Project-2

April 25, 2023

[1]:
```python
import numpy as np
import os
import pandas as pd
import cv2
from tqdm import tqdm
import io
from keras.layers import Input, Lambda, Dense, Flatten
from keras.models import Model
from keras.applications.vgg16 import VGG16
from keras.applications.vgg16 import preprocess_input
from keras.preprocessing import image
from keras.preprocessing.image import ImageDataGenerator
from keras.models import Sequential
import numpy as np
from glob import glob
import matplotlib.pyplot as plt

import warnings

import seaborn as sns
import matplotlib.pyplot as plt

from sklearn.utils import shuffle # Shuffle arrays or sparse matrices in a␣
↪consistent way
from sklearn.model_selection import train_test_split
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense,␣
↪Dropout
from tensorflow.keras.models import Sequential, load_model
from sklearn.metrics import classification_report, confusion_matrix
import warnings as wr
wr.filterwarnings('ignore')
```

[2]:
```python
labels = ['Glioma', 'Meningioma', 'Notumor', 'Pituitary']
IMG_SIZE = [224, 224]
```

[3]:
```
#Training Dataset
X_train = []
#Training Labels
Y_train = []

img_size=224

for i in labels:
    dataset_path = os.path.join('dataset', 'Training', i)
    for j in tqdm(os.listdir(dataset_path)):
        image = cv2.imread(os.path.join(dataset_path, j))
        image = cv2.resize(image, (img_size, img_size))
        X_train.append(image)
        Y_train.append(i)


for i in labels:
    dataset_path = os.path.join('dataset', 'Testing', i) # Join two or more␣
 ↪pathname components
    for j in tqdm(os.listdir(dataset_path)):
        image = cv2.imread(os.path.join(dataset_path, j))
        image = cv2.resize(image, (img_size, img_size))
        X_train.append(image)
        Y_train.append(i)

#Converting list into array
X_train = np.array(X_train)
Y_train = np.array(Y_train)
```

```
100%|          | 1321/1321 [00:02<00:00, 440.58it/s]
100%|          | 1339/1339 [00:04<00:00, 313.06it/s]
100%|          | 1595/1595 [00:03<00:00, 424.49it/s]
100%|          | 1457/1457 [00:04<00:00, 306.82it/s]
100%|          | 300/300 [00:00<00:00, 365.94it/s]
100%|          | 306/306 [00:00<00:00, 485.90it/s]
100%|          | 405/405 [00:00<00:00, 737.65it/s]
100%|          | 300/300 [00:00<00:00, 458.54it/s]
```

[4]:
```
#Training dataset size
X_train.shape
```

[4]:
```
(7023, 224, 224, 3)
```

[5]:
```
# Shuffling data
X_train, Y_train = shuffle(X_train, Y_train, random_state=42)
```

