

Classification based on extracted features

```
In [1]: import os
os.environ["CUDA_VISIBLE_DEVICES"] = '1'

#from keras.applications.vgg16 import VGG16 as BaseModel
#from keras.applications.vgg16 import preprocess_input

from keras.applications.xception import Xception as BaseModel
from keras.applications.xception import preprocess_input

from keras.preprocessing import image
from keras.models import Model
import numpy as np
```

Using TensorFlow backend.

```
/home/daryna/.local/lib/python3.7/site-packages/tensorflow/python  
/framework/dtypes.py:516: FutureWarning: Passing (type, 1) or 'lt  
ype' as a synonym of type is deprecated; in a future version of n  
umpy, it will be understood as (type, (1,)) / '(1,)type'.
```

```
_np_qint8 = np.dtype [("qint8", np.int8, 1)]
```

```
/home/daryna/.local/lib/python3.7/site-packages/tensorflow/python  
/framework/dtypes.py:517: FutureWarning: Passing (type, 1) or 'lt  
ype' as a synonym of type is deprecated; in a future version of n  
umpy, it will be understood as (type, (1,)) / '(1,)type'.
```

```
_np_quint8 = np.dtype [("quint8", np.uint8, 1)]
```

```
/home/daryna/.local/lib/python3.7/site-packages/tensorflow/python  
/framework/dtypes.py:518: FutureWarning: Passing (type, 1) or 'lt  
ype' as a synonym of type is deprecated; in a future version of n  
umpy, it will be understood as (type, (1,)) / '(1,)type'.
```

```
_np_qint16 = np.dtype [("qint16", np.int16, 1)]
```

```
/home/daryna/.local/lib/python3.7/site-packages/tensorflow/python  
/framework/dtypes.py:519: FutureWarning: Passing (type, 1) or 'lt  
ype' as a synonym of type is deprecated; in a future version of n  
umpy, it will be understood as (type, (1,)) / '(1,)type'.
```

```
_np_quint16 = np.dtype [("quint16", np.uint16, 1)]
```

```
/home/daryna/.local/lib/python3.7/site-packages/tensorflow/python  
/framework/dtypes.py:520: FutureWarning: Passing (type, 1) or 'lt  
ype' as a synonym of type is deprecated; in a future version of n  
umpy, it will be understood as (type, (1,)) / '(1,)type'.
```

```
_np_qint32 = np.dtype [("qint32", np.int32, 1)]
```

```
/home/daryna/.local/lib/python3.7/site-packages/tensorflow/python  
/framework/dtypes.py:525: FutureWarning: Passing (type, 1) or 'lt  
ype' as a synonym of type is deprecated; in a future version of n  
umpy, it will be understood as (type, (1,)) / '(1,)type'.
```

```
np_resource = np.dtype [("resource", np.ubyte, 1)]
```

```
/home/daryna/.local/lib/python3.7/site-packages/tensorboard/compa  
t/tensorflow_stub/dtypes.py:541: FutureWarning: Passing (type, 1)  
or 'ltype' as a synonym of type is deprecated; in a future versio  
n of numpy, it will be understood as (type, (1,)) / '(1,)type'.
```

```
_np_qint8 = np.dtype [("qint8", np.int8, 1)]
```

```
/home/daryna/.local/lib/python3.7/site-packages/tensorboard/compa  
t/tensorflow_stub/dtypes.py:542: FutureWarning: Passing (type, 1)  
or 'ltype' as a synonym of type is deprecated; in a future versio  
n of numpy, it will be understood as (type, (1,)) / '(1,)type'.
```

```
_np_quint8 = np.dtype [("quint8", np.uint8, 1)]
```

```
/home/daryna/.local/lib/python3.7/site-packages/tensorboard/compa  
t/tensorflow_stub/dtypes.py:543: FutureWarning: Passing (type, 1)  
or 'ltype' as a synonym of type is deprecated; in a future versio  
n of numpy, it will be understood as (type, (1,)) / '(1,)type'.
```

```
_np_qint16 = np.dtype [("qint16", np.int16, 1)]
```

```
/home/daryna/.local/lib/python3.7/site-packages/tensorboard/compa  
t/tensorflow_stub/dtypes.py:544: FutureWarning: Passing (type, 1)  
or 'ltype' as a synonym of type is deprecated; in a future versio  
n of numpy, it will be understood as (type, (1,)) / '(1,)type'.
```

```
_np_quint16 = np.dtype [("quint16", np.uint16, 1)]
```

```
/home/daryna/.local/lib/python3.7/site-packages/tensorboard/compa  
t/tensorflow_stub/dtypes.py:545: FutureWarning: Passing (type, 1)  
or 'ltype' as a synonym of type is deprecated; in a future versio  
n of numpy, it will be understood as (type, (1,)) / '(1,)type'.
```

```
_np_qint32 = np.dtype [("qint32", np.int32, 1)]
```

```
/home/daryna/.local/lib/python3.7/site-packages/tensorboard/compa  
t/tensorflow_stub/dtypes.py:550: FutureWarning: Passing (type, 1)  
or 'ltype' as a synonym of type is deprecated; in a future versio
```

```
n of numpy, it will be understood as (type, (1,)) / '(1,)type'.  
nn_resource = nn_dtype/f/"resource" nn_dtype = 111)
```

```
In [2]: model = BaseModel(weights='imagenet', include_top=True)
```

```
WARNING:tensorflow:From /home/daryna/anaconda3/envs/ml_ukma/lib/p  
ython3.7/site-packages/keras/backend/tensorflow_backend.py:4070:  
The name tf.nn.max_pool is deprecated. Please use tf.nn.max_pool2  
d instead.
```

```
Downloading data from https://github.com/fchollet/deep-learning-m  
odels/releases/download/v0.4/xception_weights_tf_dim_ordering_tf_  
kernels.h5  
91889664/91884032 [=====] - 30s 0us/step
```

