ProjectCode_AIE19012

December 5, 2020

Project - Python for Machine Learning

Retinal Defect Classification using CNN from OCT images

Import Modules

[1]:
```
# Importing required Libraries
import os
import numpy as np
import pandas as pd
import random
import tensorflow as tf
from tensorflow.keras.preprocessing.image import ImageDataGenerator, load_img
import matplotlib.pyplot as plt
```

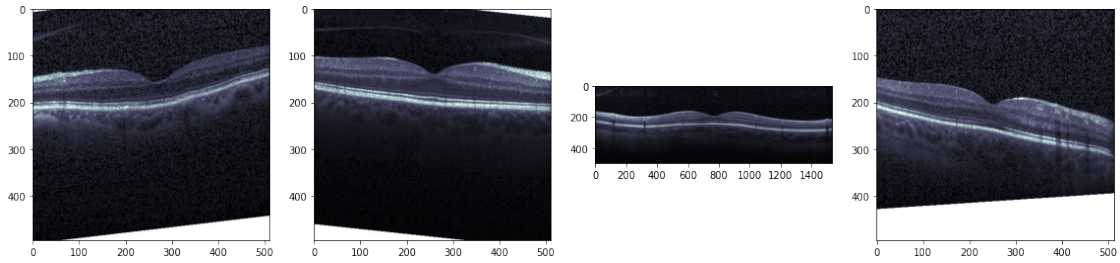
Setting the path and Loading the Data

[2]:
```
# Setting the path
path = 'C:/Users/Acer/Documents/Python Scripts/Machine Learning/Project/'

# Loading the Training Data
train_path = os.path.join(path,'train/')
train_normal_pth = os.path.join(train_path, 'NORMAL')
train_dme_pth = os.path.join(train_path, 'DME')
train_drusen_pth = os.path.join(train_path, 'DRUSEN')
train_cnv_pth = os.path.join(train_path, 'CNV')

# Loading the Testing Data
test_path = os.path.join(path, 'test/')
test_normal_pth = os.path.join(test_path, 'NORMAL')
test_dme_pth = os.path.join(test_path, 'DME')
test_drusen_pth = os.path.join(test_path, 'DRUSEN')
test_cnv_pth = os.path.join(test_path, 'CNV')

# Loading the Validating Data
val_path = os.path.join(path, 'val/')
val_normal_pth = os.path.join(val_path, 'NORMAL')
val_dme_pth = os.path.join(val_path, 'DME')
val_drusen_pth = os.path.join(val_path, 'DRUSEN')
val_cnv_pth = os.path.join(val_path, 'CNV')
```

Verification of Data by displaying the Data

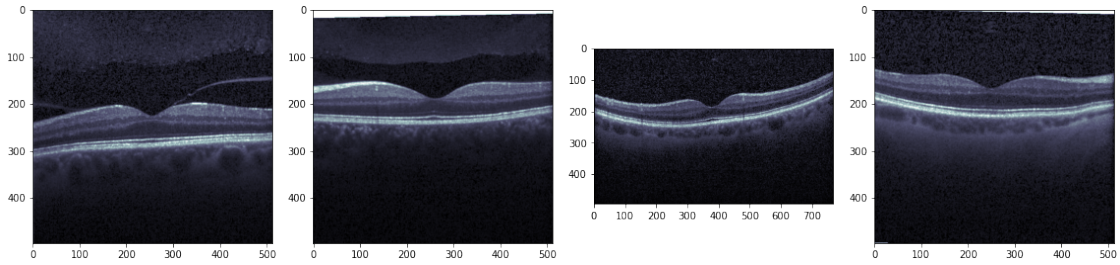
[3]:
```
# Function to display the loaded data
def plot_imgs(item_dir, num_imgs=4):
    all_item_dirs = os.listdir(item_dir)
    item_files = [os.path.join(item_dir, file) for file in all_item_dirs][:
 ↪num_imgs]

    plt.figure(figsize=(16, 16))
    for idx, img_path in enumerate(item_files):
        plt.subplot(1, 4, idx+1)

        img = plt.imread(img_path)
        plt.imshow(img, cmap='bone')

    plt.tight_layout()
```

[4]:
```
plot_imgs(train_normal_pth)
```



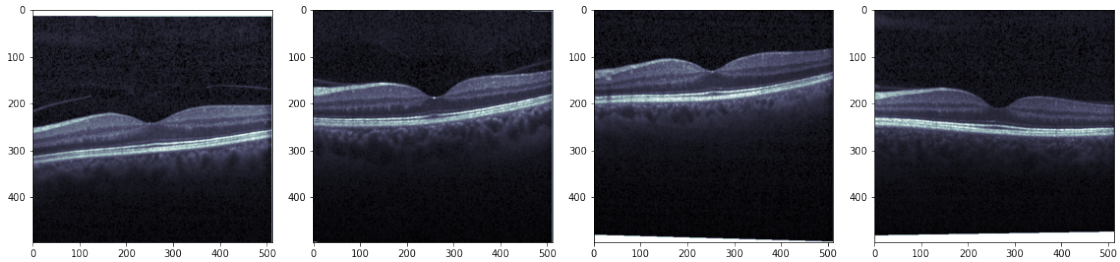
Data from Normal Catergory in Training Set

[5]:
```
plot_imgs(test_normal_pth)
```



Data from Normal Catergory in Test Set

[6]:
```
plot_imgs(val_normal_pth)
```



Data from Normal Catergory in Validation Set

Taking the details of Data

[7]:
```
# Function to take the dimensions of images
import glob
from PIL import Image
def Images_details_Print_data(data, path):
    print("Image path : ", path)
    for k, v in data.items():
        print("%s:\t%s" % (k, v))

def Images_details(path):
    files = [f for f in glob.glob(path + "**/*.*", recursive=True)]
    data = {}
    data['images_count'] = len(files)
    data['min_width'] = 10**100
    data['max_width'] = 0
    data['min_height'] = 10**100
    data['max_height'] = 0

    for f in files:
        im = Image.open(f)
        width, height = im.size
        data['min_width'] = min(width, data['min_width'])
        data['min_height'] = min(height, data['min_height'])
        data['max_width'] = max(width, data['max_height'])
        data['max_height'] = max(height, data['max_height'])

    Images_details_Print_data(data, path)
```