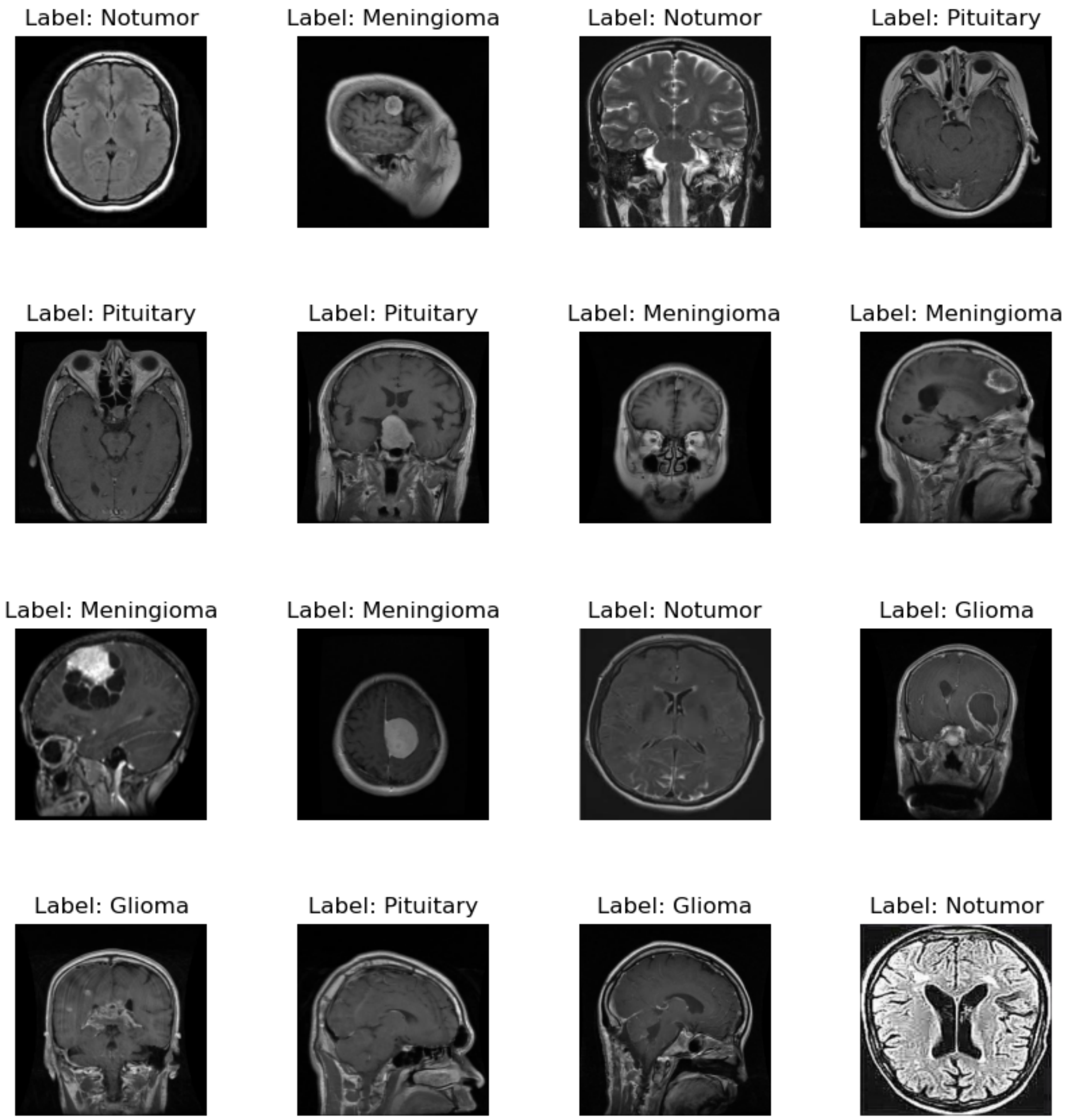
[6]:
```
#After shuffling sample size remains same
X_train.shape
```

[6]: (7023, 224, 224, 3)

[7]:
```
grid_w = 4
grid_h = 4
f, ax = plt.subplots(grid_w, grid_h)
f.set_size_inches(8, 8)

image_index = 0
for i in range(0, grid_w):
    for j in range(0, grid_h):
        ax[i][j].axis('off')
        ax[i][j].set_title('Label: '+Y_train[image_index])
        ax[i][j].imshow(X_train[image_index])
        image_index += 1

plt.subplots_adjust(left=0, bottom=0, right=1, top=1, wspace=0.2, hspace=0.55)
```



[8]:
```
X_train, X_test, Y_train, Y_test = train_test_split(X_train, Y_train,␣
  ↪test_size=0.2, random_state=42)
```

[9]:
```
y_train_new = []
#y_valid_new = []
y_test_new = []

for i in Y_train:
    y_train_new.append(labels.index(i))
Y_train = to_categorical(y_train_new)
```

```
for i in Y_test:
    y_test_new.append(labels.index(i))

Y_test = to_categorical(y_test_new)
```

[10]:
```
Y_train
```

[10]:
```
array([[0., 1., 0., 0.],
       [1., 0., 0., 0.],
       [0., 0., 1., 0.],
       …,
       [0., 0., 1., 0.],
       [0., 1., 0., 0.],
       [1., 0., 0., 0.]], dtype=float32)
```

[11]:
```
vgg16 = VGG16(input_shape=IMG_SIZE + [3], weights='imagenet', include_top=False)
for layer in vgg16.layers:
  layer.trainable = False
```