In [3]: `model.summary()`

Model: "xception"

Layer (type) Connected to	Output Shape	Param #
=====		
input_1 (InputLayer)	(None, 299, 299, 3)	0
block1_conv1 (Conv2D) input_1[0][0]	(None, 149, 149, 32)	864
block1_conv1_bn (BatchNormaliza block1_conv1[0][0]	(None, 149, 149, 32)	128
block1_conv1_act (Activation) block1_conv1_bn[0][0]	(None, 149, 149, 32)	0
block1_conv2 (Conv2D) block1_conv1_act[0][0]	(None, 147, 147, 64)	18432
block1_conv2_bn (BatchNormaliza block1_conv2[0][0]	(None, 147, 147, 64)	256
block1_conv2_act (Activation) block1_conv2_bn[0][0]	(None, 147, 147, 64)	0
block2_sepconv1 (SeparableConv2 block1_conv2_act[0][0]	(None, 147, 147, 128)	8768
block2_sepconv1_bn (BatchNormal block2_sepconv1[0][0]	(None, 147, 147, 128)	512
block2_sepconv2_act (Activation block2_sepconv1_bn[0][0]	(None, 147, 147, 128)	0
block2_sepconv2 (SeparableConv2 block2_sepconv2_act[0][0]	(None, 147, 147, 128)	17536
block2_sepconv2_bn (BatchNormal block2_sepconv2[0][0]	(None, 147, 147, 128)	512
conv2d_1 (Conv2D) block1_conv2_act[0][0]	(None, 74, 74, 128)	8192
block2_pool (MaxPooling2D)	(None, 74, 74, 128)	0

block2_sepconv2_bn[0][0]

batch_normalization_1 (BatchNormal (None, 74, 74, 128) 512
conv2d_1[0][0]

add_1 (Add) (None, 74, 74, 128) 0
block2_pool[0][0]

batch_normalization_1[0][0]

block3_sepconv1_act (Activation (None, 74, 74, 128) 0
add_1[0][0]

block3_sepconv1 (SeparableConv2 (None, 74, 74, 256) 33920
block3_sepconv1_act[0][0]

block3_sepconv1_bn (BatchNormal (None, 74, 74, 256) 1024
block3_sepconv1[0][0]

block3_sepconv2_act (Activation (None, 74, 74, 256) 0
block3_sepconv1_bn[0][0]

block3_sepconv2 (SeparableConv2 (None, 74, 74, 256) 67840
block3_sepconv2_act[0][0]

block3_sepconv2_bn (BatchNormal (None, 74, 74, 256) 1024
block3_sepconv2[0][0]

conv2d_2 (Conv2D) (None, 37, 37, 256) 32768
add_1[0][0]

block3_pool (MaxPooling2D) (None, 37, 37, 256) 0
block3_sepconv2_bn[0][0]

batch_normalization_2 (BatchNormal (None, 37, 37, 256) 1024
conv2d_2[0][0]

add_2 (Add) (None, 37, 37, 256) 0
block3_pool[0][0]

batch_normalization_2[0][0]

block4_sepconv1_act (Activation (None, 37, 37, 256) 0
add_2[0][0]

block4_sepconv1 (SeparableConv2 (None, 37, 37, 728) 188672

block4_sepconv1_act[0][0]

block4_sepconv1_bn (BatchNormal (None, 37, 37, 728) 2912
block4_sepconv1[0][0]

block4_sepconv2_act (Activation (None, 37, 37, 728) 0
block4_sepconv1_bn[0][0]

block4_sepconv2 (SeparableConv2 (None, 37, 37, 728) 536536
block4_sepconv2_act[0][0]

block4_sepconv2_bn (BatchNormal (None, 37, 37, 728) 2912
block4_sepconv2[0][0]

conv2d_3 (Conv2D) (None, 19, 19, 728) 186368
add_2[0][0]

block4_pool (MaxPooling2D) (None, 19, 19, 728) 0
block4_sepconv2_bn[0][0]

batch_normalization_3 (BatchNor (None, 19, 19, 728) 2912
conv2d_3[0][0]

add_3 (Add) (None, 19, 19, 728) 0
block4_pool[0][0]

batch_normalization_3[0][0]

block5_sepconv1_act (Activation (None, 19, 19, 728) 0
add_3[0][0]

block5_sepconv1 (SeparableConv2 (None, 19, 19, 728) 536536
block5_sepconv1_act[0][0]

block5_sepconv1_bn (BatchNormal (None, 19, 19, 728) 2912
block5_sepconv1[0][0]

block5_sepconv2_act (Activation (None, 19, 19, 728) 0
block5_sepconv1_bn[0][0]