[8]:
```
Images_details(train_normal_pth)
Images_details(train_dme_pth)
Images_details(train_drusen_pth)
Images_details(train_cnv_pth)
```

```
Image path :  C:/Users/Acer/Documents/Python Scripts/Machine
Learning/Project/train/NORMAL
```

```
images_count:   26315
min_width:      384
max_width:      512
min_height:     496
max_height:     512
Image path :  C:/Users/Acer/Documents/Python Scripts/Machine
Learning/Project/train/DME
images_count:   11348
min_width:      512
max_width:      512
min_height:     496
max_height:     512
Image path :  C:/Users/Acer/Documents/Python Scripts/Machine
Learning/Project/train/DRUSEN
images_count:   8616
min_width:      512
max_width:      768
min_height:     496
max_height:     496
Image path :  C:/Users/Acer/Documents/Python Scripts/Machine
Learning/Project/train/CNV
images_count:   37205
min_width:      384
max_width:      1536
min_height:     496
max_height:     496
```

Details from Training Set

[9]:
```
Images_details(test_normal_pth)
Images_details(test_dme_pth)
Images_details(test_drusen_pth)
Images_details(test_cnv_pth)
```

```
Image path :  C:/Users/Acer/Documents/Python Scripts/Machine
Learning/Project/test/NORMAL
images_count:   242
min_width:      512
max_width:      512
min_height:     496
max_height:     496
Image path :  C:/Users/Acer/Documents/Python Scripts/Machine
Learning/Project/test/DME
images_count:   242
min_width:      512
max_width:      768
min_height:     496
max_height:     496
Image path :  C:/Users/Acer/Documents/Python Scripts/Machine
```

```
Learning/Project/test/DRUSEN
images_count:   242
min_width:      512
max_width:      512
min_height:     496
max_height:     496
Image path :  C:/Users/Acer/Documents/Python Scripts/Machine
Learning/Project/test/CNV
images_count:   242
min_width:      512
max_width:      512
min_height:     496
max_height:     496
```

Details from Testing Set

[10]:
```
Images_details(val_normal_pth)
Images_details(val_dme_pth)
Images_details(val_drusen_pth)
Images_details(val_cnv_pth)
```

```
Image path :  C:/Users/Acer/Documents/Python Scripts/Machine
Learning/Project/val/NORMAL
images_count:   8
min_width:      512
max_width:      512
min_height:     496
max_height:     496
Image path :  C:/Users/Acer/Documents/Python Scripts/Machine
Learning/Project/val/DME
images_count:   8
min_width:      512
max_width:      768
min_height:     496
max_height:     496
Image path :  C:/Users/Acer/Documents/Python Scripts/Machine
Learning/Project/val/DRUSEN
images_count:   8
min_width:      512
max_width:      512
min_height:     496
max_height:     496
Image path :  C:/Users/Acer/Documents/Python Scripts/Machine
Learning/Project/val/CNV
images_count:   8
min_width:      512
max_width:      768
min_height:     496
max_height:     496
```

Details from Validation Set

[11]:
```
in_path = 'C:/Users/Acer/Documents/Python Scripts/Machine Learning/Project/'

for _set in ['train', 'test', 'val']:
    normal = len(os.listdir(in_path + _set + '/NORMAL'))
    dme = len(os.listdir(in_path + _set + '/DME'))
    drusen = len(os.listdir(in_path + _set + '/DRUSEN'))
    cnv = len(os.listdir(in_path + _set + '/CNV'))
    print('{}, Normal images: {}, DME images: {}, DRUSEN images: {}, CNV images:
 ↪ {}'.format(_set, normal, dme, drusen, cnv))
```

```
train, Normal images: 26315, DME images: 11348, DRUSEN images: 8616, CNV images:
37205
test, Normal images: 242, DME images: 243, DRUSEN images: 243, CNV images: 243
val, Normal images: 8, DME images: 9, DRUSEN images: 9, CNV images: 9
```

[12]:
```
datadir = in_path
traindir = datadir + 'train/'
validdir = datadir + 'val/'
testdir = datadir + 'test/'
```

[13]:
```
# Function to summarise the details of Dataset into a Dataframe
categories = []
img_categories = []
n_train = []
n_valid = []
n_test = []
hs = []
ws = []

for d in os.listdir(traindir):
    categories.append(d)

    train_imgs = os.listdir(traindir + d)
    valid_imgs = os.listdir(validdir + d)
    test_imgs = os.listdir(testdir + d)
    n_train.append(len(train_imgs))
    n_valid.append(len(valid_imgs))
    n_test.append(len(test_imgs))

    for i in train_imgs:
        img_categories.append(d)
        img = Image.open(traindir + d + '/' + i)
        img_array = np.array(img)
        hs.append(img_array.shape[0])
        ws.append(img_array.shape[1])
```

