(None, 6, 6, 448)	573440	mixed8[0][0]
batch_normalization_81 (BatchNo	(None, 6, 6, 448)	1344	conv2d_81[0][0]
activation_81 (Activation)	(None, 6, 6, 448)	0	batch_normalization_81[0][0]
conv2d_78 (Conv2D)	(None, 6, 6, 384)	491520	mixed8[0][0]
conv2d_82 (Conv2D)	(None, 6, 6, 384)	1548288	activation_81[0][0]
batch_normalization_78 (BatchNo	(None, 6, 6, 384)	1152	conv2d_78[0][0]
batch_normalization_82 (BatchNo	(None, 6, 6, 384)	1152	conv2d_82[0][0]
activation_78 (Activation)	(None, 6, 6, 384)	0	batch_normalization_78[0][0]
activation_82 (Activation)	(None, 6, 6, 384)	0	batch_normalization_82[0][0]
conv2d_79 (Conv2D)	(None, 6, 6, 384)	442368	activation_78[0][0]
conv2d_80 (Conv2D)	(None, 6, 6, 384)	442368	activation_78[0][0]
conv2d_83 (Conv2D)	(None, 6, 6, 384)	442368	activation_82[0][0]
conv2d_84 (Conv2D)	(None, 6, 6, 384)	442368	activation_82[0][0]
average_pooling2d_8 (AveragePoo	(None, 6, 6, 1280)	0	mixed8[0][0]
conv2d_77 (Conv2D)	(None, 6, 6, 320)	409600	mixed8[0][0]
batch_normalization_79 (BatchNo	(None, 6, 6, 384)	1152	conv2d_79[0][0]
batch_normalization_80 (BatchNo	(None, 6, 6, 384)	1152	conv2d_80[0][0]
batch_normalization_83 (BatchNo	(None, 6, 6, 384)	1152	conv2d_83[0][0]
batch_normalization_84 (BatchNo	(None, 6, 6, 384)	1152	conv2d_84[0][0]
conv2d_85 (Conv2D)	(None, 6, 6, 192)	245760	average_pooling2d_8[0][0]
batch_normalization_77 (BatchNo	(None, 6, 6, 320)	960	conv2d_77[0][0]
activation_79 (Activation)	(None, 6, 6, 384)	0	batch_normalization_79[0][0]
activation_80 (Activation)	(None, 6, 6, 384)	0	batch_normalization_80[0][0]
activation_83 (Activation)	(None, 6, 6, 384)	0	batch_normalization_83[0][0]
activation_84 (Activation)	(None, 6, 6, 384)	0	batch_normalization_84[0][0]
batch_normalization_85 (BatchNo	(None, 6, 6, 192)	576	conv2d_85[0][0]
activation_77 (Activation)	(None, 6, 6, 320)	0	batch_normalization_77[0][0]
mixed9_0 (Concatenate)	(None, 6, 6, 768)	0	activation_79[0][0] activation_80[0][0]
concatenate_1 (Concatenate)	(None, 6, 6, 768)	0	activation_83[0][0] activation_84[0][0]
activation_85 (Activation)	(None, 6, 6, 192)	0	batch_normalization_85[0][0]
mixed9 (Concatenate)	(None, 6, 6, 2048)	0	activation_77[0][0] mixed9_0[0][0] concatenate_1[0][0] activation_85[0][0]
conv2d_90 (Conv2D)	(None, 6, 6, 448)	917504	mixed9[0][0]
batch_normalization_90 (BatchNo	(None, 6, 6, 448)	1344	conv2d_90[0][0]
activation_90 (Activation)	(None, 6, 6, 448)	0	batch_normalization_90[0][0]
conv2d_87 (Conv2D)	(None, 6, 6, 384)	786432	mixed9[0][0]
conv2d_91 (Conv2D)	(None, 6, 6, 384)	1548288	activation_90[0][0]
batch_normalization_87 (BatchNo	(None, 6, 6, 384)	1152	conv2d_87[0][0]
batch_normalization_91 (BatchNo	(None, 6, 6, 384)	1152	conv2d_91[0][0]
activation_87 (Activation)	(None, 6, 6, 384)	0	batch_normalization_87[0][0]
activation_91 (Activation)	(None, 6, 6, 384)	0	batch_normalization_91[0][0]
conv2d_88 (Conv2D)	(None, 6, 6, 384)	442368	activation_87[0][0]

