CV_Assignment3

January 1, 2021

[ ]:
```
-!pip install --upgrade --ignore-installed kaggle
```

```
Processing /root/.cache/pip/wheels/3a/d1/7e/6ce09b72b770149802c653a0278382162914
6983ee5a360f10/kaggle-1.5.10-cp36-none-any.whl
Collecting python-dateutil
  Using cached https://files.pythonhosted.org/packages/d4/70/d60450c3dd48ef87586
924207ae8907090de0b306af2bce5d134d78615cb/python_dateutil-2.8.1-py2.py3-none-
any.whl
Collecting urllib3
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d6861b2c017f3d094538c0fb98fa61d4dc43e69b9/urllib3-1.26.2-py2.py3-none-any.whl
Collecting certifi
  Using cached https://files.pythonhosted.org/packages/5e/a0/5f06e1e1d463903cf0c
0eebeb751791119ed7a4b3737fdc9a77f1cdfb51f/certifi-2020.12.5-py2.py3-none-any.whl
Processing /root/.cache/pip/wheels/67/b8/ba/041548f30a6fc058c9b3f79a5b7b6aea925a
15dd1e5c4992a4/python_slugify-4.0.1-py2.py3-none-any.whl
Collecting requests
  Using cached https://files.pythonhosted.org/packages/29/c1/24814557f1d22c56d50
280771a17307e6bf87b70727d975fd6b2ce6b014a/requests-2.25.1-py2.py3-none-any.whl
Collecting six>=1.10
  Using cached https://files.pythonhosted.org/packages/ee/ff/48bde5c0f013094d729
fe4b0316ba2a24774b3ff1c52d924a8a4cb04078a/six-1.15.0-py2.py3-none-any.whl
Collecting tqdm
  Using cached https://files.pythonhosted.org/packages/05/bb/9403e1f30ed060e1683
5c9b275620ca89191a41ccc2b995b88efbc32dfd9/tqdm-4.55.0-py2.py3-none-any.whl
Collecting text-unidecode>=1.3
  Using cached https://files.pythonhosted.org/packages/a6/a5/c0b6468d3824fe3fde3
0dbb5e1f687b291608f9473681bbf7dabbf5a87d7/text_unidecode-1.3-py2.py3-none-
any.whl
Collecting idna<3,>=2.5
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f50de919327bf3a00f091b5baba8dfa9460f3a8a8/idna-2.10-py2.py3-none-any.whl
Collecting chardet<5,>=3.0.2
  Using cached https://files.pythonhosted.org/packages/19/c7/fa589626997dd07bd87
d9269342ccb74b1720384a4d739a1872bd84fbe68/chardet-4.0.0-py2.py3-none-any.whl
ERROR: nbclient 0.5.1 has requirement jupyter-client>=6.1.5, but you'll

have jupyter-client 5.3.5 which is incompatible.
```

```
ERROR: google-colab 1.0.0 has requirement requests~=2.23.0, but you'll have
requests 2.25.1 which is incompatible.
ERROR: datascience 0.10.6 has requirement folium==0.2.1, but you'll have
folium 0.8.3 which is incompatible.
ERROR: albumentations 0.1.12 has requirement imgaug<0.2.7,>=0.2.5, but
you'll have imgaug 0.2.9 which is incompatible.
Installing collected packages: six, python-dateutil, urllib3, certifi, text-
unidecode, python-slugify, idna, chardet, requests, tqdm, kaggle
Successfully installed certifi-2020.12.5 chardet-4.0.0 idna-2.10 kaggle-1.5.10
python-dateutil-2.8.1 python-slugify-4.0.1 requests-2.25.1 six-1.15.0 text-
unidecode-1.3 tqdm-4.55.0 urllib3-1.26.2
```

[ ]:
```
from google.colab import files
files.upload()
```

```
<IPython.core.display.HTML object>


Saving kaggle.json to kaggle (1).json
```

[ ]:
```
{'kaggle.json':
 b'{"username":"abraranwarqureshi","key":"9d5eceb9384d08f498e32d1b2e2b212d"}'}
```

[ ]:
```
!mkdir ~/.kaggle #created at root folder in colab
```

[ ]:
```
#copy
!cp kaggle.json ~/.kaggle
```

[ ]:
```
! chmod 600 ~/.kaggle/kaggle.json
```

[ ]:
```
! kaggle datasets list
```

[ ]:
```
!kaggle datasets download -d puneet6060/intel-image-classification
```

[ ]:
```
!unzip -q intel-image-classification.zip
```

[32]:
```
from google.colab import drive
drive.mount('/content/drive')
path = "/content/drive/My Drive/"
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call
drive.mount("/content/drive", force_remount=True).
```

[4]:
```
from keras.applications.resnet50 import ResNet50
from keras.models import Model
from keras.layers import Dense
```

```
from keras.layers import Flatten
```

[5]:
```
# Select model for classification with weights trained for imagenet
model = ResNet50(weights='imagenet', include_top=False, input_shape=(150, 150,␣
↪3))
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/resnet/resnet50_weights_tf_dim_ordering_tf_kernels_notop.h5
94773248/94765736 [==============================] - 1s 0us/step
```

[6]:
```
# Add custom layers
flat1 = Flatten()(model.layers[-1].output) # flatten last layer
class1 = Dense(1024, activation='relu')(flat1) # add FC layer on previous layer
output = Dense(6, activation='softmax')(class1) # add softmax layer
```

[7]:
```
# Only make new added layers trainable
for layer in model.layers[:-3]:
            layer.trainable = False

for layer in model.layers:
            print(layer, layer.trainable)
```

```
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<tensorflow.python.keras.layers.normalization_v2.BatchNormalization object at
0x7f1e3025ba58> True
<tensorflow.python.keras.layers.merge.Add object at 0x7f1e301a53c8> True
<tensorflow.python.keras.layers.core.Activation object at 0x7f1e3023fbe0> True
```