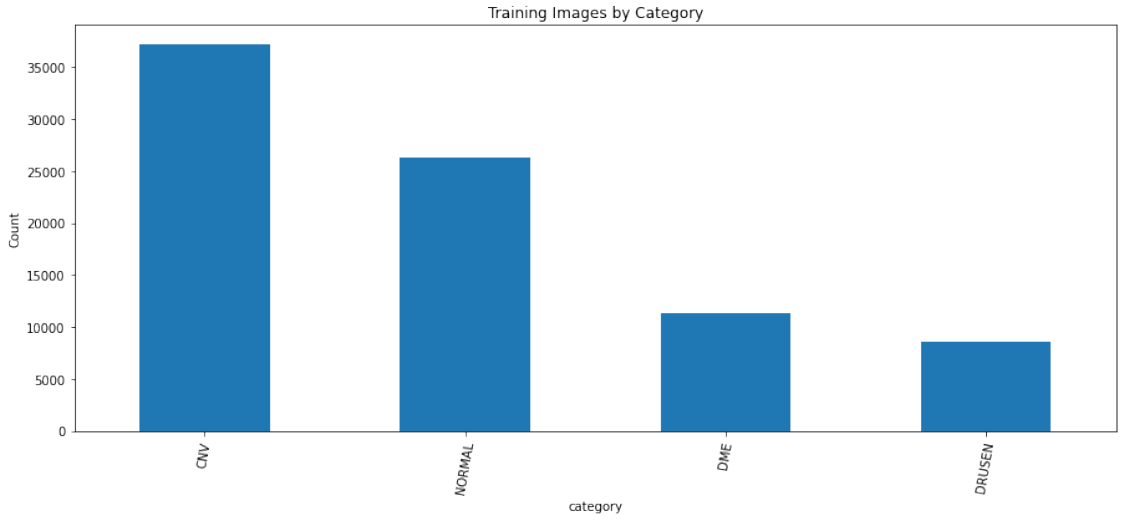
```
cat_df = pd.DataFrame({'category': categories,'n_train': n_train,'n_valid':␣
↪n_valid, 'n_test': n_test}).sort_values('category')
image_df = pd.DataFrame({'category': img_categories,'height': hs,'width': ws})
cat_df.sort_values('n_train', ascending=False, inplace=True)
cat_df.head()
```

[13]:

	category	n_train	n_valid	n_test
0	CNV	37205	9	243
3	NORMAL	26315	8	242
1	DME	11348	9	243
2	DRUSEN	8616	9	243

Statistics of Dataset

[14]:
```
cat_df.set_index('category')['n_train'].plot.bar(figsize=(15, 6))
plt.xticks(rotation=80)
plt.ylabel('Count')
plt.title('Training Images by Category')
plt.show()
```



[15]:
```
img_dsc = image_df.groupby('category').describe()
img_dsc.head()
```

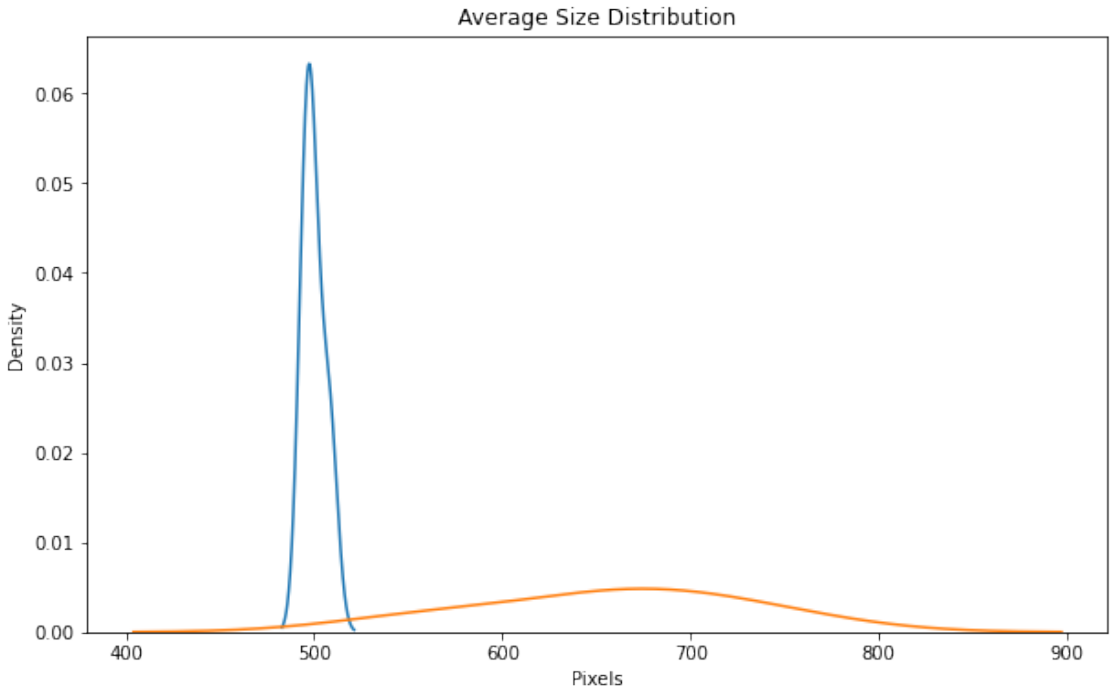
[15]:

	height							
	count	mean	std	min	25%	50%	75%	max
category								
CNV	37205.0	496.000000	0.000000	496.0	496.0	496.0	496.0	496.0
DME	11348.0	508.208671	6.803761	496.0	512.0	512.0	512.0	512.0
DRUSEN	8616.0	496.000000	0.000000	496.0	496.0	496.0	496.0	496.0
NORMAL	26315.0	500.132700	7.003275	496.0	496.0	496.0	512.0	512.0

	width							
	count	mean	std	min	25%	50%	75%	max
category								
CNV	37205.0	736.372423	338.497157	384.0	512.0	512.0	768.0	1536.0
DME	11348.0	564.788157	191.861512	512.0	512.0	512.0	512.0	1536.0
DRUSEN	8616.0	670.692665	280.842588	512.0	512.0	512.0	768.0	1536.0
NORMAL	26315.0	659.670606	288.606761	384.0	512.0	512.0	768.0	1536.0

