ML Model

December 16, 2022

1 MPI-CBG Puzzle

We have 2 types of images with points, the points are of two types, type 1 and type 2 we are required to train a model which can classify the points in the images to type 1 or type 2

[51]:
```
!pip install opencv-python
```

```
Requirement already satisfied: opencv-python in c:\users\prathvik g
s\anaconda3\lib\site-packages (4.6.0.66)
Requirement already satisfied: numpy>=1.19.3 in c:\users\prathvik g
s\anaconda3\lib\site-packages (from opencv-python) (1.21.5)
```

Importing all the necessary libraries and frameworks

[52]:
```
import numpy as np
import matplotlib.pyplot as plt
import os
import tensorflow as tf
import cv2
from tensorflow import keras
from  matplotlib import pyplot as plt
import matplotlib.image as mpimg
```

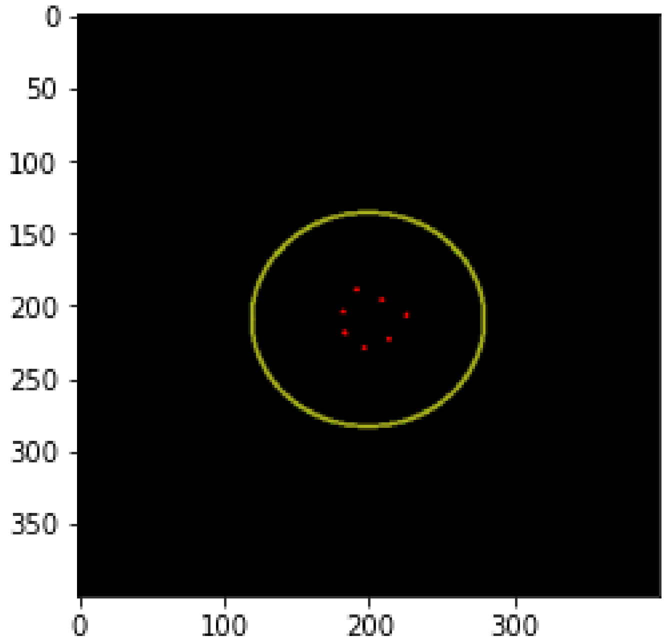
Path to the datasets in my machine

[53]:
```
datadir=r"C:\Users\Prathvik G S\Desktop\data\train"
catagories=["Type1","Type2"]
```

Note that we can grayscale the image (reducing rbg) so as to reduce the size of daya by 3 fold if the accuracy of the output isn't affected, or in other words we can grasycale the images if we don't loose any data from that
A sample image from the training set

[54]:
```
for category in catagories:
    path=os.path.join(datadir,category)
    for img in os.listdir(path):
        img_array=cv2.imread(os.path.join(path,img))
        plt.imshow(img_array)
        plt.show()
```

```
            break
        break
```



Size of the array storing the pixel values

[55]:
```
print(img_array.shape)
```

```
(400, 400, 3)
```

We can Normalise the images so as to contain the same number of pixels but here all the images have a size of $400x400$ so no need of normalising them in this case

Creating the training data

[56]:
```
training_data=[]

def create_training_data():
    for category in catagories:
        path=os.path.join(datadir,category)
        class_num=catagories.index(category)
        for img in os.listdir(path):
            img_array=cv2.imread(os.path.join(path,img))
            training_data.append([img_array,class_num])
create_training_data()
```

The number of labeled data set is 2000 where 1000 are of type 1 and type 2 each

[57]:
```
print(len(training_data))
```

2000

We randomly shuffle the dataset because when we created the data set, the first 1000 images are of type 1 and remaining are of type 2, so we shuffle them to make it random

[58]:
```
import random
random.shuffle(training_data)
```

[59]:
```
x=[]
y=[]
```

Seperating the x and the y label

[60]:
```
for features,label in training_data:
    x.append(features)
    y.append(label)
```

[61]:
```
x=np.array(x)
```

[62]:
```
y=np.array(y)
y=y.reshape(-1,1)
```

X has the training set, each image is now a $400 * 400 * 3$ array (a 3d array with pixel values for RBG colors) and y has its labels, 0 corresponds to type-1 and 1 corresponds to type-2