[8]:
```
# Check model flow
model = Model(inputs=model.inputs, outputs=output)
model.summary()
```

```
Model: "model"
__________________________________________________________________________________
__________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================
==================
input_1 (InputLayer)            [(None, 150, 150, 3) 0
__________________________________________________________________________________
__________________
conv1_pad (ZeroPadding2D)       (None, 156, 156, 3)  0           input_1[0][0]
__________________________________________________________________________________
__________________
conv1_conv (Conv2D)             (None, 75, 75, 64)   9472        conv1_pad[0][0]
__________________________________________________________________________________
__________________
conv1_bn (BatchNormalization)   (None, 75, 75, 64)   256
conv1_conv[0][0]
__________________________________________________________________________________
__________________
conv1_relu (Activation)         (None, 75, 75, 64)   0           conv1_bn[0][0]
__________________________________________________________________________________
__________________
pool1_pad (ZeroPadding2D)       (None, 77, 77, 64)   0
```

```
conv1_relu[0][0]
__________________________________________________________________________________
__________________
pool1_pool (MaxPooling2D)       (None, 38, 38, 64)   0           pool1_pad[0][0]
__________________________________________________________________________________
__________________
conv2_block1_1_conv (Conv2D)    (None, 38, 38, 64)   4160
pool1_pool[0][0]
__________________________________________________________________________________
__________________
conv2_block1_1_bn (BatchNormali (None, 38, 38, 64)   256
conv2_block1_1_conv[0][0]
__________________________________________________________________________________
__________________
conv2_block1_1_relu (Activation (None, 38, 38, 64)   0
conv2_block1_1_bn[0][0]
__________________________________________________________________________________
__________________
conv2_block1_2_conv (Conv2D)    (None, 38, 38, 64)   36928
conv2_block1_1_relu[0][0]
__________________________________________________________________________________
__________________
conv2_block1_2_bn (BatchNormali (None, 38, 38, 64)   256
conv2_block1_2_conv[0][0]
__________________________________________________________________________________
__________________
conv2_block1_2_relu (Activation (None, 38, 38, 64)   0
conv2_block1_2_bn[0][0]
__________________________________________________________________________________
__________________
conv2_block1_0_conv (Conv2D)    (None, 38, 38, 256)  16640
pool1_pool[0][0]
__________________________________________________________________________________
__________________
conv2_block1_3_conv (Conv2D)    (None, 38, 38, 256)  16640
conv2_block1_2_relu[0][0]
__________________________________________________________________________________
__________________
conv2_block1_0_bn (BatchNormali (None, 38, 38, 256)  1024
conv2_block1_0_conv[0][0]
__________________________________________________________________________________
__________________
conv2_block1_3_bn (BatchNormali (None, 38, 38, 256)  1024
conv2_block1_3_conv[0][0]
__________________________________________________________________________________
__________________
conv2_block1_add (Add)          (None, 38, 38, 256)  0
conv2_block1_0_bn[0][0]
```

```
conv2_block1_3_bn[0][0]
__________________________________________________________________________________
__________________
conv2_block1_out (Activation)   (None, 38, 38, 256)  0
conv2_block1_add[0][0]
__________________________________________________________________________________
__________________
conv2_block2_1_conv (Conv2D)    (None, 38, 38, 64)   16448
conv2_block1_out[0][0]
__________________________________________________________________________________
__________________
conv2_block2_1_bn (BatchNormali (None, 38, 38, 64)   256
conv2_block2_1_conv[0][0]
__________________________________________________________________________________
__________________
conv2_block2_1_relu (Activation (None, 38, 38, 64)   0
conv2_block2_1_bn[0][0]
__________________________________________________________________________________
__________________
conv2_block2_2_conv (Conv2D)    (None, 38, 38, 64)   36928
conv2_block2_1_relu[0][0]
__________________________________________________________________________________
__________________
conv2_block2_2_bn (BatchNormali (None, 38, 38, 64)   256
conv2_block2_2_conv[0][0]
__________________________________________________________________________________
__________________
conv2_block2_2_relu (Activation (None, 38, 38, 64)   0
conv2_block2_2_bn[0][0]
__________________________________________________________________________________
__________________
conv2_block2_3_conv (Conv2D)    (None, 38, 38, 256)  16640
conv2_block2_2_relu[0][0]
__________________________________________________________________________________
__________________
conv2_block2_3_bn (BatchNormali (None, 38, 38, 256)  1024
conv2_block2_3_conv[0][0]
__________________________________________________________________________________
__________________
conv2_block2_add (Add)          (None, 38, 38, 256)  0
conv2_block1_out[0][0]
conv2_block2_3_bn[0][0]
__________________________________________________________________________________
__________________
conv2_block2_out (Activation)   (None, 38, 38, 256)  0
conv2_block2_add[0][0]
__________________________________________________________________________________
__________________
```

```
conv2_block3_1_conv (Conv2D)    (None, 38, 38, 64)   16448
conv2_block2_out[0][0]
__________________________________________________________________________________
__________________
conv2_block3_1_bn (BatchNormali (None, 38, 38, 64)   256
conv2_block3_1_conv[0][0]
__________________________________________________________________________________
__________________
conv2_block3_1_relu (Activation (None, 38, 38, 64)   0
conv2_block3_1_bn[0][0]
__________________________________________________________________________________
__________________
conv2_block3_2_conv (Conv2D)    (None, 38, 38, 64)   36928
conv2_block3_1_relu[0][0]
__________________________________________________________________________________
__________________
conv2_block3_2_bn (BatchNormali (None, 38, 38, 64)   256
conv2_block3_2_conv[0][0]
__________________________________________________________________________________
__________________
conv2_block3_2_relu (Activation (None, 38, 38, 64)   0
conv2_block3_2_bn[0][0]
__________________________________________________________________________________
__________________
conv2_block3_3_conv (Conv2D)    (None, 38, 38, 256)  16640
conv2_block3_2_relu[0][0]
__________________________________________________________________________________
__________________
conv2_block3_3_bn (BatchNormali (None, 38, 38, 256)  1024
conv2_block3_3_conv[0][0]
__________________________________________________________________________________
__________________
conv2_block3_add (Add)          (None, 38, 38, 256)  0
conv2_block2_out[0][0]
conv2_block3_3_bn[0][0]
__________________________________________________________________________________
__________________
conv2_block3_out (Activation)   (None, 38, 38, 256)  0
conv2_block3_add[0][0]
__________________________________________________________________________________
__________________
conv3_block1_1_conv (Conv2D)    (None, 19, 19, 128)  32896
conv2_block3_out[0][0]
__________________________________________________________________________________
__________________
conv3_block1_1_bn (BatchNormali (None, 19, 19, 128)  512
conv3_block1_1_conv[0][0]
__________________________________________________________________________________
```

```
------------------
conv3_block1_1_relu (Activation (None, 19, 19, 128)  0
conv3_block1_1_bn[0][0]
------------------------------------------------------------------------------
------------------
conv3_block1_2_conv (Conv2D)    (None, 19, 19, 128)  147584
conv3_block1_1_relu[0][0]
------------------------------------------------------------------------------
------------------
conv3_block1_2_bn (BatchNormali (None, 19, 19, 128)  512
conv3_block1_2_conv[0][0]
------------------------------------------------------------------------------
------------------
conv3_block1_2_relu (Activation (None, 19, 19, 128)  0
conv3_block1_2_bn[0][0]
------------------------------------------------------------------------------
------------------
conv3_block1_0_conv (Conv2D)    (None, 19, 19, 512)  131584
conv2_block3_out[0][0]
------------------------------------------------------------------------------
------------------
conv3_block1_3_conv (Conv2D)    (None, 19, 19, 512)  66048
conv3_block1_2_relu[0][0]
------------------------------------------------------------------------------
------------------
conv3_block1_0_bn (BatchNormali (None, 19, 19, 512)  2048
conv3_block1_0_conv[0][0]
------------------------------------------------------------------------------
------------------
conv3_block1_3_bn (BatchNormali (None, 19, 19, 512)  2048
conv3_block1_3_conv[0][0]
------------------------------------------------------------------------------
------------------
conv3_block1_add (Add)          (None, 19, 19, 512)  0
conv3_block1_0_bn[0][0]
conv3_block1_3_bn[0][0]
------------------------------------------------------------------------------
------------------
conv3_block1_out (Activation)   (None, 19, 19, 512)  0
conv3_block1_add[0][0]
------------------------------------------------------------------------------
------------------
conv3_block2_1_conv (Conv2D)    (None, 19, 19, 128)  65664
conv3_block1_out[0][0]
------------------------------------------------------------------------------
------------------
conv3_block2_1_bn (BatchNormali (None, 19, 19, 128)  512
conv3_block2_1_conv[0][0]
```

```
__________________________________________________________________________________
__________________
conv3_block2_1_relu (Activation (None, 19, 19, 128)  0
conv3_block2_1_bn[0][0]
__________________________________________________________________________________
__________________
conv3_block2_2_conv (Conv2D)    (None, 19, 19, 128)  147584
conv3_block2_1_relu[0][0]
__________________________________________________________________________________
__________________
conv3_block2_2_bn (BatchNormali (None, 19, 19, 128)  512
conv3_block2_2_conv[0][0]
__________________________________________________________________________________
__________________
conv3_block2_2_relu (Activation (None, 19, 19, 128)  0
conv3_block2_2_bn[0][0]
__________________________________________________________________________________
__________________
conv3_block2_3_conv (Conv2D)    (None, 19, 19, 512)  66048
conv3_block2_2_relu[0][0]