[16]:
```
import seaborn as sns
plt.figure(figsize=(10, 6))
sns.kdeplot(img_dsc['height']['mean'], label='Average Height')
sns.kdeplot(img_dsc['width']['mean'], label='Average Width')
plt.xlabel('Pixels')
plt.ylabel('Density')
plt.title('Average Size Distribution')
```

[16]:
```
Text(0.5, 1.0, 'Average Size Distribution')
```



Building a CNN Model

[17]:
```
# Importing required Libraries
import os
from glob import glob
import matplotlib.pyplot as plt
```

```
import random
import cv2
import pandas as pd
import numpy as np
import matplotlib.gridspec as gridspec
import seaborn as sns
import zlib
import itertools
import sklearn
import itertools
import scipy
import skimage
from skimage.transform import resize
import csv
from tqdm import tqdm
import warnings
warnings.filterwarnings("ignore")
from sklearn import model_selection
from sklearn.model_selection import train_test_split, KFold, cross_val_score,␣
↪StratifiedKFold, GridSearchCV
from sklearn.utils import class_weight
from sklearn.metrics import confusion_matrix, make_scorer, accuracy_score,␣
↪classification_report
import tensorflow
from tensorflow.keras.layers import Dense, Dropout, Activation, Flatten,␣
↪Conv2D, MaxPooling2D, Lambda, MaxPool2D, BatchNormalization
from tensorflow.python.keras.utils import np_utils
from tensorflow.python.keras.utils.np_utils import to_categorical
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras import models, layers, optimizers
from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix, accuracy_score
from sklearn.utils import class_weight
from tensorflow.keras.optimizers import SGD, RMSprop, Adam, Adagrad, Adadelta,␣
↪RMSprop
from tensorflow.keras.models import Sequential, model_from_json
from tensorflow.keras.layers import Activation,Dense, Dropout, Flatten, Conv2D,␣
↪MaxPool2D
from tensorflow.keras.layers import MaxPooling2D,AveragePooling2D,␣
↪GlobalAveragePooling2D,BatchNormalization
from tensorflow.keras.preprocessing.image import array_to_img, img_to_array,␣
↪load_img, ImageDataGenerator
from tensorflow.keras.callbacks import ReduceLROnPlateau, ModelCheckpoint
from tensorflow.keras import backend as K
from tensorflow.keras.applications.vgg16 import VGG16
from tensorflow.keras.models import Model
```

```
from tensorflow.keras.applications.mobilenet import MobileNet
from tensorflow.keras.applications.inception_v3 import InceptionV3
from imblearn.over_sampling import RandomOverSampler
from sklearn.metrics import roc_auc_score
from sklearn.metrics import roc_curve
from sklearn.metrics import auc
%matplotlib inline
```

Build a model architecture (Sequential) with Dense layers

[18]:
```
# Model Parameters
image_size = 256
batch_size = 16
num_classes = 4
epochs = 10
```

[19]:
```
# baseline model
model = tf.keras.models.Sequential([
    tf.keras.layers.Conv2D(32, (3,3), activation='relu', input_shape=(150, 150,␣
 ↪3)),
    tf.keras.layers.MaxPooling2D(2, 2),
    tf.keras.layers.Conv2D(64, (3,3), activation='relu'),
    tf.keras.layers.MaxPooling2D(2,2),
    tf.keras.layers.Conv2D(128, (3,3), activation='relu'),
    tf.keras.layers.MaxPooling2D(2,2),
    tf.keras.layers.Conv2D(128, (3,3), activation='relu'),
    tf.keras.layers.MaxPooling2D(2,2),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(512, activation='relu'),
    tf.keras.layers.Dense(4, activation='softmax')
])

print(model.summary())
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 148, 148, 32)      896
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 74, 74, 32)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 72, 72, 64)        18496
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 36, 36, 64)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 34, 34, 128)       73856
_________________________________________________________________
```

```
max_pooling2d_2 (MaxPooling2 (None, 17, 17, 128)       0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 15, 15, 128)       147584
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 7, 7, 128)         0
_________________________________________________________________
flatten (Flatten)            (None, 6272)              0
_________________________________________________________________
dense (Dense)                (None, 512)               3211776
_________________________________________________________________
dense_1 (Dense)              (None, 4)                 2052
=================================================================
Total params: 3,454,660
Trainable params: 3,454,660
Non-trainable params: 0
_________________________________________________________________
None
```

[20]:
```
model.compile(loss = 'categorical_crossentropy',optimizer = 'adam',metrics =␣
↪['accuracy'])
```

[21]:
```
filepath="weights_baseline.best.hdf5"
checkpoint = ModelCheckpoint(filepath, monitor='val_acc', verbose=1,␣
↪save_best_only=True, mode='max')
callbacks_list = [checkpoint]
```

[22]:
```
train_datagen = ImageDataGenerator(
      rescale = 1./255,
      rotation_range = 40,
      width_shift_range = 0.2,
      height_shift_range = 0.2,
      shear_range = 0.2,
      zoom_range = 0.2,
      horizontal_flip = True,
      fill_mode = 'nearest')

train_generator = train_datagen.flow_from_directory(
    train_path,
    target_size = (150, 150),
    class_mode = 'categorical',
    batch_size = 100
)
```

```
Found 83484 images belonging to 4 classes.
```

[23]:
```
validation_datagen = ImageDataGenerator(rescale = 1./255)

validation_generator = validation_datagen.flow_from_directory(
```

```
    test_path,
    target_size = (150, 150),
    class_mode = 'categorical',
    batch_size = 20
)
```