[12]:
```
x = Flatten()(vgg16.output)
prediction = Dense(4, activation='softmax')(x)
CNN_model = Model(inputs=vgg16.input, outputs=prediction)
```

[13]:
```
CNN_model.summary()
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 224, 224, 3)]     0

 block1_conv1 (Conv2D)       (None, 224, 224, 64)      1792

 block1_conv2 (Conv2D)       (None, 224, 224, 64)      36928

 block1_pool (MaxPooling2D)  (None, 112, 112, 64)      0

 block2_conv1 (Conv2D)       (None, 112, 112, 128)     73856

 block2_conv2 (Conv2D)       (None, 112, 112, 128)     147584

 block2_pool (MaxPooling2D)  (None, 56, 56, 128)       0

 block3_conv1 (Conv2D)       (None, 56, 56, 256)       295168
```

```
 block3_conv2 (Conv2D)       (None, 56, 56, 256)       590080

 block3_conv3 (Conv2D)       (None, 56, 56, 256)       590080

 block3_pool (MaxPooling2D)  (None, 28, 28, 256)       0

 block4_conv1 (Conv2D)       (None, 28, 28, 512)       1180160

 block4_conv2 (Conv2D)       (None, 28, 28, 512)       2359808

 block4_conv3 (Conv2D)       (None, 28, 28, 512)       2359808

 block4_pool (MaxPooling2D)  (None, 14, 14, 512)       0

 block5_conv1 (Conv2D)       (None, 14, 14, 512)       2359808

 block5_conv2 (Conv2D)       (None, 14, 14, 512)       2359808

 block5_conv3 (Conv2D)       (None, 14, 14, 512)       2359808

 block5_pool (MaxPooling2D)  (None, 7, 7, 512)         0

 flatten (Flatten)           (None, 25088)             0

 dense (Dense)               (None, 4)                 100356

=================================================================
Total params: 14,815,044
Trainable params: 100,356
Non-trainable params: 14,714,688
_________________________________________________________________
```

[14]:

```
CNN_model.compile(
  loss='categorical_crossentropy',
  optimizer='adam',
  metrics=['accuracy']
)
```

[15]:

```
# Model Scaling
X_train_scaled = X_train.astype('float32')
X_test_scaled = X_test.astype('float32')


X_train_scaled /= 255
X_test_scaled /= 255
```

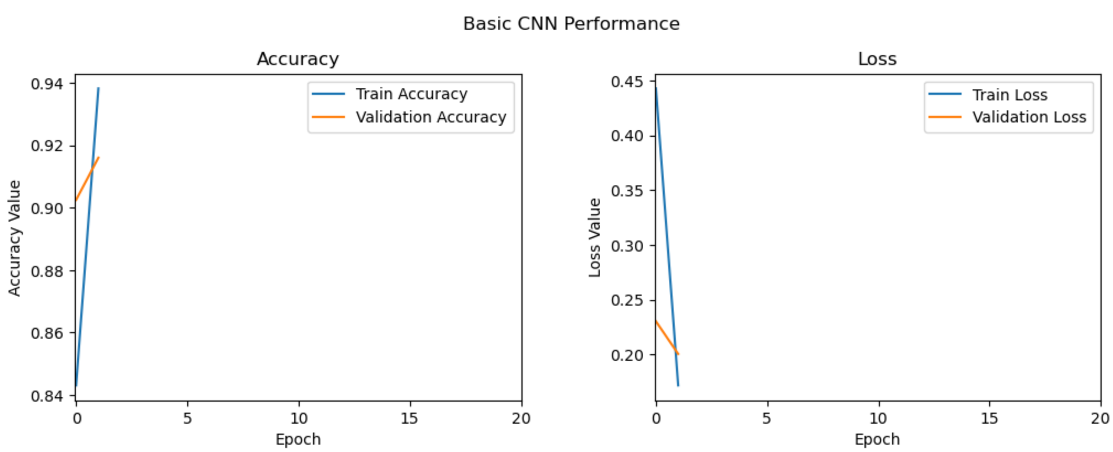
```
[16]: model_training = CNN_model.fit(x=X_train_scaled, y=Y_train,
                          validation_data=(X_test_scaled, Y_test),
                          batch_size=32,
                          epochs=2,
                          verbose=1)
```

```
Epoch 1/2
176/176 [==============================] - 1393s 8s/step - loss: 0.4427 -
accuracy: 0.8430 - val_loss: 0.2302 - val_accuracy: 0.9025
Epoch 2/2
176/176 [==============================] - 876s 5s/step - loss: 0.1718 -
accuracy: 0.9382 - val_loss: 0.2004 - val_accuracy: 0.9160
```

```
[21]: f, (ax1, ax2) = plt.subplots(1, 2, figsize=(12, 4))
t = f.suptitle('Basic CNN Performance', fontsize=12)
f.subplots_adjust(top=0.85, wspace=0.3)

epoch_list = list(range(1,21))
ax1.plot(model_training.history['accuracy'], label='Train Accuracy')
ax1.plot(model_training.history['val_accuracy'], label='Validation Accuracy')
ax1.set_xticks(np.arange(0, 21, 5))
ax1.set_ylabel('Accuracy Value')
ax1.set_xlabel('Epoch')
ax1.set_title('Accuracy')
l1 = ax1.legend(loc="best")

ax2.plot(model_training.history['loss'], label='Train Loss')
ax2.plot(model_training.history['val_loss'], label='Validation Loss')
ax2.set_xticks(np.arange(0, 21, 5))
ax2.set_ylabel('Loss Value')
ax2.set_xlabel('Epoch')
ax2.set_title('Loss')
l2 = ax2.legend(loc="best")
```