__________________________________________________________________________________
__________________
conv3_block2_3_bn (BatchNormali (None, 19, 19, 512)  2048
conv3_block2_3_conv[0][0]
__________________________________________________________________________________
__________________
conv3_block2_add (Add)          (None, 19, 19, 512)  0
conv3_block1_out[0][0]
conv3_block2_3_bn[0][0]
__________________________________________________________________________________
__________________
conv3_block2_out (Activation)   (None, 19, 19, 512)  0
conv3_block2_add[0][0]
__________________________________________________________________________________
__________________
conv3_block3_1_conv (Conv2D)    (None, 19, 19, 128)  65664
conv3_block2_out[0][0]
__________________________________________________________________________________
__________________
conv3_block3_1_bn (BatchNormali (None, 19, 19, 128)  512
conv3_block3_1_conv[0][0]
__________________________________________________________________________________
__________________
conv3_block3_1_relu (Activation (None, 19, 19, 128)  0
conv3_block3_1_bn[0][0]
__________________________________________________________________________________
__________________
conv3_block3_2_conv (Conv2D)    (None, 19, 19, 128)  147584
```

```
conv3_block3_1_relu[0][0]
__________________________________________________________________________________
__________________
conv3_block3_2_bn (BatchNormali (None, 19, 19, 128)  512
conv3_block3_2_conv[0][0]
__________________________________________________________________________________
__________________
conv3_block3_2_relu (Activation (None, 19, 19, 128)  0
conv3_block3_2_bn[0][0]
__________________________________________________________________________________
__________________
conv3_block3_3_conv (Conv2D)    (None, 19, 19, 512)  66048
conv3_block3_2_relu[0][0]
__________________________________________________________________________________
__________________
conv3_block3_3_bn (BatchNormali (None, 19, 19, 512)  2048
conv3_block3_3_conv[0][0]
__________________________________________________________________________________
__________________
conv3_block3_add (Add)          (None, 19, 19, 512)  0
conv3_block2_out[0][0]
conv3_block3_3_bn[0][0]
__________________________________________________________________________________
__________________
conv3_block3_out (Activation)   (None, 19, 19, 512)  0
conv3_block3_add[0][0]
__________________________________________________________________________________
__________________
conv3_block4_1_conv (Conv2D)    (None, 19, 19, 128)  65664
conv3_block3_out[0][0]
__________________________________________________________________________________
__________________
conv3_block4_1_bn (BatchNormali (None, 19, 19, 128)  512
conv3_block4_1_conv[0][0]
__________________________________________________________________________________
__________________
conv3_block4_1_relu (Activation (None, 19, 19, 128)  0
conv3_block4_1_bn[0][0]
__________________________________________________________________________________
__________________
conv3_block4_2_conv (Conv2D)    (None, 19, 19, 128)  147584
conv3_block4_1_relu[0][0]
__________________________________________________________________________________
__________________
conv3_block4_2_bn (BatchNormali (None, 19, 19, 128)  512
conv3_block4_2_conv[0][0]
__________________________________________________________________________________
__________________
```

```
conv3_block4_2_relu (Activation (None, 19, 19, 128)  0
conv3_block4_2_bn[0][0]
__________________________________________________________________________________
__________________
conv3_block4_3_conv (Conv2D)    (None, 19, 19, 512)  66048
conv3_block4_2_relu[0][0]
__________________________________________________________________________________
__________________
conv3_block4_3_bn (BatchNormali (None, 19, 19, 512)  2048
conv3_block4_3_conv[0][0]
__________________________________________________________________________________
__________________
conv3_block4_add (Add)          (None, 19, 19, 512)  0
conv3_block3_out[0][0]
conv3_block4_3_bn[0][0]
__________________________________________________________________________________
__________________
conv3_block4_out (Activation)   (None, 19, 19, 512)  0
conv3_block4_add[0][0]
__________________________________________________________________________________
__________________
conv4_block1_1_conv (Conv2D)    (None, 10, 10, 256)  131328
conv3_block4_out[0][0]
__________________________________________________________________________________
__________________
conv4_block1_1_bn (BatchNormali (None, 10, 10, 256)  1024
conv4_block1_1_conv[0][0]
__________________________________________________________________________________
__________________
conv4_block1_1_relu (Activation (None, 10, 10, 256)  0
conv4_block1_1_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block1_2_conv (Conv2D)    (None, 10, 10, 256)  590080
conv4_block1_1_relu[0][0]
__________________________________________________________________________________
__________________
conv4_block1_2_bn (BatchNormali (None, 10, 10, 256)  1024
conv4_block1_2_conv[0][0]
__________________________________________________________________________________
__________________
conv4_block1_2_relu (Activation (None, 10, 10, 256)  0
conv4_block1_2_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block1_0_conv (Conv2D)    (None, 10, 10, 1024) 525312
conv3_block4_out[0][0]
__________________________________________________________________________________
```

```
__________________
conv4_block1_3_conv (Conv2D)    (None, 10, 10, 1024) 263168
conv4_block1_2_relu[0][0]
__________________________________________________________________________________
__________________
conv4_block1_0_bn (BatchNormali (None, 10, 10, 1024) 4096
conv4_block1_0_conv[0][0]
__________________________________________________________________________________
__________________
conv4_block1_3_bn (BatchNormali (None, 10, 10, 1024) 4096
conv4_block1_3_conv[0][0]
__________________________________________________________________________________
__________________
conv4_block1_add (Add)          (None, 10, 10, 1024) 0
conv4_block1_0_bn[0][0]
conv4_block1_3_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block1_out (Activation)   (None, 10, 10, 1024) 0
conv4_block1_add[0][0]
__________________________________________________________________________________
__________________
conv4_block2_1_conv (Conv2D)    (None, 10, 10, 256)  262400
conv4_block1_out[0][0]
__________________________________________________________________________________
__________________
conv4_block2_1_bn (BatchNormali (None, 10, 10, 256)  1024
conv4_block2_1_conv[0][0]
__________________________________________________________________________________
__________________
conv4_block2_1_relu (Activation (None, 10, 10, 256)  0
conv4_block2_1_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block2_2_conv (Conv2D)    (None, 10, 10, 256)  590080
conv4_block2_1_relu[0][0]
__________________________________________________________________________________
__________________
conv4_block2_2_bn (BatchNormali (None, 10, 10, 256)  1024
conv4_block2_2_conv[0][0]
__________________________________________________________________________________
__________________
conv4_block2_2_relu (Activation (None, 10, 10, 256)  0
conv4_block2_2_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block2_3_conv (Conv2D)    (None, 10, 10, 1024) 263168
conv4_block2_2_relu[0][0]
```

```
__________________________________________________________________________
__________________
conv4_block2_3_bn (BatchNormali (None, 10, 10, 1024) 4096
conv4_block2_3_conv[0][0]
__________________________________________________________________________
__________________
conv4_block2_add (Add)          (None, 10, 10, 1024) 0
conv4_block1_out[0][0]
conv4_block2_3_bn[0][0]
__________________________________________________________________________
__________________
conv4_block2_out (Activation)   (None, 10, 10, 1024) 0
conv4_block2_add[0][0]
__________________________________________________________________________
__________________
conv4_block3_1_conv (Conv2D)    (None, 10, 10, 256)  262400
conv4_block2_out[0][0]
__________________________________________________________________________
__________________
conv4_block3_1_bn (BatchNormali (None, 10, 10, 256)  1024
conv4_block3_1_conv[0][0]
__________________________________________________________________________
__________________
conv4_block3_1_relu (Activation (None, 10, 10, 256)  0
conv4_block3_1_bn[0][0]
__________________________________________________________________________
__________________
conv4_block3_2_conv (Conv2D)    (None, 10, 10, 256)  590080
conv4_block3_1_relu[0][0]
__________________________________________________________________________
__________________
conv4_block3_2_bn (BatchNormali (None, 10, 10, 256)  1024
conv4_block3_2_conv[0][0]
__________________________________________________________________________
__________________
conv4_block3_2_relu (Activation (None, 10, 10, 256)  0
conv4_block3_2_bn[0][0]
__________________________________________________________________________
__________________
conv4_block3_3_conv (Conv2D)    (None, 10, 10, 1024) 263168
conv4_block3_2_relu[0][0]
__________________________________________________________________________
__________________
conv4_block3_3_bn (BatchNormali (None, 10, 10, 1024) 4096
conv4_block3_3_conv[0][0]
__________________________________________________________________________
__________________
conv4_block3_add (Add)          (None, 10, 10, 1024) 0
```

```
conv4_block2_out[0][0]
conv4_block3_3_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block3_out (Activation)   (None, 10, 10, 1024) 0
conv4_block3_add[0][0]
__________________________________________________________________________________
__________________
conv4_block4_1_conv (Conv2D)    (None, 10, 10, 256)  262400
conv4_block3_out[0][0]
__________________________________________________________________________________
__________________
conv4_block4_1_bn (BatchNormali (None, 10, 10, 256)  1024
conv4_block4_1_conv[0][0]
__________________________________________________________________________________
__________________
conv4_block4_1_relu (Activation (None, 10, 10, 256)  0
conv4_block4_1_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block4_2_conv (Conv2D)    (None, 10, 10, 256)  590080
conv4_block4_1_relu[0][0]
__________________________________________________________________________________
__________________
conv4_block4_2_bn (BatchNormali (None, 10, 10, 256)  1024
conv4_block4_2_conv[0][0]
__________________________________________________________________________________
__________________
conv4_block4_2_relu (Activation (None, 10, 10, 256)  0