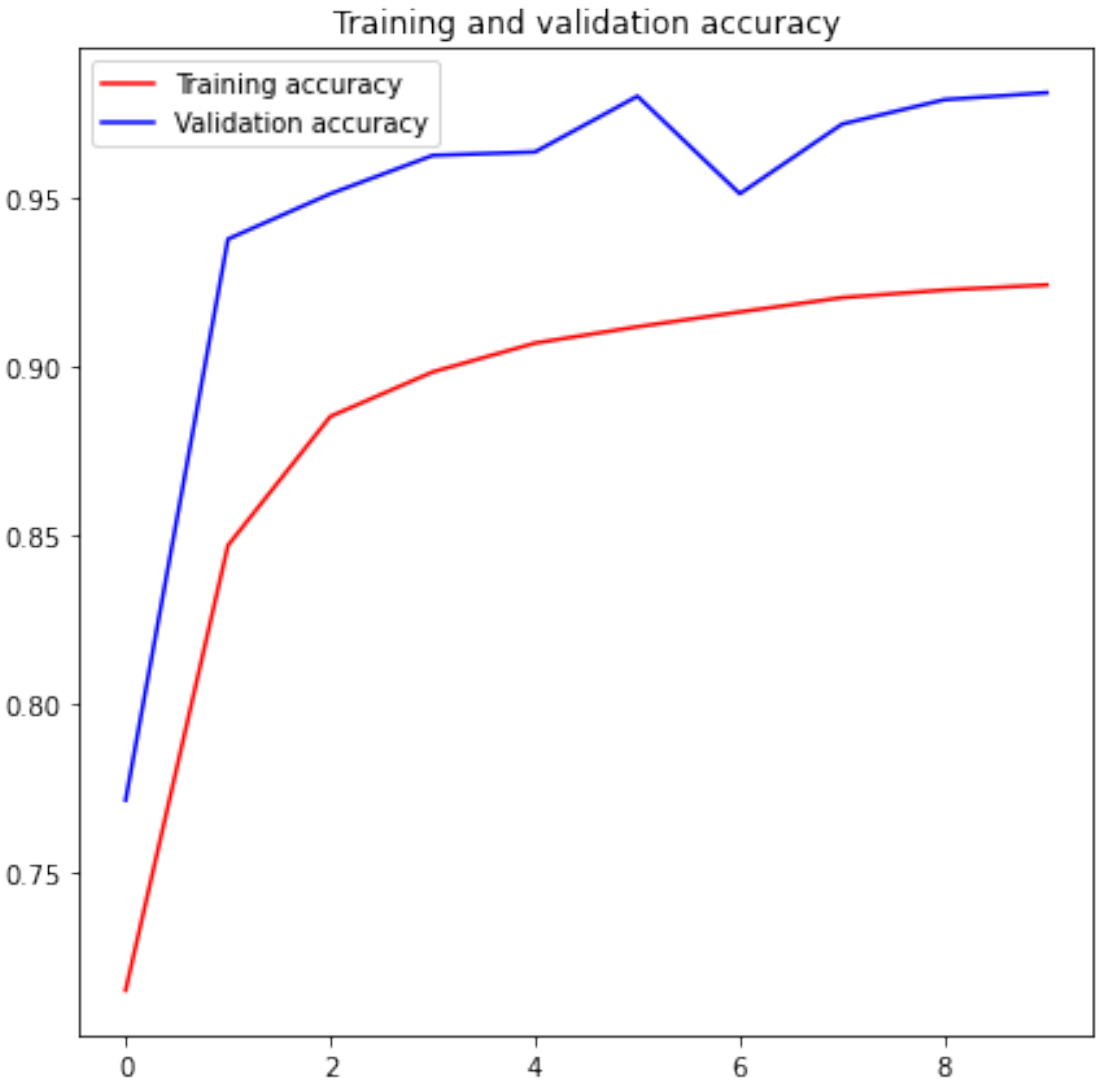
```
Found 968 images belonging to 4 classes.
```

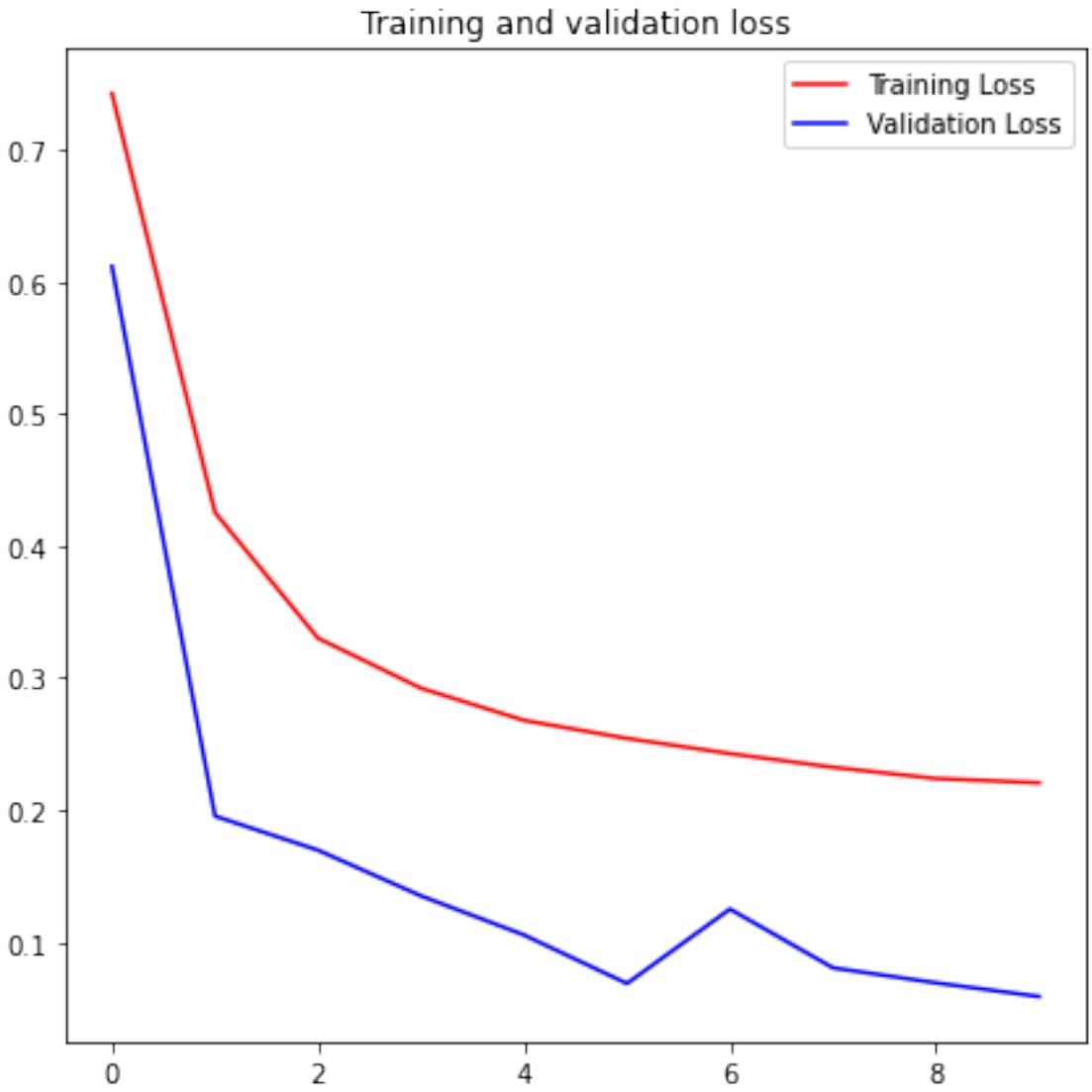
Train the model

[24]:
```
history = model.fit(
      train_generator,
      steps_per_epoch = np.ceil(83484/100),  # 83484 images = batch_size * steps
      epochs = 10,
      validation_data=validation_generator,
      validation_steps = np.ceil(968/20),  # 968 images = batch_size * steps
      verbose = 1)
```

```
Epoch 1/10
835/835 [==============================] - 3171s 4s/step - loss: 0.7424 -
accuracy: 0.7153 - val_loss: 0.6115 - val_accuracy: 0.7717
Epoch 2/10
835/835 [==============================] - 3129s 4s/step - loss: 0.4253 -
accuracy: 0.8472 - val_loss: 0.1954 - val_accuracy: 0.9380
Epoch 3/10
835/835 [==============================] - 3149s 4s/step - loss: 0.3301 -
accuracy: 0.8854 - val_loss: 0.1696 - val_accuracy: 0.9514
Epoch 4/10
835/835 [==============================] - 3126s 4s/step - loss: 0.2922 -
accuracy: 0.8986 - val_loss: 0.1350 - val_accuracy: 0.9628
Epoch 5/10
835/835 [==============================] - 3131s 4s/step - loss: 0.2679 -
accuracy: 0.9072 - val_loss: 0.1055 - val_accuracy: 0.9638
Epoch 6/10
835/835 [==============================] - 3106s 4s/step - loss: 0.2542 -
accuracy: 0.9120 - val_loss: 0.0687 - val_accuracy: 0.9804
Epoch 7/10
835/835 [==============================] - 3093s 4s/step - loss: 0.2427 -
accuracy: 0.9164 - val_loss: 0.1250 - val_accuracy: 0.9514
Epoch 8/10
835/835 [==============================] - 3113s 4s/step - loss: 0.2323 -
accuracy: 0.9207 - val_loss: 0.0805 - val_accuracy: 0.9721
Epoch 9/10
835/835 [==============================] - 3582s 4s/step - loss: 0.2238 -
accuracy: 0.9229 - val_loss: 0.0692 - val_accuracy: 0.9793
Epoch 10/10
835/835 [==============================] - 3185s 4s/step - loss: 0.2206 -
accuracy: 0.9244 - val_loss: 0.0588 - val_accuracy: 0.9814
```

[25]:
```
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(len(acc))

plt.figure(figsize=(7,7))

plt.plot(epochs, acc, 'r', label='Training accuracy')
plt.plot(epochs, val_acc, 'b', label='Validation accuracy')
plt.title('Training and validation accuracy')
plt.legend()

plt.figure(figsize=(7,7))

plt.plot(epochs, loss, 'r', label='Training Loss')
plt.plot(epochs, val_loss, 'b', label='Validation Loss')
plt.title('Training and validation loss')
plt.legend()

plt.show()
```


Training and validation accuracy
Training accuracy
Validation accuracy
0.95
0.90
0.85
0.80
0.75
0
2
4
6
8



Test the Model

[26]:
```
dest_path = 'C:/Users/Acer/Documents/Python Scripts/Machine Learning/Project/
↪test_working'
```

[27]:
```
import os
import shutil
dest = dest_path
for i in ['NORMAL', 'DME', 'DRUSEN', 'CNV']:
    src = os.path.join(val_path, i)
    src_files = os.listdir(src)
    for file_name in src_files:
        if(file_name != ".DS_Store"):
            full_file_name = os.path.join(src, file_name)
```

```
            if os.path.isfile(full_file_name):
                shutil.copy(full_file_name, dest)
```

[28]:
```
len(os.listdir(dest))
```

[28]: 32

[29]:
```
test_img = os.listdir(dest)

test_df = pd.DataFrame({'Image': test_img})
test_df
```

[29]:

	Image
0	CNV-6294785-1.jpeg
1	CNV-6294785-2.jpeg
2	CNV-6652117-1.jpeg
3	CNV-6668596-1.jpeg
4	CNV-6851127-1.jpeg
5	CNV-6875371-1.jpeg
6	CNV-8184974-1.jpeg
7	CNV-8598714-1.jpeg
8	DME-9583225-1.jpeg
9	DME-9583225-2.jpeg
10	DME-9603124-1.jpeg
11	DME-9655949-1.jpeg
12	DME-9721607-1.jpeg
13	DME-9721607-2.jpeg
14	DME-9925591-1.jpeg
15	DME-9925591-2.jpeg
16	DRUSEN-9800172-2.jpeg
17	DRUSEN-9837663-1.jpeg
18	DRUSEN-9861332-1.jpeg
19	DRUSEN-9884539-1.jpeg
20	DRUSEN-9884539-2.jpeg
21	DRUSEN-9894035-1.jpeg
22	DRUSEN-9894035-2.jpeg
23	DRUSEN-9928043-1.jpeg
24	NORMAL-4872585-1.jpeg
25	NORMAL-5156112-1.jpeg
26	NORMAL-5171640-1.jpeg
27	NORMAL-5193994-1.jpeg
28	NORMAL-5246808-1.jpeg
29	NORMAL-5246808-2.jpeg
30	NORMAL-5324912-1.jpeg
31	NORMAL-9053621-1.jpeg

[30]:
```
test_gen = ImageDataGenerator(rescale=1./255)

test_generator = test_gen.flow_from_dataframe(
    test_df,
    dest,
    x_col = 'Image',
    y_col = None,
    class_mode = None,
    target_size = (150, 150),
    batch_size = 20,
    shuffle = False
)
```

```
Found 32 validated image filenames.
```

Results

[31]:
```
predict = model.predict(test_generator, steps = int(np.ceil(32/20)))
```

[32]:
```
label_map = dict((v,k) for k,v in train_generator.class_indices.items())
label_map
```

[32]:
```
{0: 'CNV', 1: 'DME', 2: 'DRUSEN', 3: 'NORMAL'}
```

[33]:
```
test_df['Label'] = np.argmax(predict, axis = -1)
test_df['Label'] = test_df['Label'].replace(label_map)
```

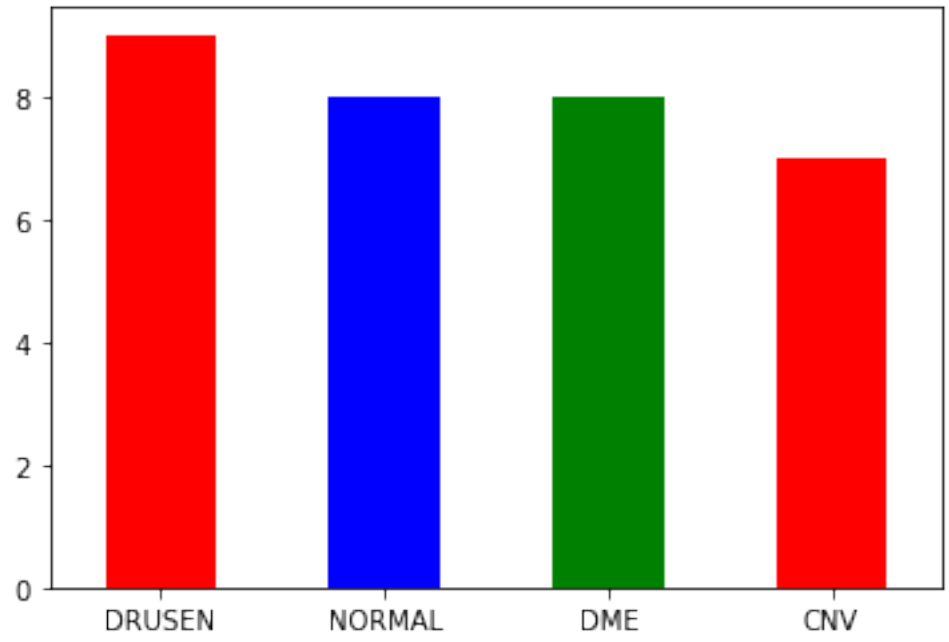
[34]:
```
test_df
```

[34]:

	Image	Label
0	CNV-6294785-1.jpeg	CNV
1	CNV-6294785-2.jpeg	DRUSEN
2	CNV-6652117-1.jpeg	CNV
3	CNV-6668596-1.jpeg	CNV
4	CNV-6851127-1.jpeg	CNV
5	CNV-6875371-1.jpeg	CNV
6	CNV-8184974-1.jpeg	CNV
7	CNV-8598714-1.jpeg	CNV
8	DME-9583225-1.jpeg	DME
9	DME-9583225-2.jpeg	DME
10	DME-9603124-1.jpeg	DME
11	DME-9655949-1.jpeg	DME
12	DME-9721607-1.jpeg	DME
13	DME-9721607-2.jpeg	DME
14	DME-9925591-1.jpeg	DME
15	DME-9925591-2.jpeg	DME
16	DRUSEN-9800172-2.jpeg	DRUSEN
17	DRUSEN-9837663-1.jpeg	DRUSEN
18	DRUSEN-9861332-1.jpeg	DRUSEN

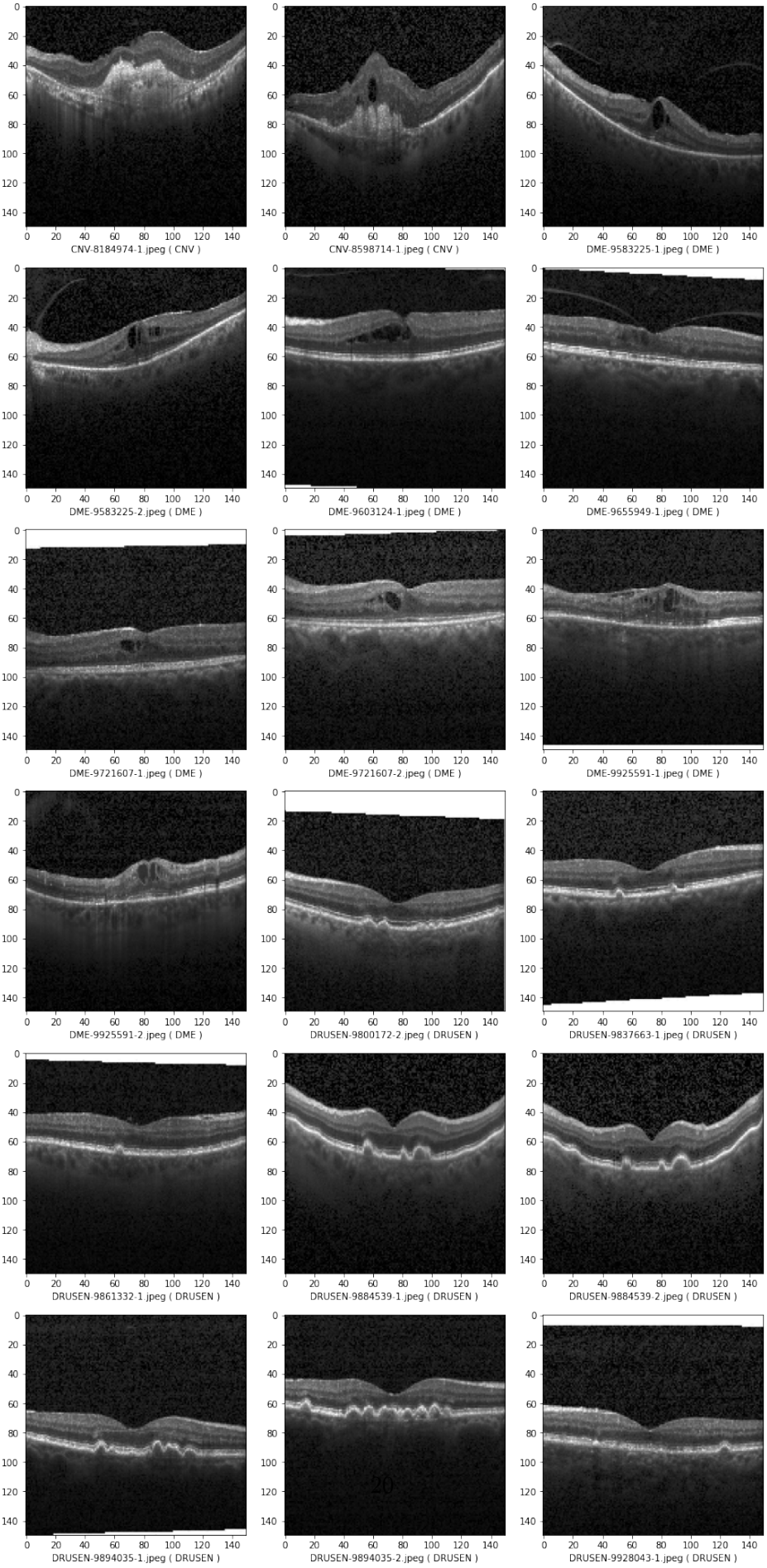
```
19  DRUSEN-9884539-1.jpeg  DRUSEN
20  DRUSEN-9884539-2.jpeg  DRUSEN
21  DRUSEN-9894035-1.jpeg  DRUSEN
22  DRUSEN-9894035-2.jpeg  DRUSEN
23  DRUSEN-9928043-1.jpeg  DRUSEN
24  NORMAL-4872585-1.jpeg  NORMAL
25  NORMAL-5156112-1.jpeg  NORMAL
26  NORMAL-5171640-1.jpeg  NORMAL
27  NORMAL-5193994-1.jpeg  NORMAL
28  NORMAL-5246808-1.jpeg  NORMAL
29  NORMAL-5246808-2.jpeg  NORMAL
30  NORMAL-5324912-1.jpeg  NORMAL
31  NORMAL-9053621-1.jpeg  NORMAL
```

[35]:
```
test_df.Label.value_counts().plot.bar(color = ['red','blue','green'])
plt.xticks(rotation = 0)
plt.show()
```



[36]:
```
v = random.randint(0, 24)

sample_test = test_df.iloc[v:(v+18)].reset_index(drop = True)
sample_test.head()

plt.figure(figsize=(12, 24))
for index, row in sample_test.iterrows():
```

```
    filename = row['Image']
    category = row['Label']
    img = load_img(dest +"/" + filename, target_size = (150, 150))
    plt.subplot(6, 3, index + 1)
    plt.imshow(img)
    plt.xlabel(filename + ' ( ' + "{}".format(category) + ' )' )
plt.tight_layout()
plt.show()
```


CNV-8184974-1.jpeg (CNV)
CNV-8598714-1.jpeg (CNV)
DME-9583225-1.jpeg (DME)
DME-9583225-2.jpeg (DME)
DME-9603124-1.jpeg (DME)
DME-9655949-1.jpeg (DME)
DME-9721607-1.jpeg (DME)
DME-9721607-2.jpeg (DME)
DME-9925591-1.jpeg (DME)
DME-9925591-2.jpeg (DME)
DRUSEN-9800172-2.jpeg (DRUSEN)
DRUSEN-9837663-1.jpeg (DRUSEN)
DRUSEN-9861332-1.jpeg (DRUSEN)
DRUSEN-9884539-1.jpeg (DRUSEN)
DRUSEN-9884539-2.jpeg (DRUSEN)
DRUSEN-9894035-1.jpeg (DRUSEN)
DRUSEN-9894035-2.jpeg (DRUSEN)
DRUSEN-9928043-1.jpeg (DRUSEN)

Accuracy

[37]:
```
lis = []
for ind in test_df.index:
    if(test_df['Label'][ind] in test_df['Image'][ind]):
        lis.append(1)
    else:
        lis.append(0)
print("Accuracy of the model on test data is {:.2f}%".format((sum(lis)/
 ↪len(lis))*100))
```

```
Accuracy of the model on test data is 96.88%
```

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