[23]:

```
# Getting model predictions
test_predictions = CNN_model.predict(X_test_scaled)
preds = np.argmax(test_predictions, axis=1)
actual_label = np.argmax(Y_test, axis=1)
print(classification_report(actual_label, preds))
```

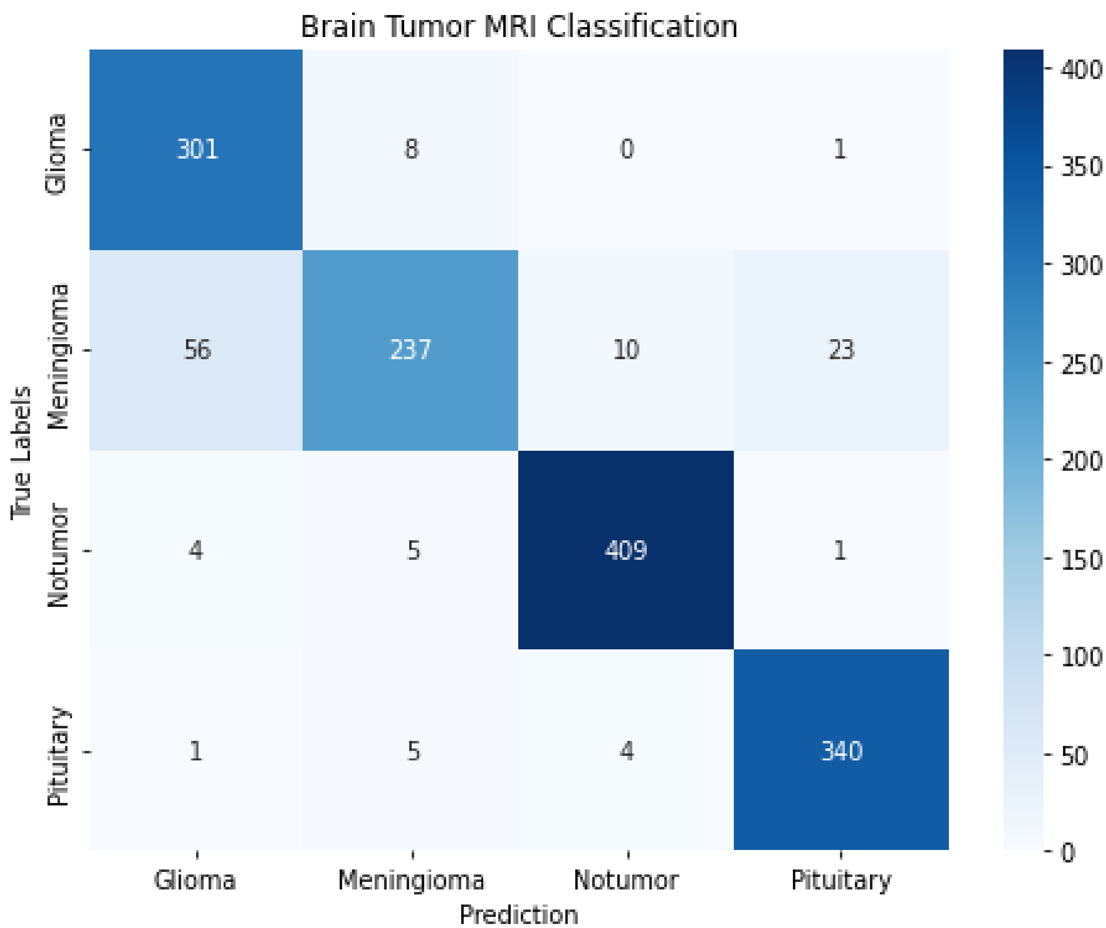
```
44/44 [==============================] - 177s 4s/step
              precision    recall  f1-score   support

           0       0.83      0.97      0.90       310
           1       0.93      0.73      0.82       326
           2       0.97      0.98      0.97       419
           3       0.93      0.97      0.95       350

    accuracy                           0.92      1405
   macro avg       0.91      0.91      0.91      1405
weighted avg       0.92      0.92      0.91      1405
```