[63]:
```
x.shape
```

[63]:
```
(2000, 400, 400, 3)
```

[64]:
```
y.shape
```

[64]:
```
(2000, 1)
```

Before training the data, we split the data into 2 parts, one is the training set and the other the Test set to check the accuracy of our model on unseen data, here I split the data in the following manner

Training set- 60% which corresponds to 1200 images
The test set- 40% which corresponds to 800 images

Once we get a good accuracy we can divide it into 80:20 and finally we can use the whole data to train the model and then use the model to make predictions for new data whose output we don't know

2 Using 60% data to train and using 40% to test

[69]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(x, y, test_size = 0.4,␣
↪random_state = 0)
```

Building the model, we use convolutional neural network to build our model

[70]:
```
cnn = tf.keras.models.Sequential()
cnn.add(tf.keras.layers.Conv2D(filters=32, kernel_size=3, activation='relu',␣
↪input_shape=[400, 400, 3]))
cnn.add(tf.keras.layers.MaxPool2D(pool_size=2, strides=2))
cnn.add(tf.keras.layers.Conv2D(filters=32, kernel_size=3, activation='relu'))
cnn.add(tf.keras.layers.MaxPool2D(pool_size=2, strides=2))
cnn.add(tf.keras.layers.Flatten())
cnn.add(tf.keras.layers.Dense(units=128, activation='relu'))
cnn.add(tf.keras.layers.Dense(units=1, activation='sigmoid'))
cnn.compile(optimizer = 'adam', loss = 'binary_crossentropy', metrics =␣
↪['accuracy'])
```

Summary of our **Neural Network Model**

[77]:
```
cnn.summary()
print("no. of layers")
print(len(cnn.layers))
```

```
Model: "sequential_3"

_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_6 (Conv2D)           (None, 398, 398, 32)      896

 max_pooling2d_6 (MaxPooling  (None, 199, 199, 32)     0
 2D)

 conv2d_7 (Conv2D)           (None, 197, 197, 32)      9248

 max_pooling2d_7 (MaxPooling  (None, 98, 98, 32)       0
 2D)

 flatten_3 (Flatten)         (None, 307328)            0

 dense_6 (Dense)             (None, 128)               39338112

 dense_7 (Dense)             (None, 1)                 129

=================================================================
Total params: 39,348,385
Trainable params: 39,348,385
```

```
Non-trainable params: 0
_________________________________________________________________
no. of layers
7
```

Training the model with our Data
We can play around with the batch size and no. of epochs to get the optimal value

[72]:
```python
cnn.fit(X_train, y_train,batch_size = 25, epochs = 2)
```

```
Epoch 1/2
48/48 [==============================] - 119s 2s/step - loss: 17.2773 -
accuracy: 0.8650
Epoch 2/2
48/48 [==============================] - 115s 2s/step - loss: 0.0117 - accuracy:
0.9967
```

[72]:
```
<keras.callbacks.History at 0x1d0c44e04f0>
```

predicting the type for the test set

[73]:
```python
y_pred = cnn.predict(X_test)
y_pred = (y_pred > 0.5)
```

```
25/25 [==============================] - 13s 533ms/step
```

The confusion matrix and the accuracy of our model on the test set

[75]:
```python
from sklearn.metrics import confusion_matrix, accuracy_score
cm = confusion_matrix(y_test, y_pred)
print("Confusion Matrix is")
print(cm)
print("The accuracy is")
print(accuracy_score(y_test, y_pred)*100)
```

```
Confusion Matrix is
[[379   1]
 [  3 417]]
The accuracy is
99.5
```

The model has a accuracy of **99.5%** , we can see through the confusion matrix that only **4** out of the **800** test data set were misclassified and **796** correctly, hence the model is neither overfitted nor underfitted

3 Training the model with 80% of the data

Here we use the same model

[21]:
```python
X_train, X_test, y_train, y_test = train_test_split(x, y, test_size = 0.2,␣
↪random_state = 0)
```

[22]:
```
cnn.fit(X_train, y_train,batch_size = 32, epochs = 2)
```

```
Epoch 1/2
50/50 [==============================] - 123s 2s/step - loss: 0.0233 - accuracy:
0.9925
Epoch 2/2
50/50 [==============================] - 119s 2s/step - loss: 0.0011 - accuracy:
0.9994
```

[22]:
```
<keras.callbacks.History at 0x1d081788a00>
```

Confusion matrix and accuracy of the model on the test set

[23]:
```
y_pred = cnn.predict(X_test)
y_pred = (y_pred > 0.5)
cm = confusion_matrix(y_test, y_pred)
print(cm)
print(accuracy_score(y_test, y_pred)*100)
```

```
13/13 [==============================] - 6s 412ms/step
[[201   0]
 [  2 197]]
99.5
```

Only 1 out of the 400 test data was predicted wrongly, the accuracy is 99.75% which id good, from this can also know that our data isn't overfitted as it performs well on an unseen dataset of 400

4 Using 100% of the training the data to classify the image in the test folder

Using all the data to train the model and classify the images in the test folder

[79]:
```
cnn.fit(x,y, batch_size=25, epochs=2)
```

```
Epoch 1/2
80/80 [==============================] - 177s 2s/step - loss: 0.0102 - accuracy:
0.9960
Epoch 2/2
80/80 [==============================] - 157s 2s/step - loss: 0.0013 - accuracy:
1.0000
```

[79]:
```
<keras.callbacks.History at 0x1d0b0152820>
```

creating the Test dataset to be classified

[80]:
```
datadir=r"C:\Users\Prathvik G S\Desktop\data\test"
catagories=["TestSet"]
test_data=[]

def create_test_data():
```

```
    for category in catagories:
        path=os.path.join(datadir,category)
        class_num=catagories.index(category)
        for img in os.listdir(path):
            img_array=cv2.imread(os.path.join(path,img))
            test_data.append(img_array)
```

[81]:
```
create_test_data()
```

We have 20 images with points to be classified

[82]:
```
test_data=np.array(test_data)
test_data.shape
```

[82]: (20, 400, 400, 3)

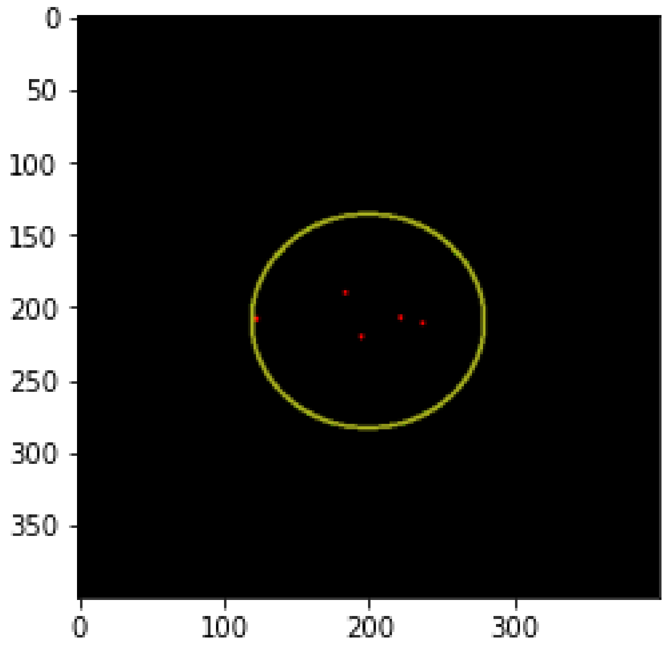
[104]:
```
y_pred = cnn.predict(test_data)
y_pred=y_pred>0.5
```

```
1/1 [==============================] - 0s 376ms/step
```

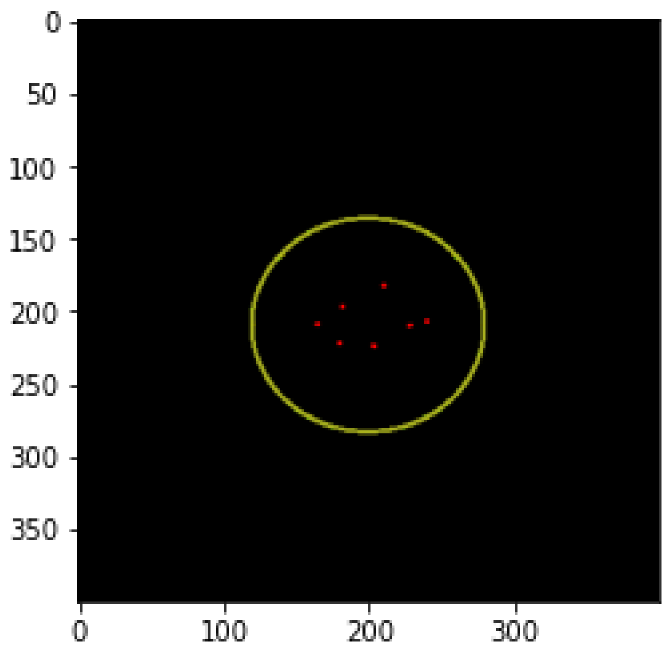
displaying the images with type

[106]:
```
for i in range(4):
    if(y_pred[i]==1):
        print("Type 2")
        plt.imshow(test_data[i])
        plt.show()
    else:
        print("Type 1")
        plt.imshow(test_data[i])
        plt.show()
```

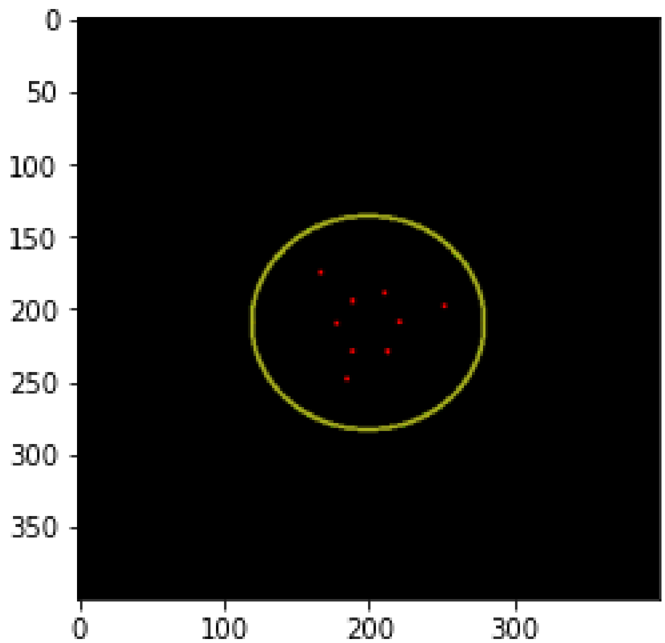
```
Type 1
```


0
50
100
150
200
250
300
350
0
100
200
300

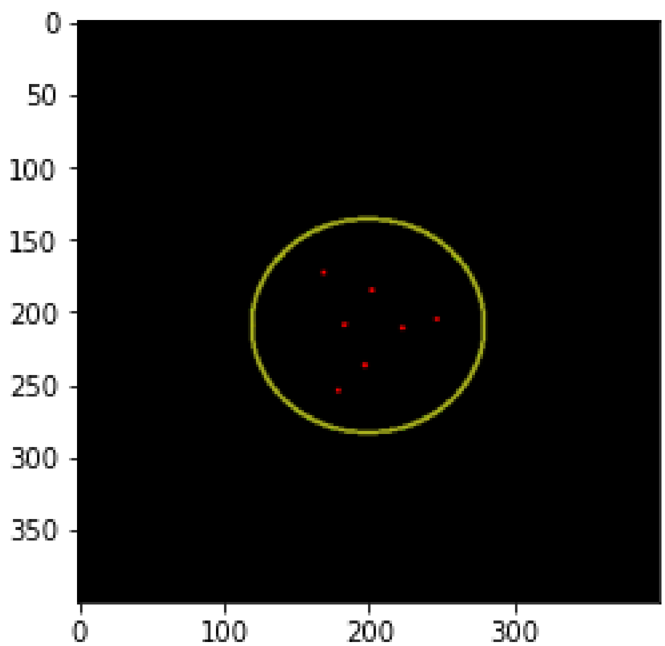
Type 1


0
50
100
150
200
250
300
350
0
100
200
300

Type 1



Type 2



[108]:
```
print(y_pred*1)
```

```
[[0]
 [0]
 [0]
 [1]
 [1]
 [0]
 [0]
 [0]
 [0]
 [0]
 [0]
 [0]
 [0]
 [0]
 [0]
 [0]
 [0]
 [0]
 [0]
 [0]]
```

[109]:
```
y_pred=y_pred>0.5
y_pred=y_pred.reshape(1,len(y_pred))
print("Type1-18, Type2-2")
print(y_pred*1)
```

```
Type1-18, Type2-2
[[0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]]
```

Most of the images belong to type 1

5 Reducing the data by removing color and checking the outcome

[31]:
```
datadir=r"C:\Users\Prathvik G S\Desktop\data\train"
catagories=["Type1","Type2"]
training_data=[]

def create_training_data():
    for category in catagories:
        path=os.path.join(datadir,category)
        class_num=catagories.index(category)
        for img in os.listdir(path):
            img_array=cv2.imread(os.path.join(path,img),cv2.IMREAD_GRAYSCALE)
            training_data.append([img_array,class_num])
create_training_data()
```

[32]:
```
print(len(training_data))
```

2000

[33]:
```
import random
random.shuffle(training_data)
x=[]
y=[]
for features,label in training_data:
    x.append(features)
    y.append(label)
x=np.array(x)
y=np.array(y)
y=y.reshape(-1,1)
x.shape
```

[33]: (2000, 400, 400)

[34]:
```
datadir=r"C:\Users\Prathvik G S\Desktop\data\test"
catagories=["TestSet"]
test_data=[]

def create_test_data():
    for category in catagories:
        path=os.path.join(datadir,category)
        class_num=catagories.index(category)
        for img in os.listdir(path):
            img_array=cv2.imread(os.path.join(path,img),cv2.IMREAD_GRAYSCALE)
            test_data.append(img_array)

create_test_data()
test_data=np.array(test_data)
test_data.shape
```

[34]: (20, 400, 400)

[35]:
```
cnn2 = tf.keras.models.Sequential()
cnn2.add(tf.keras.layers.Conv2D(filters=32, kernel_size=3, activation='relu',␣
↪input_shape=[400, 400, 1]))
cnn2.add(tf.keras.layers.MaxPool2D(pool_size=2, strides=2))
cnn2.add(tf.keras.layers.Conv2D(filters=32, kernel_size=3, activation='relu'))
cnn2.add(tf.keras.layers.MaxPool2D(pool_size=2, strides=2))
cnn2.add(tf.keras.layers.Flatten())
cnn2.add(tf.keras.layers.Dense(units=128, activation='relu'))
cnn2.add(tf.keras.layers.Dense(units=1, activation='sigmoid'))
cnn2.compile(optimizer = 'adam', loss = 'binary_crossentropy', metrics =␣
↪['accuracy'])
```

[48]:
```
X_train, X_test, y_train, y_test = train_test_split(x, y, test_size = 0.2,␣
↪random_state = 0)
cnn2.fit(X_train,y_train, batch_size=25, epochs=4)
```

```
Epoch 1/4
64/64 [==============================] - 139s 2s/step - loss: 0.6932 - accuracy:
0.4963
Epoch 2/4
64/64 [==============================] - 152s 2s/step - loss: 0.6932 - accuracy:
0.5025
Epoch 3/4
64/64 [==============================] - 137s 2s/step - loss: 0.6932 - accuracy:
0.4875
Epoch 4/4
64/64 [==============================] - 135s 2s/step - loss: 0.6932 - accuracy:
0.5025
```

[48]:
```
<keras.callbacks.History at 0x1d0af781730>
```

[49]:
```
y_pred2 = cnn2.predict(test_data)
y_pred2 = (y_pred2 > 0.5)
```

```
1/1 [==============================] - 0s 298ms/step
```

[50]:
```
y_pred = cnn2.predict(X_test)
y_pred = (y_pred > 0.5)
cm = confusion_matrix(y_test, y_pred)
print(cm)
print(accuracy_score(y_test, y_pred)*100)
```

```
13/13 [==============================] - 5s 395ms/step
[[  0 204]
 [  0 196]]
49.0
```

We can see through the confusion matrix and the accuracy that it is better we keep the colours as even after 4 epochs (compared to 2 epochs with colors) we are unable to get an accuracy of more than 50%, so it is better not to remove colors from the images.

Hence We built the required model with a good accuracy

[ ]:
```

```