conv4_block4_2_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block4_3_conv (Conv2D)    (None, 10, 10, 1024) 263168
conv4_block4_2_relu[0][0]
__________________________________________________________________________________
__________________
conv4_block4_3_bn (BatchNormali (None, 10, 10, 1024) 4096
conv4_block4_3_conv[0][0]
__________________________________________________________________________________
__________________
conv4_block4_add (Add)          (None, 10, 10, 1024) 0
conv4_block3_out[0][0]
conv4_block4_3_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block4_out (Activation)   (None, 10, 10, 1024) 0
conv4_block4_add[0][0]
__________________________________________________________________________________
```

```
__________________
conv4_block5_1_conv (Conv2D)    (None, 10, 10, 256)  262400
conv4_block4_out[0][0]
__________________________________________________________________________________
__________________
conv4_block5_1_bn (BatchNormali (None, 10, 10, 256)  1024
conv4_block5_1_conv[0][0]
__________________________________________________________________________________
__________________
conv4_block5_1_relu (Activation (None, 10, 10, 256)  0
conv4_block5_1_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block5_2_conv (Conv2D)    (None, 10, 10, 256)  590080
conv4_block5_1_relu[0][0]
__________________________________________________________________________________
__________________
conv4_block5_2_bn (BatchNormali (None, 10, 10, 256)  1024
conv4_block5_2_conv[0][0]
__________________________________________________________________________________
__________________
conv4_block5_2_relu (Activation (None, 10, 10, 256)  0
conv4_block5_2_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block5_3_conv (Conv2D)    (None, 10, 10, 1024) 263168
conv4_block5_2_relu[0][0]
__________________________________________________________________________________
__________________
conv4_block5_3_bn (BatchNormali (None, 10, 10, 1024) 4096
conv4_block5_3_conv[0][0]
__________________________________________________________________________________
__________________
conv4_block5_add (Add)          (None, 10, 10, 1024) 0
conv4_block4_out[0][0]
conv4_block5_3_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block5_out (Activation)   (None, 10, 10, 1024) 0
conv4_block5_add[0][0]
__________________________________________________________________________________
__________________
conv4_block6_1_conv (Conv2D)    (None, 10, 10, 256)  262400
conv4_block5_out[0][0]
__________________________________________________________________________________
__________________
conv4_block6_1_bn (BatchNormali (None, 10, 10, 256)  1024
conv4_block6_1_conv[0][0]
```

```
__________________________________________________________________________________
__________________
conv4_block6_1_relu (Activation (None, 10, 10, 256)  0
conv4_block6_1_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block6_2_conv (Conv2D)    (None, 10, 10, 256)  590080
conv4_block6_1_relu[0][0]
__________________________________________________________________________________
__________________
conv4_block6_2_bn (BatchNormali (None, 10, 10, 256)  1024
conv4_block6_2_conv[0][0]
__________________________________________________________________________________
__________________
conv4_block6_2_relu (Activation (None, 10, 10, 256)  0
conv4_block6_2_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block6_3_conv (Conv2D)    (None, 10, 10, 1024) 263168
conv4_block6_2_relu[0][0]
__________________________________________________________________________________
__________________
conv4_block6_3_bn (BatchNormali (None, 10, 10, 1024) 4096
conv4_block6_3_conv[0][0]
__________________________________________________________________________________
__________________
conv4_block6_add (Add)          (None, 10, 10, 1024) 0
conv4_block5_out[0][0]
conv4_block6_3_bn[0][0]
__________________________________________________________________________________
__________________
conv4_block6_out (Activation)   (None, 10, 10, 1024) 0
conv4_block6_add[0][0]
__________________________________________________________________________________
__________________
conv5_block1_1_conv (Conv2D)    (None, 5, 5, 512)    524800
conv4_block6_out[0][0]
__________________________________________________________________________________
__________________
conv5_block1_1_bn (BatchNormali (None, 5, 5, 512)    2048
conv5_block1_1_conv[0][0]
__________________________________________________________________________________
__________________
conv5_block1_1_relu (Activation (None, 5, 5, 512)    0
conv5_block1_1_bn[0][0]
__________________________________________________________________________________
__________________
conv5_block1_2_conv (Conv2D)    (None, 5, 5, 512)    2359808
```

```
conv5_block1_1_relu[0][0]
__________________________________________________________________________________
__________________
conv5_block1_2_bn (BatchNormali (None, 5, 5, 512)    2048
conv5_block1_2_conv[0][0]
__________________________________________________________________________________
__________________
conv5_block1_2_relu (Activation (None, 5, 5, 512)    0
conv5_block1_2_bn[0][0]
__________________________________________________________________________________
__________________
conv5_block1_0_conv (Conv2D)    (None, 5, 5, 2048)   2099200
conv4_block6_out[0][0]
__________________________________________________________________________________
__________________
conv5_block1_3_conv (Conv2D)    (None, 5, 5, 2048)   1050624
conv5_block1_2_relu[0][0]
__________________________________________________________________________________
__________________
conv5_block1_0_bn (BatchNormali (None, 5, 5, 2048)   8192
conv5_block1_0_conv[0][0]
__________________________________________________________________________________
__________________
conv5_block1_3_bn (BatchNormali (None, 5, 5, 2048)   8192
conv5_block1_3_conv[0][0]
__________________________________________________________________________________
__________________
conv5_block1_add (Add)          (None, 5, 5, 2048)   0
conv5_block1_0_bn[0][0]
conv5_block1_3_bn[0][0]
__________________________________________________________________________________
__________________
conv5_block1_out (Activation)   (None, 5, 5, 2048)   0
conv5_block1_add[0][0]
__________________________________________________________________________________
__________________
conv5_block2_1_conv (Conv2D)    (None, 5, 5, 512)    1049088
conv5_block1_out[0][0]
__________________________________________________________________________________
__________________
conv5_block2_1_bn (BatchNormali (None, 5, 5, 512)    2048
conv5_block2_1_conv[0][0]
__________________________________________________________________________________
__________________
conv5_block2_1_relu (Activation (None, 5, 5, 512)    0
conv5_block2_1_bn[0][0]
__________________________________________________________________________________
__________________
```

```
conv5_block2_2_conv (Conv2D)    (None, 5, 5, 512)    2359808
conv5_block2_1_relu[0][0]
__________________________________________________________________________________
__________________
conv5_block2_2_bn (BatchNormali (None, 5, 5, 512)    2048
conv5_block2_2_conv[0][0]
__________________________________________________________________________________
__________________
conv5_block2_2_relu (Activation (None, 5, 5, 512)    0
conv5_block2_2_bn[0][0]
__________________________________________________________________________________
__________________
conv5_block2_3_conv (Conv2D)    (None, 5, 5, 2048)   1050624
conv5_block2_2_relu[0][0]
__________________________________________________________________________________
__________________
conv5_block2_3_bn (BatchNormali (None, 5, 5, 2048)   8192
conv5_block2_3_conv[0][0]
__________________________________________________________________________________
__________________
conv5_block2_add (Add)          (None, 5, 5, 2048)   0
conv5_block1_out[0][0]
conv5_block2_3_bn[0][0]
__________________________________________________________________________________
__________________
conv5_block2_out (Activation)   (None, 5, 5, 2048)   0
conv5_block2_add[0][0]
__________________________________________________________________________________
__________________
conv5_block3_1_conv (Conv2D)    (None, 5, 5, 512)    1049088
conv5_block2_out[0][0]
__________________________________________________________________________________
__________________
conv5_block3_1_bn (BatchNormali (None, 5, 5, 512)    2048
conv5_block3_1_conv[0][0]
__________________________________________________________________________________
__________________
conv5_block3_1_relu (Activation (None, 5, 5, 512)    0
conv5_block3_1_bn[0][0]
__________________________________________________________________________________
__________________
conv5_block3_2_conv (Conv2D)    (None, 5, 5, 512)    2359808
conv5_block3_1_relu[0][0]
__________________________________________________________________________________
__________________
conv5_block3_2_bn (BatchNormali (None, 5, 5, 512)    2048
conv5_block3_2_conv[0][0]
__________________________________________________________________________________
```

```
------------------
conv5_block3_2_relu (Activation (None, 5, 5, 512)    0
conv5_block3_2_bn[0][0]
------------------------------------------------------------------------------------
------------------
conv5_block3_3_conv (Conv2D)    (None, 5, 5, 2048)   1050624
conv5_block3_2_relu[0][0]
------------------------------------------------------------------------------------
------------------
conv5_block3_3_bn (BatchNormali (None, 5, 5, 2048)   8192
conv5_block3_3_conv[0][0]
------------------------------------------------------------------------------------
------------------
conv5_block3_add (Add)          (None, 5, 5, 2048)   0
conv5_block2_out[0][0]
conv5_block3_3_bn[0][0]
------------------------------------------------------------------------------------
------------------
conv5_block3_out (Activation)   (None, 5, 5, 2048)   0
conv5_block3_add[0][0]
------------------------------------------------------------------------------------
------------------
flatten (Flatten)               (None, 51200)        0
conv5_block3_out[0][0]
------------------------------------------------------------------------------------
------------------
dense (Dense)                   (None, 1024)         52429824    flatten[0][0]
------------------------------------------------------------------------------------
------------------
dense_1 (Dense)                 (None, 6)            6150        dense[0][0]
====================================================================================
==================
Total params: 76,023,686
Trainable params: 52,440,070
Non-trainable params: 23,583,616
------------------------------------------------------------------------------------
------------------
```

[9]:
```
import os
import cv2
import numpy as np
from imutils import paths
import matplotlib.pyplot as plt
```

[27]:
```
# Set dataset paths
train_dir = path + "intel-image-classification/seg_train/seg_train/"
test_dir = path + "intel-image-classification/seg_test/seg_test/"
```

```
pred_dir = path + "test-data/seg_pred/seg_pred/"
vis_dir = path + "predict/"
```

[22]:
```
# Create dataset batches for model with image augmentation
from tensorflow.keras.preprocessing.image import ImageDataGenerator

train_datagen = ImageDataGenerator(
    rotation_range=90,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True,)

val_datagen = ImageDataGenerator()

train_generator = train_datagen.flow_from_directory(
        train_dir,  # This is the source directory for training images
        target_size=(150, 150),  # All images will be resized to 150x150
        batch_size=64,
        seed=1)

validation_generator = val_datagen.flow_from_directory(
        test_dir,
        shuffle=False,
        target_size=(150, 150),
        batch_size=64,
        seed=1)

pred_datagen = ImageDataGenerator()

prediction_generator = pred_datagen.flow_from_directory(
        pred_dir,
        shuffle=False,
        target_size=(150, 150),
        batch_size=64,
        seed=1)
```

```
Found 14034 images belonging to 6 classes.
Found 3000 images belonging to 6 classes.
Found 7301 images belonging to 6 classes.
```

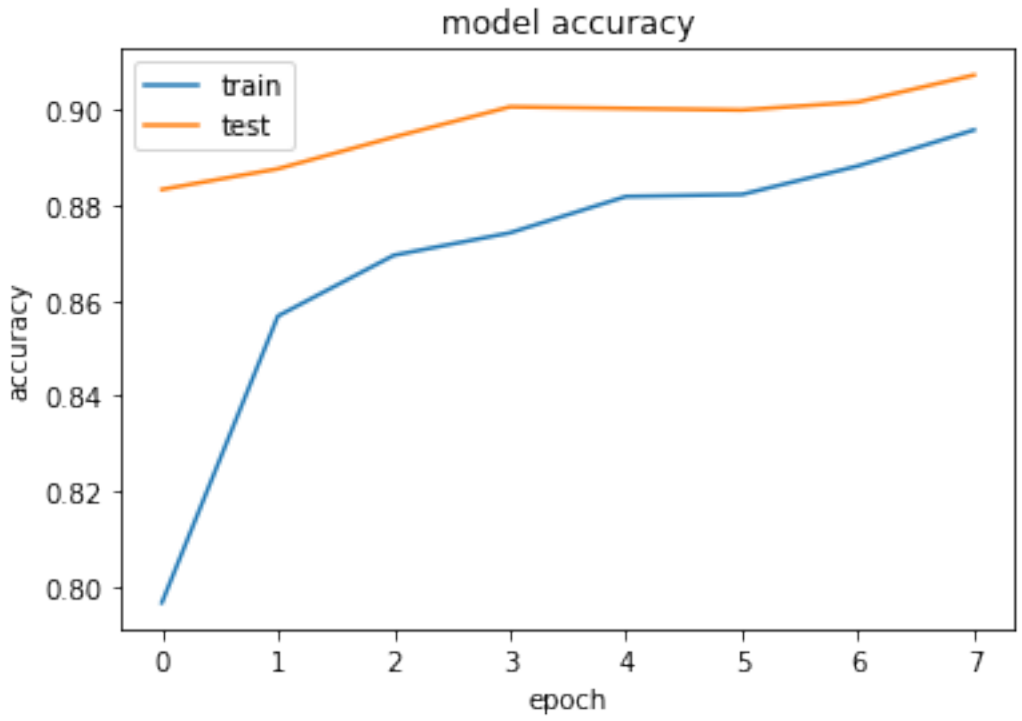
[12]:
```
# Compile model
from keras.optimizers import SGD
sgd = SGD(lr=0.001, decay=1e-7, momentum=.9)
model.compile(loss='categorical_crossentropy', optimizer=sgd,␣
 ↪metrics=['accuracy'])
```

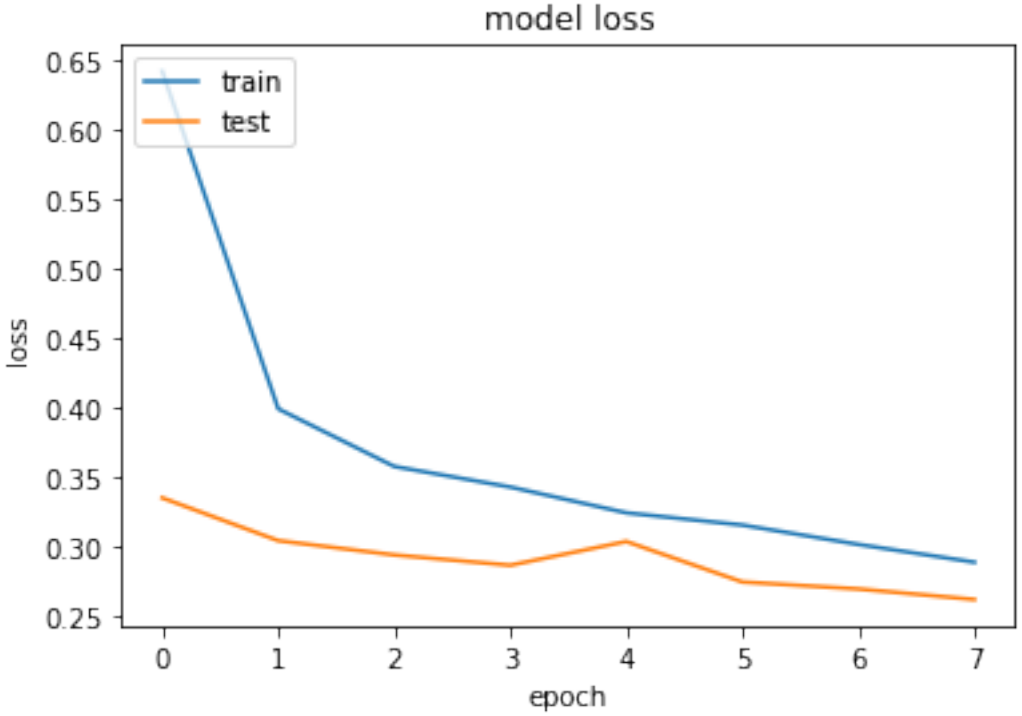
[13]:
```
# Train model
H = model.fit(
      train_generator,
      epochs=8,
      validation_data=validation_generator,
      verbose=1)
```

```
Epoch 1/8
220/220 [==============================] - 3247s 15s/step - loss: 0.9887 -
accuracy: 0.7256 - val_loss: 0.3352 - val_accuracy: 0.8833
Epoch 2/8
220/220 [==============================] - 99s 448ms/step - loss: 0.4128 -
accuracy: 0.8518 - val_loss: 0.3044 - val_accuracy: 0.8877
Epoch 3/8
220/220 [==============================] - 98s 444ms/step - loss: 0.3499 -
accuracy: 0.8708 - val_loss: 0.2942 - val_accuracy: 0.8943
Epoch 4/8
220/220 [==============================] - 98s 446ms/step - loss: 0.3389 -
accuracy: 0.8751 - val_loss: 0.2868 - val_accuracy: 0.9007
Epoch 5/8
220/220 [==============================] - 98s 444ms/step - loss: 0.3322 -
accuracy: 0.8780 - val_loss: 0.3038 - val_accuracy: 0.9003
Epoch 6/8
220/220 [==============================] - 98s 446ms/step - loss: 0.3161 -
accuracy: 0.8831 - val_loss: 0.2748 - val_accuracy: 0.9000
Epoch 7/8
220/220 [==============================] - 98s 446ms/step - loss: 0.3040 -
accuracy: 0.8891 - val_loss: 0.2698 - val_accuracy: 0.9017
Epoch 8/8
220/220 [==============================] - 98s 444ms/step - loss: 0.2989 -
accuracy: 0.8929 - val_loss: 0.2622 - val_accuracy: 0.9073
```

[14]:
```
# summarize history for accuracy
plt.plot(H.history['accuracy'])
plt.plot(H.history['val_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
# summarize history for loss
plt.plot(H.history['loss'])
plt.plot(H.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
```

```
plt.show()
```


model accuracy
train
test
accuracy
0.90
0.88
0.86
0.84
0.82
0.80
0
1
2
3
4
5
6
7
epoch


model loss
train
test
loss
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0
1
2
3
4
5
6
7
epoch

[41]:
```
# save the model's trained weights
model.save_weights(path + 'resnet_transfer_trained_wts.h5')
```

[15]:
```
# load the model's trained weights
model.load_weights(path + 'resnet_transfer_trained_wts.h5')
```

[23]:
```
# evaluate the model on a test dataset
results = model.evaluate(prediction_generator, batch_size=64, verbose=1)
print("test loss, test acc:", results)
```

```
115/115 [==============================] - 16s 138ms/step - loss: 0.3649 -
accuracy: 0.8821
test loss, test acc: [0.3648953139781952, 0.8820709586143494]
```

[24]:
```
# model prediction
prediction = model.predict(prediction_generator, batch_size=64, verbose=1)
```

```
115/115 [==============================] - 15s 134ms/step
```

[38]:
```
# Confusion Matrix
from sklearn.metrics import classification_report, confusion_matrix
pred = np.argmax(prediction, axis=1)
print('Confusion Matrix:')
print(confusion_matrix(prediction_generator.classes, pred))
```

```
Confusion Matrix:
[[1006    4    7    2   12  113]
 [   3 1144    3    7    4    5]
 [   3    7 1020  242   53    5]
 [   5    7   73 1140   70    2]
 [  11    7   35   73  993    9]
 [  67   10    9    4    9 1137]]
```

[39]:
```
# Classification Report
print('Classification Report:')
target_names = ['Buildings', 'Forest', 'Glacier', 'Mountain', 'Sea', 'Street']
print(classification_report(prediction_generator.classes, pred,␣
 ↪target_names=target_names))
```

```
Classification Report:
              precision    recall  f1-score   support

   Buildings       0.92      0.88      0.90      1144
      Forest       0.97      0.98      0.98      1166
     Glacier       0.89      0.77      0.82      1330
    Mountain       0.78      0.88      0.82      1297
```

```
          Sea       0.87      0.88      0.88      1128
       Street       0.89      0.92      0.91      1236

     accuracy                           0.88      7301
    macro avg       0.89      0.88      0.88      7301
 weighted avg       0.88      0.88      0.88      7301
```

[43]:
```
# Visual Results
vis_datagen = ImageDataGenerator()

vis_generator = vis_datagen.flow_from_directory(
        vis_dir,
        shuffle=False,
        target_size=(150, 150),  # All images will be resized to 150x150
        batch_size=1,
        seed=1)

visual = model.predict(vis_generator, batch_size=1, verbose=1)
vis = np.argmax(visual, axis=1)
print('Confusion Matrix:')
print(confusion_matrix(vis_generator.classes, vis))
```

```
Found 6 images belonging to 6 classes.
6/6 [==============================] - 0s 17ms/step
Confusion Matrix:
[[1 0 0 0 0 0]
 [0 1 0 0 0 0]
 [0 0 1 0 0 0]
 [0 0 0 1 0 0]
 [0 0 0 1 0 0]
 [0 0 0 0 0 1]]
```