[24]:

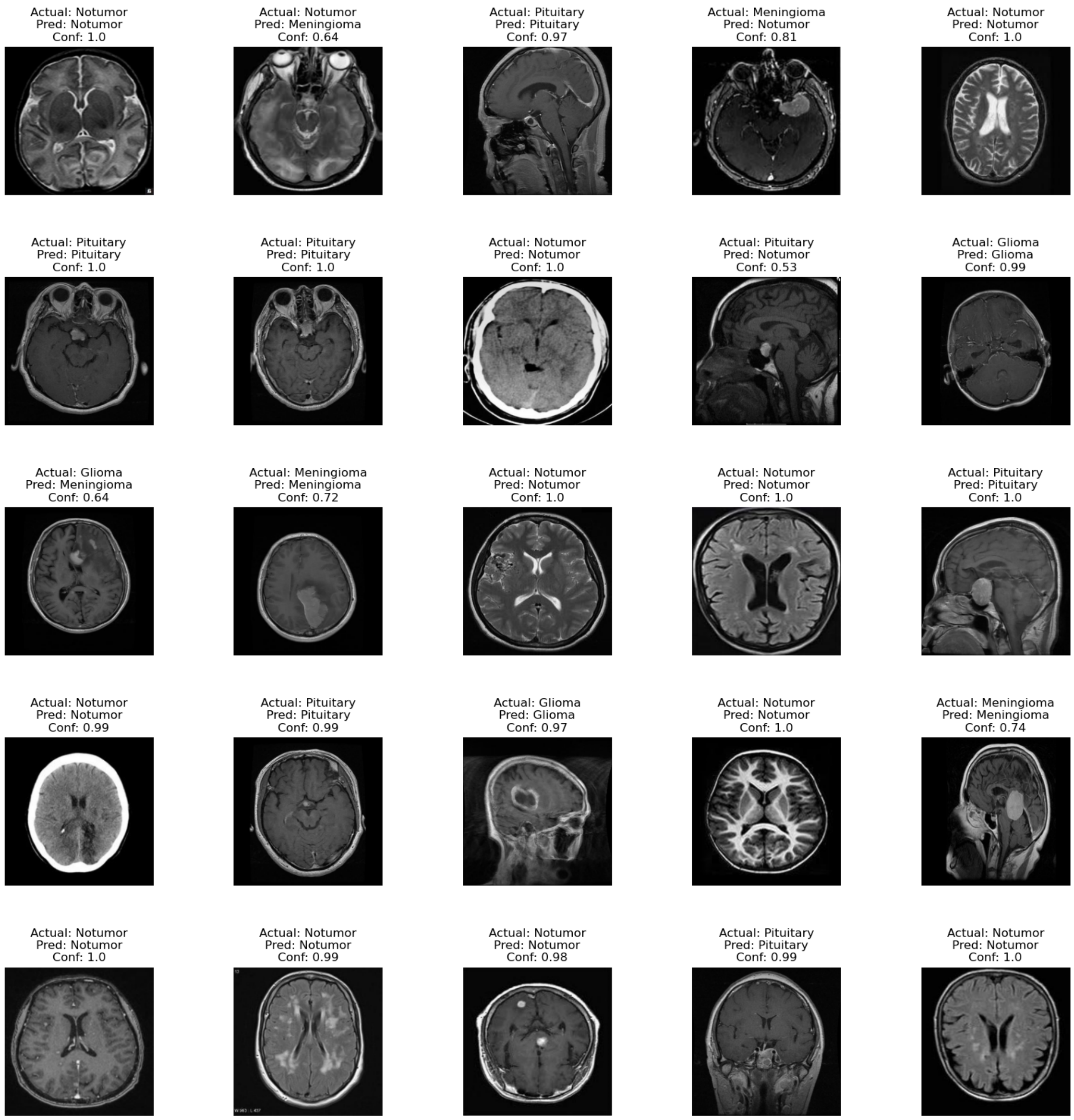
```
cnf = confusion_matrix(actual_label, preds)
plt.figure(figsize=(8,6), dpi=70, facecolor='w', edgecolor='k')
ax = sns.heatmap(cnf, cmap='Blues', annot=True, fmt = 'd', xticklabels=labels,␣
  ↪yticklabels=labels)
plt.title('Brain Tumor MRI Classification')
plt.xlabel('Prediction')
plt.ylabel('True Labels')
plt.show(ax)
```