block5_sepconv2 (SeparableConv2 (None, 19, 19, 728) 536536
block5_sepconv2_act[0][0]

block5_sepconv2_bn (BatchNormal (None, 19, 19, 728) 2912
block5_sepconv2[0][0]

block5_sepconv3_act (Activation (None, 19, 19, 728) 0 block5_sepconv2_bn[0][0]	
block5_sepconv3 (SeparableConv2 (None, 19, 19, 728) 536536 block5_sepconv3_act[0][0]	
block5_sepconv3_bn (BatchNormal (None, 19, 19, 728) 2912 block5_sepconv3[0][0]	
add_4 (Add) (None, 19, 19, 728) 0 block5_sepconv3_bn[0][0]	
add_3[0][0]	
block6_sepconv1_act (Activation (None, 19, 19, 728) 0 add_4[0][0]	
block6_sepconv1 (SeparableConv2 (None, 19, 19, 728) 536536 block6_sepconv1_act[0][0]	
block6_sepconv1_bn (BatchNormal (None, 19, 19, 728) 2912 block6_sepconv1[0][0]	
block6_sepconv2_act (Activation (None, 19, 19, 728) 0 block6_sepconv1_bn[0][0]	
block6_sepconv2 (SeparableConv2 (None, 19, 19, 728) 536536 block6_sepconv2_act[0][0]	
block6_sepconv2_bn (BatchNormal (None, 19, 19, 728) 2912 block6_sepconv2[0][0]	
block6_sepconv3_act (Activation (None, 19, 19, 728) 0 block6_sepconv2_bn[0][0]	
block6_sepconv3 (SeparableConv2 (None, 19, 19, 728) 536536 block6_sepconv3_act[0][0]	
block6_sepconv3_bn (BatchNormal (None, 19, 19, 728) 2912 block6_sepconv3[0][0]	
add_5 (Add) (None, 19, 19, 728) 0 block6_sepconv3_bn[0][0]	
add_4[0][0]	

block7_sepconv1_act (Activation (None, 19, 19, 728) 0 add_5[0][0]	
block7_sepconv1 (SeparableConv2 (None, 19, 19, 728) 536536 block7_sepconv1_act[0][0]	
block7_sepconv1_bn (BatchNormal (None, 19, 19, 728) 2912 block7_sepconv1[0][0]	
block7_sepconv2_act (Activation (None, 19, 19, 728) 0 block7_sepconv1_bn[0][0]	
block7_sepconv2 (SeparableConv2 (None, 19, 19, 728) 536536 block7_sepconv2_act[0][0]	
block7_sepconv2_bn (BatchNormal (None, 19, 19, 728) 2912 block7_sepconv2[0][0]	
block7_sepconv3_act (Activation (None, 19, 19, 728) 0 block7_sepconv2_bn[0][0]	
block7_sepconv3 (SeparableConv2 (None, 19, 19, 728) 536536 block7_sepconv3_act[0][0]	
block7_sepconv3_bn (BatchNormal (None, 19, 19, 728) 2912 block7_sepconv3[0][0]	
add_6 (Add) (None, 19, 19, 728) 0 block7_sepconv3_bn[0][0]	
add_5[0][0]	
block8_sepconv1_act (Activation (None, 19, 19, 728) 0 add_6[0][0]	
block8_sepconv1 (SeparableConv2 (None, 19, 19, 728) 536536 block8_sepconv1_act[0][0]	
block8_sepconv1_bn (BatchNormal (None, 19, 19, 728) 2912 block8_sepconv1[0][0]	
block8_sepconv2_act (Activation (None, 19, 19, 728) 0 block8_sepconv1_bn[0][0]	
block8_sepconv2 (SeparableConv2 (None, 19, 19, 728) 536536	

block8_sepconv2_act[0][0]

block8_sepconv2_bn (BatchNormal (None, 19, 19, 728) 2912
block8_sepconv2[0][0]

block8_sepconv3_act (Activation (None, 19, 19, 728) 0
block8_sepconv2_bn[0][0]

block8_sepconv3 (SeparableConv2 (None, 19, 19, 728) 536536
block8_sepconv3_act[0][0]

block8_sepconv3_bn (BatchNormal (None, 19, 19, 728) 2912
block8_sepconv3[0][0]

add_7 (Add) (None, 19, 19, 728) 0
block8_sepconv3_bn[0][0]

add_6[0][0]

block9_sepconv1_act (Activation (None, 19, 19, 728) 0
add_7[0][0]

block9_sepconv1 (SeparableConv2 (None, 19, 19, 728) 536536
block9_sepconv1_act[0][0]

block9_sepconv1_bn (BatchNormal (None, 19, 19, 728) 2912
block9_sepconv1[0][0]

block9_sepconv2_act (Activation (None, 19, 19, 728) 0
block9_sepconv1_bn[0][0]

block9_sepconv2 (SeparableConv2 (None, 19, 19, 728) 536536
block9_sepconv2_act[0][0]

block9_sepconv2_bn (BatchNormal (None, 19, 19, 728) 2912
block9_sepconv2[0][0]

block9_sepconv3_act (Activation (None, 19, 19, 728) 0
block9_sepconv2_bn[0][0]

block9_sepconv3 (SeparableConv2 (None, 19, 19, 728) 536536
block9_sepconv3_act[0][0]

block9_sepconv3_bn (BatchNormal (None, 19, 19, 728) 2912
block9_sepconv3[0][0]

add_8 (Add)	(None, 19, 19, 728)	0
block9_sepconv3_bn[0][0]		
add_7[0][0]		
block10_sepconv1_act (Activatio	(None, 19, 19, 728)	0
add_8[0][0]		
block10_sepconv1 (SeparableConv	(None, 19, 19, 728)	536536
block10_sepconv1_act[0][0]		
block10_sepconv1_bn (BatchNorma	(None, 19, 19, 728)	2912
block10_sepconv1[0][0]		
block10_sepconv2_act (Activatio	(None, 19, 19, 728)	0
block10_sepconv1_bn[0][0]		
block10_sepconv2 (SeparableConv	(None, 19, 19, 728)	536536
block10_sepconv2_act[0][0]		
block10_sepconv2_bn (BatchNorma	(None, 19, 19, 728)	2912
block10_sepconv2[0][0]		
block10_sepconv3_act (Activatio	(None, 19, 19, 728)	0
block10_sepconv2_bn[0][0]		
block10_sepconv3 (SeparableConv	(None, 19, 19, 728)	536536
block10_sepconv3_act[0][0]		
block10_sepconv3_bn (BatchNorma	(None, 19, 19, 728)	2912
block10_sepconv3[0][0]		
add_9 (Add)	(None, 19, 19, 728)	0
block10_sepconv3_bn[0][0]		
add_8[0][0]		
block11_sepconv1_act (Activatio	(None, 19, 19, 728)	0
add_9[0][0]		
block11_sepconv1 (SeparableConv	(None, 19, 19, 728)	536536
block11_sepconv1_act[0][0]		
block11_sepconv1_bn (BatchNorma	(None, 19, 19, 728)	2912
block11_sepconv1[0][0]		

block11_sepconv2_act (Activatio	(None, 19, 19, 728)	0
block11_sepconv1_bn[0][0]		
block11_sepconv2 (SeparableConv	(None, 19, 19, 728)	536536
block11_sepconv2_act[0][0]		
block11_sepconv2_bn (BatchNorma	(None, 19, 19, 728)	2912
block11_sepconv2[0][0]		
block11_sepconv3_act (Activatio	(None, 19, 19, 728)	0
block11_sepconv2_bn[0][0]		
block11_sepconv3 (SeparableConv	(None, 19, 19, 728)	536536
block11_sepconv3_act[0][0]		
block11_sepconv3_bn (BatchNorma	(None, 19, 19, 728)	2912
block11_sepconv3[0][0]		
add_10 (Add)	(None, 19, 19, 728)	0
block11_sepconv3_bn[0][0]		
add_9[0][0]		
block12_sepconv1_act (Activatio	(None, 19, 19, 728)	0
add_10[0][0]		
block12_sepconv1 (SeparableConv	(None, 19, 19, 728)	536536
block12_sepconv1_act[0][0]		
block12_sepconv1_bn (BatchNorma	(None, 19, 19, 728)	2912
block12_sepconv1[0][0]		
block12_sepconv2_act (Activatio	(None, 19, 19, 728)	0
block12_sepconv1_bn[0][0]		
block12_sepconv2 (SeparableConv	(None, 19, 19, 728)	536536
block12_sepconv2_act[0][0]		
block12_sepconv2_bn (BatchNorma	(None, 19, 19, 728)	2912
block12_sepconv2[0][0]		
block12_sepconv3_act (Activatio	(None, 19, 19, 728)	0
block12_sepconv2_bn[0][0]		
block12_sepconv3 (SeparableConv	(None, 19, 19, 728)	536536

block12_sepconv3_act[0][0]

block12_sepconv3_bn (BatchNorma (None, 19, 19, 728) 2912
block12_sepconv3[0][0]

add_11 (Add) (None, 19, 19, 728) 0
block12_sepconv3_bn[0][0]

add_10[0][0]

block13_sepconv1_act (Activatio (None, 19, 19, 728) 0
add_11[0][0]

block13_sepconv1 (SeparableConv (None, 19, 19, 728) 536536
block13_sepconv1_act[0][0]

block13_sepconv1_bn (BatchNorma (None, 19, 19, 728) 2912
block13_sepconv1[0][0]

block13_sepconv2_act (Activatio (None, 19, 19, 728) 0
block13_sepconv1_bn[0][0]

block13_sepconv2 (SeparableConv (None, 19, 19, 1024) 752024
block13_sepconv2_act[0][0]

block13_sepconv2_bn (BatchNorma (None, 19, 19, 1024) 4096
block13_sepconv2[0][0]

conv2d_4 (Conv2D) (None, 10, 10, 1024) 745472
add_11[0][0]

block13_pool (MaxPooling2D) (None, 10, 10, 1024) 0
block13_sepconv2_bn[0][0]

batch_normalization_4 (BatchNor (None, 10, 10, 1024) 4096
conv2d_4[0][0]

add_12 (Add) (None, 10, 10, 1024) 0
block13_pool[0][0]

batch_normalization_4[0][0]

block14_sepconv1 (SeparableConv (None, 10, 10, 1536) 1582080
add_12[0][0]

block14_sepconv1_bn (BatchNorma (None, 10, 10, 1536) 6144

```
block14_sepconv1[0][0]
```

```
block14_sepconv1_act (Activation) (None, 10, 10, 1536) 0
```

```
block14_sepconv1_bn[0][0]
```

```
block14_sepconv2 (SeparableConv) (None, 10, 10, 2048) 3159552
```

```
block14_sepconv1_act[0][0]
```

```
block14_sepconv2_bn (Batch Normalization) (None, 10, 10, 2048) 8192
```

```
block14_sepconv2[0][0]
```

```
block14_sepconv2_act (Activation) (None, 10, 10, 2048) 0
```

```
block14_sepconv2_bn[0][0]
```

```
avg_pool (GlobalAveragePooling2) (None, 2048) 0
```

```
block14_sepconv2_act[0][0]
```

```
predictions (Dense) (None, 1000) 2049000
```

```
avg_pool[0][0]
```

```
=====
```

```
Total params: 22,910,480
```

```
Trainable params: 22,855,952
```

```
In [4]: features_model = Model(input=model.input, output=model.layers[-2].output)
```

```
/home/daryna/anaconda3/envs/ml_ukma/lib/python3.7/site-packages/ipykernel_launcher.py:1: UserWarning: Update your `Model` call to the Keras 2 API: `Model(inputs=Tensor("in...", outputs=Tensor("av..."))`
    """Entry point for launching an IPython kernel.
```

```
In [5]: features_model.summary()
```


Model: "model_1"

Layer (type) Connected to	Output Shape	Param #
=====		
input_1 (InputLayer)	(None, 299, 299, 3)	0
block1_conv1 (Conv2D) input_1[0][0]	(None, 149, 149, 32)	864
block1_conv1_bn (BatchNormaliza block1_conv1[0][0]	(None, 149, 149, 32)	128
block1_conv1_act (Activation) block1_conv1_bn[0][0]	(None, 149, 149, 32)	0
block1_conv2 (Conv2D) block1_conv1_act[0][0]	(None, 147, 147, 64)	18432
block1_conv2_bn (BatchNormaliza block1_conv2[0][0]	(None, 147, 147, 64)	256
block1_conv2_act (Activation) block1_conv2_bn[0][0]	(None, 147, 147, 64)	0
block2_sepconv1 (SeparableConv2 block1_conv2_act[0][0]	(None, 147, 147, 128)	8768
block2_sepconv1_bn (BatchNormal block2_sepconv1[0][0]	(None, 147, 147, 128)	512
block2_sepconv2_act (Activation block2_sepconv1_bn[0][0]	(None, 147, 147, 128)	0
block2_sepconv2 (SeparableConv2 block2_sepconv2_act[0][0]	(None, 147, 147, 128)	17536
block2_sepconv2_bn (BatchNormal block2_sepconv2[0][0]	(None, 147, 147, 128)	512
conv2d_1 (Conv2D) block1_conv2_act[0][0]	(None, 74, 74, 128)	8192
block2_pool (MaxPooling2D)	(None, 74, 74, 128)	0

block2_sepconv2_bn[0][0]

batch_normalization_1 (BatchNormal (None, 74, 74, 128) 512
conv2d_1[0][0]

add_1 (Add) (None, 74, 74, 128) 0
block2_pool[0][0]

batch_normalization_1[0][0]

block3_sepconv1_act (Activation (None, 74, 74, 128) 0
add_1[0][0]

block3_sepconv1 (SeparableConv2 (None, 74, 74, 256) 33920
block3_sepconv1_act[0][0]

block3_sepconv1_bn (BatchNormal (None, 74, 74, 256) 1024
block3_sepconv1[0][0]

block3_sepconv2_act (Activation (None, 74, 74, 256) 0
block3_sepconv1_bn[0][0]

block3_sepconv2 (SeparableConv2 (None, 74, 74, 256) 67840
block3_sepconv2_act[0][0]

block3_sepconv2_bn (BatchNormal (None, 74, 74, 256) 1024
block3_sepconv2[0][0]

conv2d_2 (Conv2D) (None, 37, 37, 256) 32768
add_1[0][0]

block3_pool (MaxPooling2D) (None, 37, 37, 256) 0
block3_sepconv2_bn[0][0]

batch_normalization_2 (BatchNormal (None, 37, 37, 256) 1024
conv2d_2[0][0]

add_2 (Add) (None, 37, 37, 256) 0
block3_pool[0][0]

batch_normalization_2[0][0]

block4_sepconv1_act (Activation (None, 37, 37, 256) 0
add_2[0][0]

block4_sepconv1 (SeparableConv2 (None, 37, 37, 728) 188672

block4_sepconv1_act[0][0]

block4_sepconv1_bn (BatchNormal (None, 37, 37, 728) 2912
block4_sepconv1[0][0]

block4_sepconv2_act (Activation (None, 37, 37, 728) 0
block4_sepconv1_bn[0][0]

block4_sepconv2 (SeparableConv2 (None, 37, 37, 728) 536536
block4_sepconv2_act[0][0]

block4_sepconv2_bn (BatchNormal (None, 37, 37, 728) 2912
block4_sepconv2[0][0]

conv2d_3 (Conv2D) (None, 19, 19, 728) 186368
add_2[0][0]

block4_pool (MaxPooling2D) (None, 19, 19, 728) 0
block4_sepconv2_bn[0][0]

batch_normalization_3 (BatchNor (None, 19, 19, 728) 2912
conv2d_3[0][0]

add_3 (Add) (None, 19, 19, 728) 0
block4_pool[0][0]

batch_normalization_3[0][0]

block5_sepconv1_act (Activation (None, 19, 19, 728) 0
add_3[0][0]

block5_sepconv1 (SeparableConv2 (None, 19, 19, 728) 536536
block5_sepconv1_act[0][0]

block5_sepconv1_bn (BatchNormal (None, 19, 19, 728) 2912
block5_sepconv1[0][0]

block5_sepconv2_act (Activation (None, 19, 19, 728) 0
block5_sepconv1_bn[0][0]

block5_sepconv2 (SeparableConv2 (None, 19, 19, 728) 536536
block5_sepconv2_act[0][0]

block5_sepconv2_bn (BatchNormal (None, 19, 19, 728) 2912
block5_sepconv2[0][0]

block5_sepconv3_act (Activation (None, 19, 19, 728) 0 block5_sepconv2_bn[0][0]	
block5_sepconv3 (SeparableConv2 (None, 19, 19, 728) 536536 block5_sepconv3_act[0][0]	
block5_sepconv3_bn (BatchNormal (None, 19, 19, 728) 2912 block5_sepconv3[0][0]	
add_4 (Add) (None, 19, 19, 728) 0 block5_sepconv3_bn[0][0]	
add_3[0][0]	
block6_sepconv1_act (Activation (None, 19, 19, 728) 0 add_4[0][0]	
block6_sepconv1 (SeparableConv2 (None, 19, 19, 728) 536536 block6_sepconv1_act[0][0]	
block6_sepconv1_bn (BatchNormal (None, 19, 19, 728) 2912 block6_sepconv1[0][0]	
block6_sepconv2_act (Activation (None, 19, 19, 728) 0 block6_sepconv1_bn[0][0]	
block6_sepconv2 (SeparableConv2 (None, 19, 19, 728) 536536 block6_sepconv2_act[0][0]	
block6_sepconv2_bn (BatchNormal (None, 19, 19, 728) 2912 block6_sepconv2[0][0]	
block6_sepconv3_act (Activation (None, 19, 19, 728) 0 block6_sepconv2_bn[0][0]	
block6_sepconv3 (SeparableConv2 (None, 19, 19, 728) 536536 block6_sepconv3_act[0][0]	
block6_sepconv3_bn (BatchNormal (None, 19, 19, 728) 2912 block6_sepconv3[0][0]	
add_5 (Add) (None, 19, 19, 728) 0 block6_sepconv3_bn[0][0]	
add_4[0][0]	

block7_sepconv1_act (Activation (None, 19, 19, 728) 0 add_5[0][0])	
block7_sepconv1 (SeparableConv2 (None, 19, 19, 728) 536536 block7_sepconv1_act[0][0])	
block7_sepconv1_bn (BatchNormal (None, 19, 19, 728) 2912 block7_sepconv1[0][0])	
block7_sepconv2_act (Activation (None, 19, 19, 728) 0 block7_sepconv1_bn[0][0])	
block7_sepconv2 (SeparableConv2 (None, 19, 19, 728) 536536 block7_sepconv2_act[0][0])	
block7_sepconv2_bn (BatchNormal (None, 19, 19, 728) 2912 block7_sepconv2[0][0])	
block7_sepconv3_act (Activation (None, 19, 19, 728) 0 block7_sepconv2_bn[0][0])	
block7_sepconv3 (SeparableConv2 (None, 19, 19, 728) 536536 block7_sepconv3_act[0][0])	
block7_sepconv3_bn (BatchNormal (None, 19, 19, 728) 2912 block7_sepconv3[0][0])	
add_6 (Add) (None, 19, 19, 728) 0 block7_sepconv3_bn[0][0] add_5[0][0])	
block8_sepconv1_act (Activation (None, 19, 19, 728) 0 add_6[0][0])	
block8_sepconv1 (SeparableConv2 (None, 19, 19, 728) 536536 block8_sepconv1_act[0][0])	
block8_sepconv1_bn (BatchNormal (None, 19, 19, 728) 2912 block8_sepconv1[0][0])	
block8_sepconv2_act (Activation (None, 19, 19, 728) 0 block8_sepconv1_bn[0][0])	
block8_sepconv2 (SeparableConv2 (None, 19, 19, 728) 536536	

block8_sepconv2_act[0][0]

block8_sepconv2_bn (BatchNormal (None, 19, 19, 728) 2912
block8_sepconv2[0][0]

block8_sepconv3_act (Activation (None, 19, 19, 728) 0
block8_sepconv2_bn[0][0]

block8_sepconv3 (SeparableConv2 (None, 19, 19, 728) 536536
block8_sepconv3_act[0][0]

block8_sepconv3_bn (BatchNormal (None, 19, 19, 728) 2912
block8_sepconv3[0][0]

add_7 (Add) (None, 19, 19, 728) 0
block8_sepconv3_bn[0][0]

add_6[0][0]

block9_sepconv1_act (Activation (None, 19, 19, 728) 0
add_7[0][0]

block9_sepconv1 (SeparableConv2 (None, 19, 19, 728) 536536
block9_sepconv1_act[0][0]

block9_sepconv1_bn (BatchNormal (None, 19, 19, 728) 2912
block9_sepconv1[0][0]

block9_sepconv2_act (Activation (None, 19, 19, 728) 0
block9_sepconv1_bn[0][0]

block9_sepconv2 (SeparableConv2 (None, 19, 19, 728) 536536
block9_sepconv2_act[0][0]

block9_sepconv2_bn (BatchNormal (None, 19, 19, 728) 2912
block9_sepconv2[0][0]

block9_sepconv3_act (Activation (None, 19, 19, 728) 0
block9_sepconv2_bn[0][0]

block9_sepconv3 (SeparableConv2 (None, 19, 19, 728) 536536
block9_sepconv3_act[0][0]

block9_sepconv3_bn (BatchNormal (None, 19, 19, 728) 2912
block9_sepconv3[0][0]

add_8 (Add)	(None, 19, 19, 728)	0
block9_sepconv3_bn[0][0]		
add_7[0][0]		
block10_sepconv1_act (Activatio	(None, 19, 19, 728)	0
add_8[0][0]		
block10_sepconv1 (SeparableConv	(None, 19, 19, 728)	536536
block10_sepconv1_act[0][0]		
block10_sepconv1_bn (BatchNorma	(None, 19, 19, 728)	2912
block10_sepconv1[0][0]		
block10_sepconv2_act (Activatio	(None, 19, 19, 728)	0
block10_sepconv1_bn[0][0]		
block10_sepconv2 (SeparableConv	(None, 19, 19, 728)	536536
block10_sepconv2_act[0][0]		
block10_sepconv2_bn (BatchNorma	(None, 19, 19, 728)	2912
block10_sepconv2[0][0]		
block10_sepconv3_act (Activatio	(None, 19, 19, 728)	0
block10_sepconv2_bn[0][0]		
block10_sepconv3 (SeparableConv	(None, 19, 19, 728)	536536
block10_sepconv3_act[0][0]		
block10_sepconv3_bn (BatchNorma	(None, 19, 19, 728)	2912
block10_sepconv3[0][0]		
add_9 (Add)	(None, 19, 19, 728)	0
block10_sepconv3_bn[0][0]		
add_8[0][0]		
block11_sepconv1_act (Activatio	(None, 19, 19, 728)	0
add_9[0][0]		
block11_sepconv1 (SeparableConv	(None, 19, 19, 728)	536536
block11_sepconv1_act[0][0]		
block11_sepconv1_bn (BatchNorma	(None, 19, 19, 728)	2912
block11_sepconv1[0][0]		

block11_sepconv2_act (Activatio	(None, 19, 19, 728)	0
block11_sepconv1_bn[0][0]		
block11_sepconv2 (SeparableConv	(None, 19, 19, 728)	536536
block11_sepconv2_act[0][0]		
block11_sepconv2_bn (BatchNorma	(None, 19, 19, 728)	2912
block11_sepconv2[0][0]		
block11_sepconv3_act (Activatio	(None, 19, 19, 728)	0
block11_sepconv2_bn[0][0]		
block11_sepconv3 (SeparableConv	(None, 19, 19, 728)	536536
block11_sepconv3_act[0][0]		
block11_sepconv3_bn (BatchNorma	(None, 19, 19, 728)	2912
block11_sepconv3[0][0]		
add_10 (Add)	(None, 19, 19, 728)	0
block11_sepconv3_bn[0][0]		
add_9[0][0]		
block12_sepconv1_act (Activatio	(None, 19, 19, 728)	0
add_10[0][0]		
block12_sepconv1 (SeparableConv	(None, 19, 19, 728)	536536
block12_sepconv1_act[0][0]		
block12_sepconv1_bn (BatchNorma	(None, 19, 19, 728)	2912
block12_sepconv1[0][0]		
block12_sepconv2_act (Activatio	(None, 19, 19, 728)	0
block12_sepconv1_bn[0][0]		
block12_sepconv2 (SeparableConv	(None, 19, 19, 728)	536536
block12_sepconv2_act[0][0]		
block12_sepconv2_bn (BatchNorma	(None, 19, 19, 728)	2912
block12_sepconv2[0][0]		
block12_sepconv3_act (Activatio	(None, 19, 19, 728)	0
block12_sepconv2_bn[0][0]		
block12_sepconv3 (SeparableConv	(None, 19, 19, 728)	536536

block12_sepconv3_act[0][0]

block12_sepconv3_bn (BatchNorma (None, 19, 19, 728) 2912
block12_sepconv3[0][0]

add_11 (Add) (None, 19, 19, 728) 0
block12_sepconv3_bn[0][0]

add_10[0][0]

block13_sepconv1_act (Activatio (None, 19, 19, 728) 0
add_11[0][0]

block13_sepconv1 (SeparableConv (None, 19, 19, 728) 536536
block13_sepconv1_act[0][0]

block13_sepconv1_bn (BatchNorma (None, 19, 19, 728) 2912
block13_sepconv1[0][0]

block13_sepconv2_act (Activatio (None, 19, 19, 728) 0
block13_sepconv1_bn[0][0]

block13_sepconv2 (SeparableConv (None, 19, 19, 1024) 752024
block13_sepconv2_act[0][0]

block13_sepconv2_bn (BatchNorma (None, 19, 19, 1024) 4096
block13_sepconv2[0][0]

conv2d_4 (Conv2D) (None, 10, 10, 1024) 745472
add_11[0][0]

block13_pool (MaxPooling2D) (None, 10, 10, 1024) 0
block13_sepconv2_bn[0][0]

batch_normalization_4 (BatchNor (None, 10, 10, 1024) 4096
conv2d_4[0][0]

add_12 (Add) (None, 10, 10, 1024) 0
block13_pool[0][0]

batch_normalization_4[0][0]

block14_sepconv1 (SeparableConv (None, 10, 10, 1536) 1582080
add_12[0][0]

block14_sepconv1_bn (BatchNorma (None, 10, 10, 1536) 6144

```
block14_sepconv1[0][0]
```

```
block14_sepconv1_act (Activation (None, 10, 10, 1536)) 0
block14_sepconv1_bn[0][0]
```

```
block14_sepconv2 (SeparableConv (None, 10, 10, 2048)) 3159552
block14_sepconv1_act[0][0]
```

```
block14_sepconv2_bn (BatchNormalizatio (None, 10, 10, 2048)) 8192
block14_sepconv2[0][0]
```

```
block14_sepconv2_act (Activation (None, 10, 10, 2048)) 0
block14_sepconv2_bn[0][0]
```

```
avg_pool (GlobalAveragePooling2 (None, 2048)) 0
block14_sepconv2_act[0][0]
```

```
=====
```

```
Total params: 20,861,480
Trainable params: 20,806,952
```

```
In [6]: test_dir = 'data/training_folder/test'
        val_dir = 'data/training_folder/val'
        train_dir = 'data/training_folder/train'
        image_size = tuple(model.input.shape[1:3].as_list()) ###(224,224)
```

```
In [7]: from keras.preprocessing.image import ImageDataGenerator

test_datagen = ImageDataGenerator(preprocessing_function=preprocess_input)
val_datagen = ImageDataGenerator(preprocessing_function=preprocess_input)
train_datagen = ImageDataGenerator(preprocessing_function=preprocess_input)

test_generator = test_datagen.flow_from_directory(
    test_dir,
    target_size=image_size,
    shuffle = False,
    class_mode='categorical',
    batch_size=1)

val_generator = val_datagen.flow_from_directory(
    val_dir,
    target_size=image_size,
    shuffle = False,
    class_mode='categorical',
    batch_size=1)

train_generator = train_datagen.flow_from_directory(
    train_dir,
    target_size=image_size,
    shuffle = False,
    class_mode='categorical',
    batch_size=1)

test_filenames = test_generator.filenames
val_filenames = val_generator.filenames
train_filenames = train_generator.filenames

test_nb_samples = len(test_filenames)
val_nb_samples = len(val_filenames)
train_nb_samples = len(train_filenames)

predict_test = features_model.predict_generator(test_generator, steps=test_nb_samples)
predict_val = features_model.predict_generator(val_generator, steps=val_nb_samples)
predict_train = features_model.predict_generator(train_generator, steps=train_nb_samples)

Found 340 images belonging to 17 classes.
Found 340 images belonging to 17 classes.
Found 680 images belonging to 17 classes.
WARNING:tensorflow:From /home/daryna/anaconda3/envs/ml_ukma/lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:422: The name tf.global_variables is deprecated. Please use tf.compat.v1.global_variables instead.
```

```
In [8]: predict_train.shape
```

```
Out[8]: (680, 2048)
```

Now we'll use classical ML algorithm on extracted features

Let us use only the first two classes

```
In [9]: features_test = predict_test[test_generator.classes <=1]
        features_train = predict_val[val_generator.classes <=1]

        y_test = test_generator.classes[test_generator.classes <=1]
        y_train = val_generator.classes[val_generator.classes <=1]
```

```
In [10]: from sklearn.linear_model import LogisticRegression
```

```
In [11]: clf = LogisticRegression()
```

```
In [12]: clf.fit(features_train, y_train)
```

```
Out[12]: LogisticRegression()
```

```
In [13]: pred = clf.predict(features_test)
```

```
In [14]: from sklearn.metrics import accuracy_score
        accuracy_score(pred, y_test)
```

```
Out[14]: 0.925
```

```
In [ ]:
```

For multiple classes

```
In [15]: from sklearn.neighbors import KNeighborsClassifier
        from sklearn.ensemble import RandomForestClassifier
        from sklearn.neural_network import MLPClassifier
```

```
In [16]: n_neighbors = 20
```

```
In [17]: #clf = KNeighborsClassifier(n_neighbors=n_neighbors)
        #clf = RandomForestClassifier(random_state=42)
        clf = MLPClassifier()
```

```
In [18]: features_test = predict_test
        features_train = predict_train

        y_test = test_generator.classes
        y_train = train_generator.classes
```

```
In [19]: clf.fit(features_train, y_train)
```

```
Out[19]: MLPClassifier()
```

```
In [20]: pred = clf.predict(features_test)
```

```
In [21]: accuracy_score(pred, y_test)
```

```
Out[21]: 0.9029411764705882
```

```
In [ ]:
```