conv2d_89 (Conv2D)	(None, 6, 6, 384)	442368	activation_87[0][0]
conv2d_92 (Conv2D)	(None, 6, 6, 384)	442368	activation_91[0][0]
conv2d_93 (Conv2D)	(None, 6, 6, 384)	442368	activation_91[0][0]
average_pooling2d_9 (AveragePoo	(None, 6, 6, 2048)	0	mixed9[0][0]
conv2d_86 (Conv2D)	(None, 6, 6, 320)	655360	mixed9[0][0]
batch_normalization_88 (BatchNo	(None, 6, 6, 384)	1152	conv2d_88[0][0]
batch_normalization_89 (BatchNo	(None, 6, 6, 384)	1152	conv2d_89[0][0]
batch_normalization_92 (BatchNo	(None, 6, 6, 384)	1152	conv2d_92[0][0]
batch_normalization_93 (BatchNo	(None, 6, 6, 384)	1152	conv2d_93[0][0]
conv2d_94 (Conv2D)	(None, 6, 6, 192)	393216	average_pooling2d_9[0][0]
batch_normalization_86 (BatchNo	(None, 6, 6, 320)	960	conv2d_86[0][0]
activation_88 (Activation)	(None, 6, 6, 384)	0	batch_normalization_88[0][0]
activation_89 (Activation)	(None, 6, 6, 384)	0	batch_normalization_89[0][0]
activation_92 (Activation)	(None, 6, 6, 384)	0	batch_normalization_92[0][0]
activation_93 (Activation)	(None, 6, 6, 384)	0	batch_normalization_93[0][0]
batch_normalization_94 (BatchNo	(None, 6, 6, 192)	576	conv2d_94[0][0]
activation_86 (Activation)	(None, 6, 6, 320)	0	batch_normalization_86[0][0]
mixed9_1 (Concatenate)	(None, 6, 6, 768)	0	activation_88[0][0] activation_89[0][0]
concatenate_2 (Concatenate)	(None, 6, 6, 768)	0	activation_92[0][0] activation_93[0][0]
activation_94 (Activation)	(None, 6, 6, 192)	0	batch_normalization_94[0][0]
mixed10 (Concatenate)	(None, 6, 6, 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, 102)	208998	global_average_pooling2d_1[0][0]

Total params: 22,011,782
Trainable params: 21,977,350
Non-trainable params: 34,432

In [30]:
```
# how many layers our model has
print(len(model.layers))
```

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In [31]:
```
# set all layers trainable by default
for layer in model.layers:
    layer.trainable = True
    if isinstance(layer, keras.layers.BatchNormalization):
        # we do aggressive exponential smoothing of batch norm
        # parameters to faster adjust to our new dataset
        layer.momentum = 0.9

# fix deep layers (fine-tuning only last 50)
for layer in model.layers[:-50]:
    # fix all but batch norm layers, because we neeed to update moving averages for a new dataset!
    if not isinstance(layer, keras.layers.BatchNormalization):
        layer.trainable = False
```

In [32]:
```
# compile new model
model.compile(
    loss='categorical_crossentropy',  # we train 102-way classification
    optimizer=keras.optimizers.adamax(lr=1e-2),  # we can take big lr here because we fixed first layers
    metrics=['accuracy']  # report accuracy during training
)
```

In [33]:
```
# we will save model checkpoints to continue training in case of kernel death
model_filename = 'flowers.{0:03d}.hdf5'
last_finished_epoch = None

#### uncomment below to continue training from model checkpoint
#### fill `last_finished_epoch` with your latest finished epoch
# from keras.models import load_model
# s = reset_tf_session()
# last_finished_epoch = 10
# model = load_model(model_filename.format(last_finished_epoch))
```

Training takes **2 hours**. You're aiming for ~0.93 validation accuracy.

In [34]:
```
# fine tune for 2 epochs (full passes through all training data)
# we make 2*8 epochs, where epoch is 1/8 of our training data to see progress more often
model.fit_generator(
    train_generator(tr_files, tr_labels),
    steps_per_epoch=len(tr_files) // BATCH_SIZE // 8,
    epochs=2 * 8,
    validation_data=train_generator(te_files, te_labels),
    validation_steps=len(te_files) // BATCH_SIZE // 4,
    callbacks=[keras_utils.TqdmProgressCallback(),
               keras_utils.ModelSaveCallback(model_filename)],
    verbose=0,
    initial_epoch=last_finished_epoch or 0
)
```

```
WARNING:tensorflow:From C:\Users\Xiaowei\Anaconda3\envs\tfspark\lib\site-packages\keras\backend\tensorflow_backend.py:422: The name tf.global_variables is deprecated. Please use tf.compat.v1.global_variables instead.


Epoch 1/16

 loss: 4.4629; accuracy: 0.1809; val_loss: 25.5818… 26/? [00:11<00:00, 2.18it/s]


Model saved in flowers.000.hdf5

Epoch 2/16

 loss: 2.5822; accuracy: 0.4085; val_loss: 6.2950; … 26/? [00:08<00:00, 3.02it/s]


Model saved in flowers.001.hdf5

Epoch 3/16

 loss: 1.5480; accuracy: 0.6112; val_loss: 2.1268; … 26/? [00:08<00:00, 3.02it/s]


Model saved in flowers.002.hdf5

Epoch 4/16

 loss: 1.0886; accuracy: 0.7285; val_loss: 0.6866; … 26/? [00:08<00:00, 3.01it/s]


Model saved in flowers.003.hdf5

Epoch 5/16

 loss: 0.7582; accuracy: 0.7971; val_loss: 1.1003; … 26/? [00:08<00:00, 3.02it/s]


Model saved in flowers.004.hdf5

Epoch 6/16

 loss: 0.6719; accuracy: 0.8363; val_loss: 0.8985; … 26/? [00:08<00:00, 3.02it/s]


Model saved in flowers.005.hdf5

Epoch 7/16

 loss: 0.5240; accuracy: 0.8980; val_loss: 0.1597; … 26/? [00:08<00:00, 3.03it/s]


Model saved in flowers.006.hdf5

Epoch 8/16

 loss: 0.4045; accuracy: 0.8814; val_loss: 0.1581; … 26/? [00:08<00:00, 3.03it/s]


Model saved in flowers.007.hdf5

Epoch 9/16

 loss: 0.2865; accuracy: 0.9250; val_loss: 0.3577; … 26/? [00:08<00:00, 2.93it/s]


Model saved in flowers.008.hdf5

Epoch 10/16

 loss: 0.2194; accuracy: 0.9368; val_loss: 0.1490; … 26/? [00:08<00:00, 3.03it/s]
```

```
Model saved in flowers.009.hdf5

Epoch 11/16

 loss: 0.1323; accuracy: 0.9719; val_loss: 0.1292; … 26/? [00:08<00:00, 3.02it/s]


Model saved in flowers.010.hdf5

Epoch 12/16

 loss: 0.1212; accuracy: 0.9812; val_loss: 0.1845; … 26/? [00:08<00:00, 3.03it/s]


Model saved in flowers.011.hdf5

Epoch 13/16

 loss: 0.0707; accuracy: 0.9909; val_loss: 0.3618; … 26/? [00:08<00:00, 3.06it/s]


Model saved in flowers.012.hdf5

Epoch 14/16

 loss: 0.0660; accuracy: 0.9938; val_loss: 0.2628; … 26/? [00:08<00:00, 3.03it/s]


Model saved in flowers.013.hdf5

Epoch 15/16

 loss: 0.0522; accuracy: 0.9953; val_loss: 0.3940; … 26/? [00:08<00:00, 2.98it/s]


Model saved in flowers.014.hdf5

Epoch 16/16

 loss: 0.0372; accuracy: 0.9991; val_loss: 0.2020; … 26/? [00:08<00:00, 3.03it/s]


Model saved in flowers.015.hdf5
```

Out[34]: `<keras.callbacks.callbacks.History at 0x2238b38b448>`

In [35]:

```
## GRADED PART, DO NOT CHANGE!
# Accuracy on validation set
test_accuracy = model.evaluate_generator(
    train_generator(te_files, te_labels),
    len(te_files) // BATCH_SIZE // 2
)[1]
grader.set_answer("wuwwC", test_accuracy)
print(test_accuracy)
```

```
0.9537500143051147
```

In [35]:

```
# you can make submission with answers so far to check yourself at this stage
grader.submit(COURSERA_EMAIL, COURSERA_TOKEN)
```

```
Submitted to Coursera platform. See results on assignment page!
```

That's it! Congratulations!

What you've done:

- prepared images for the model
- implemented your own batch generator
- fine-tuned the pre-trained model