[25]:
```
grid_w = 5
grid_h = 5
f, ax = plt.subplots(grid_w, grid_h)
f.set_size_inches(15, 15)

image_index = 0
for i in range(0, grid_w):
    for j in range(0, grid_h):
        actual = actual_label[image_index]
        predicted = preds[image_index]
        confidence = round(test_predictions[image_index][predicted], 2)
        ax[i][j].axis('off')
        ax[i][j].set_title('Actual: '+labels[actual]+'\nPred: 
 ↪'+labels[predicted] + '\nConf: ' +str(confidence))
        ax[i][j].imshow(X_test[image_index])
        image_index += 1

plt.subplots_adjust(left=0, bottom=0, right=1, top=1, wspace=0.5, hspace=0.55)
```


Actual: Notumor
Pred: Notumor
Conf: 1.0
Actual: Notumor
Pred: Meningioma
Conf: 0.64
Actual: Pituitary
Pred: Pituitary
Conf: 0.97
Actual: Meningioma
Pred: Notumor
Conf: 0.81
Actual: Notumor
Pred: Notumor
Conf: 1.0
Actual: Pituitary
Pred: Pituitary
Conf: 1.0
Actual: Pituitary
Pred: Pituitary
Conf: 1.0
Actual: Notumor
Pred: Notumor
Conf: 1.0
Actual: Pituitary
Pred: Notumor
Conf: 0.53
Actual: Glioma
Pred: Glioma
Conf: 0.99
Actual: Glioma
Pred: Meningioma
Conf: 0.64
Actual: Meningioma
Pred: Meningioma
Conf: 0.72
Actual: Notumor
Pred: Notumor
Conf: 1.0
Actual: Notumor
Pred: Notumor
Conf: 1.0
Actual: Pituitary
Pred: Pituitary
Conf: 1.0
Actual: Notumor
Pred: Notumor
Conf: 0.99
Actual: Pituitary
Pred: Pituitary
Conf: 0.99
Actual: Glioma
Pred: Glioma
Conf: 0.97
Actual: Notumor
Pred: Notumor
Conf: 1.0
Actual: Meningioma
Pred: Meningioma
Conf: 0.74
Actual: Notumor
Pred: Notumor
Conf: 1.0
Actual: Notumor
Pred: Notumor
Conf: 0.99
Actual: Notumor
Pred: Notumor
Conf: 0.98
Actual: Pituitary
Pred: Pituitary
Conf: 0.99
Actual: Notumor
Pred: Notumor
Conf: 1.0

[ ]: