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Advancing Brain Tumor Detection: Optimizing Deep Learning Models with CNNs and Quantum Neural Networks for Enhanced MRI Analysis

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   - tumor types
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4. Part II : Types of Tumors :
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Introduction :

Brain cancer is a cancerous tumor of the brain, whether it is located in the brain itself or in another part of the body. A tumor consists of a mass of cells that multiply uncontrollably and independently.

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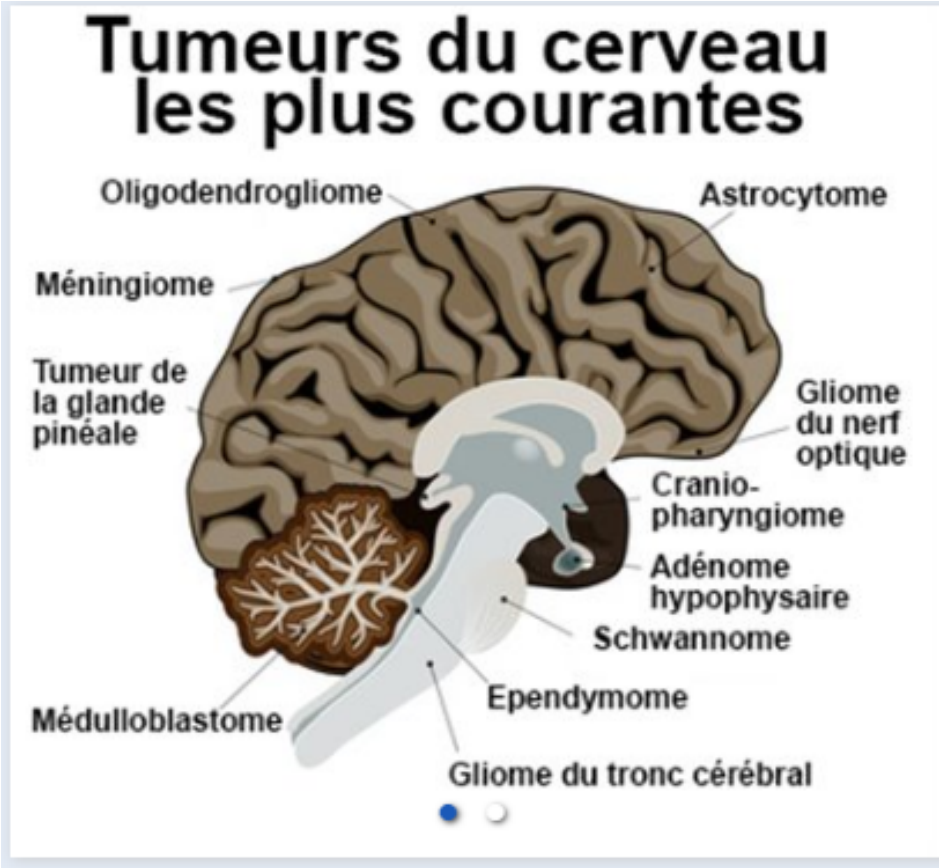
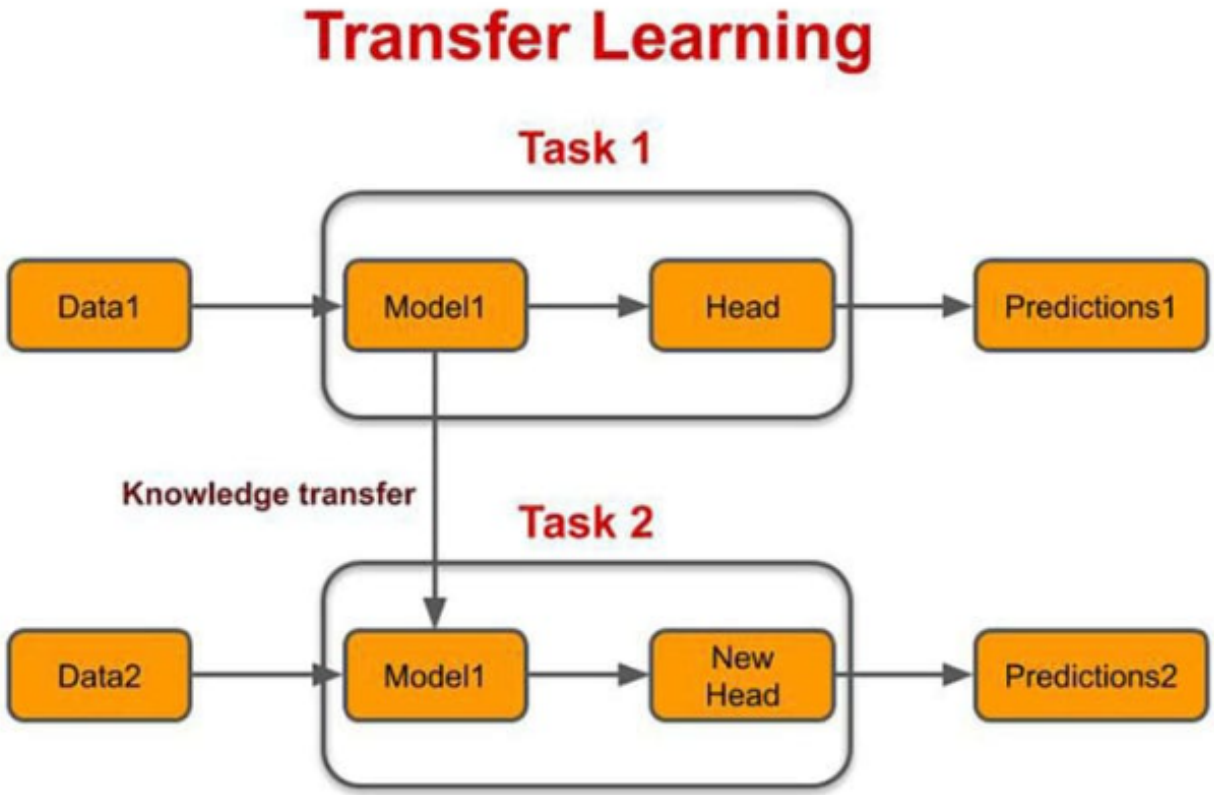
tumor types :

It is a collection of pathological cells (benign or malignant). Tumors can be primary (developed directly from brain cells) or secondary (developed indirectly from a metastasis or from a microbe, as in a brain abscess).



transfer learning :

Transfer learning is an approach that allows for transferring knowledge from one model to another.




Importing data via Google Drive. :

- **Importing data via Google Drive.**

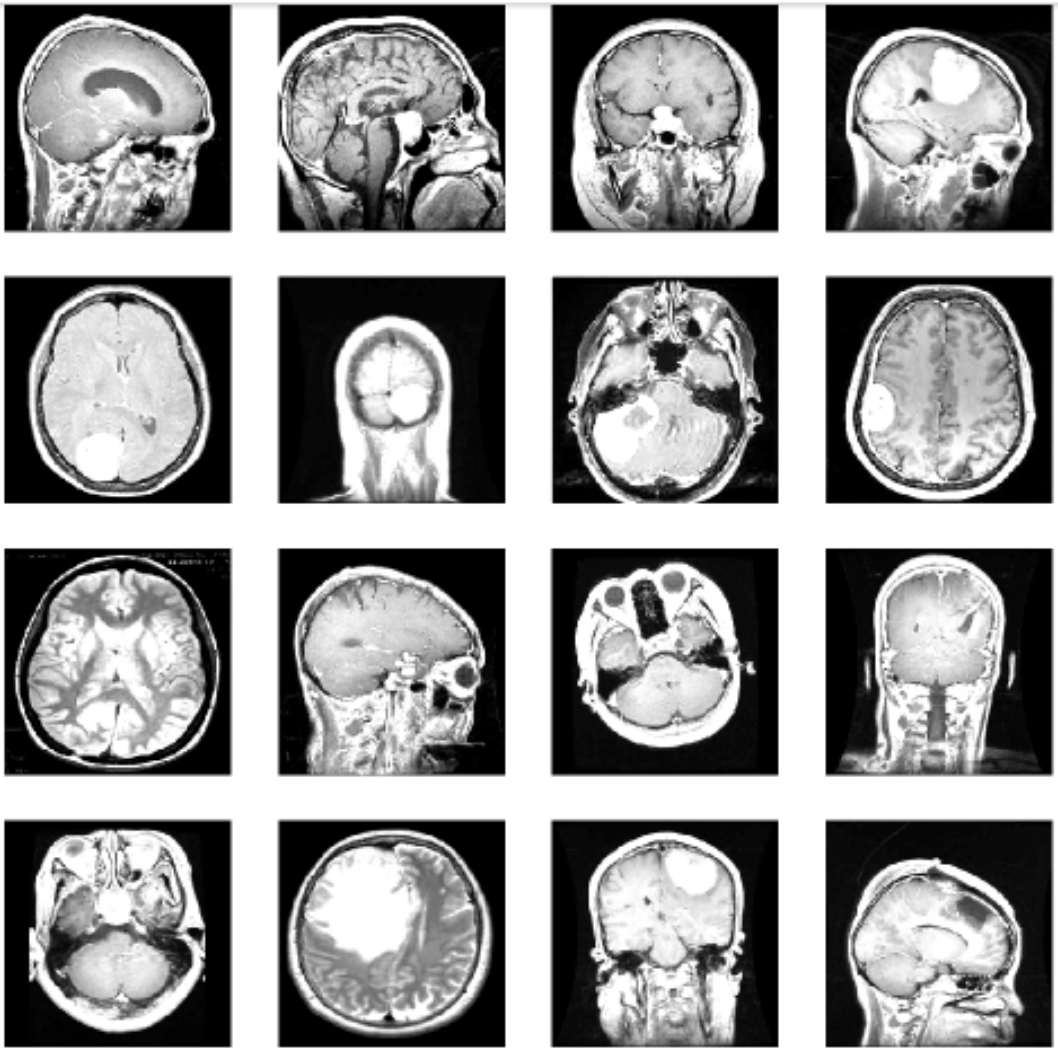
It contains 1,061 images with tumors and 503 images without tumors. The MRI images are resized to a width, height, and channel of (240 $\times$ 240 $\times$ 3)

- **Class balancing using the Oversampling method**

To have 2,122 images : 1061 with tumors and 1061 without tumors.

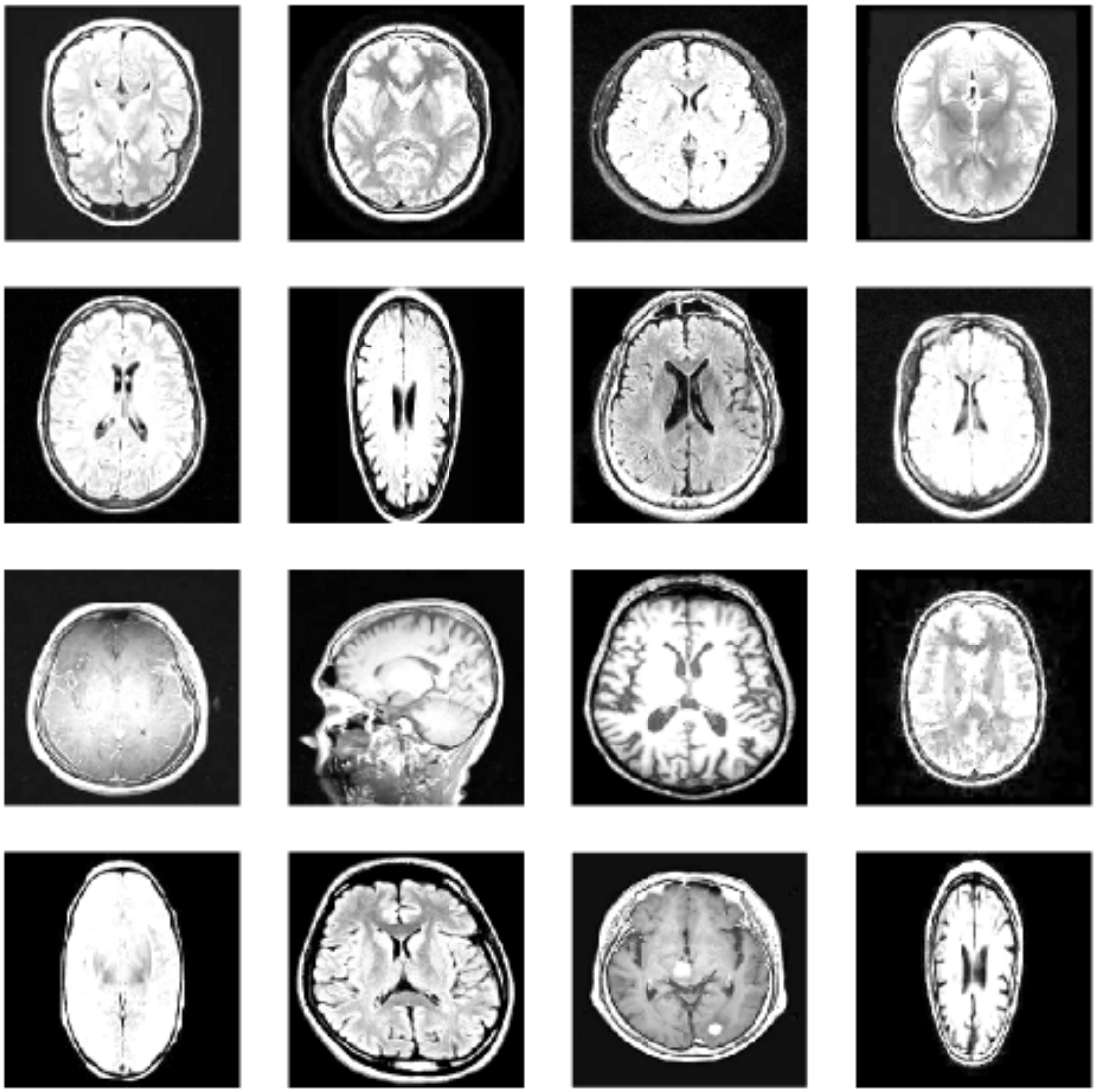
DATASET 1 :

- Visualize the 16 images from the DATASET :
  - **Images With Tumor :**



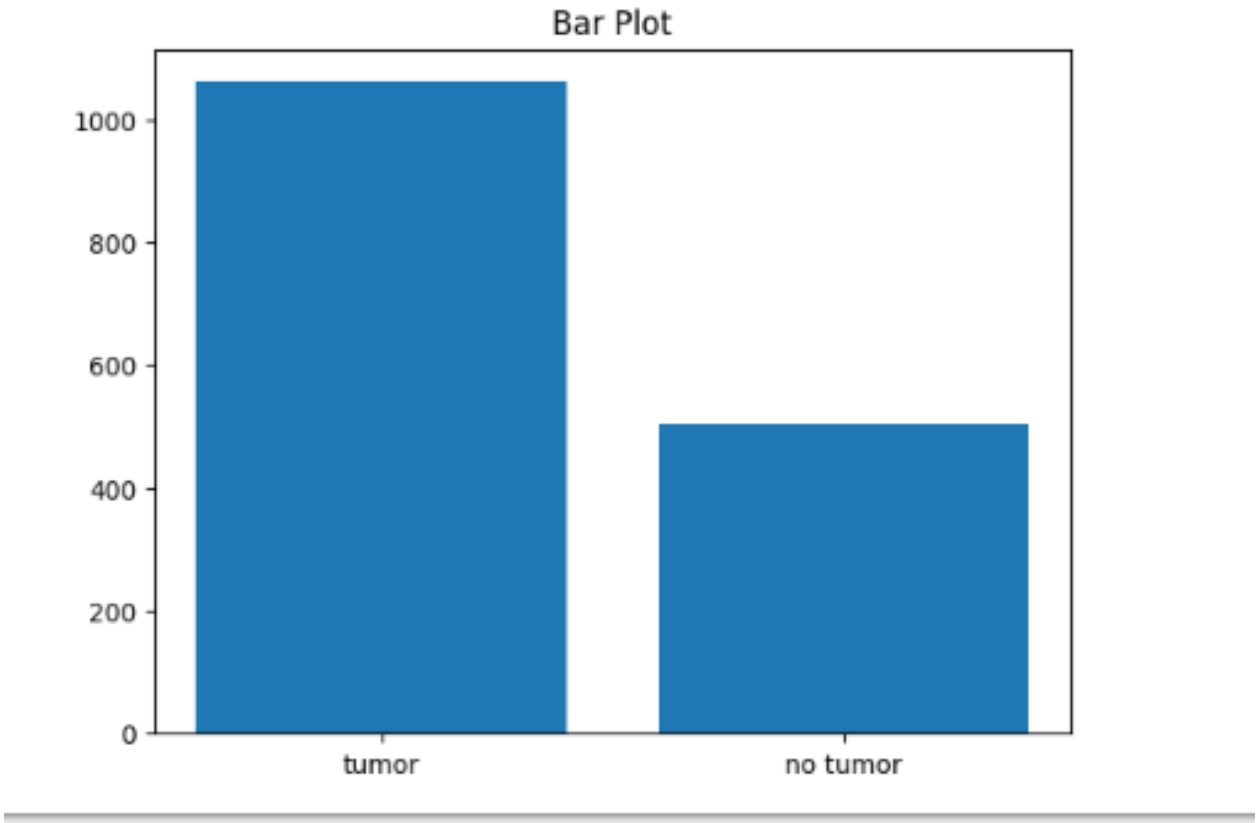
DATASET 1 :

- **Images Without Tumor :**



DATASET 1 :

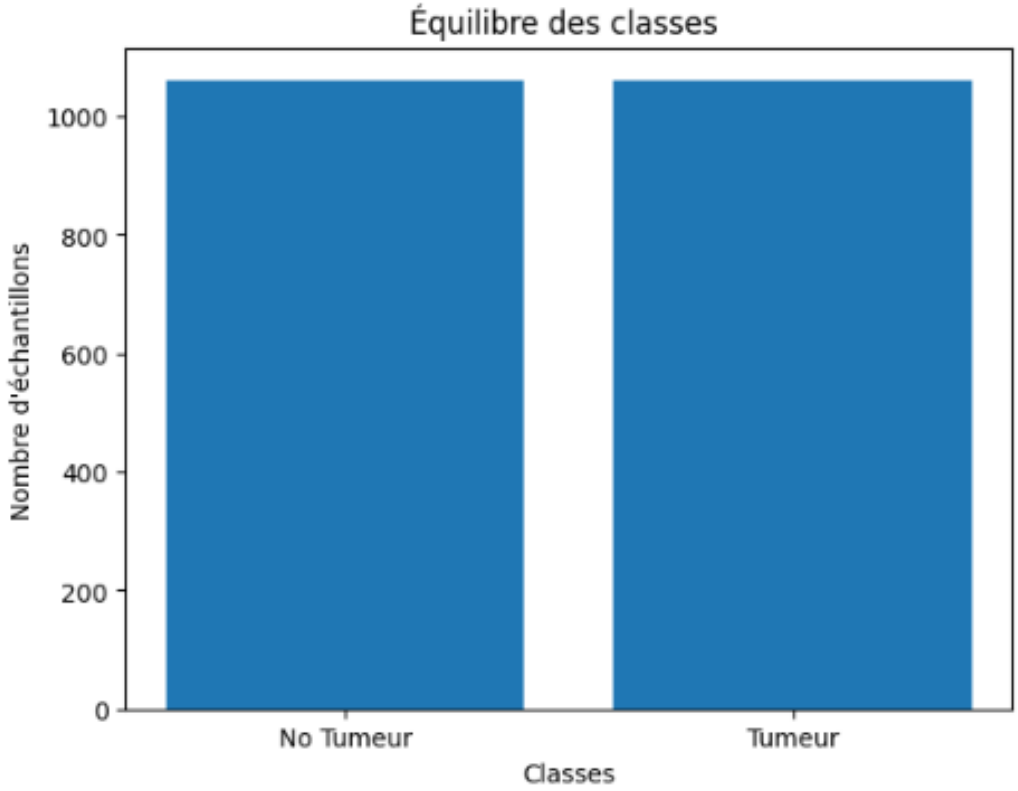
- Visualize BALANCED DATASET :




DATASET 1 :

Oversampling consists of rebalancing the data by artificially increasing the number of instances in the minority class.

- Visualize BALANCED DATASET with OVERSAMPLING :




Division of the database :

- Divide the database into 2 datasets : Train set, Test set

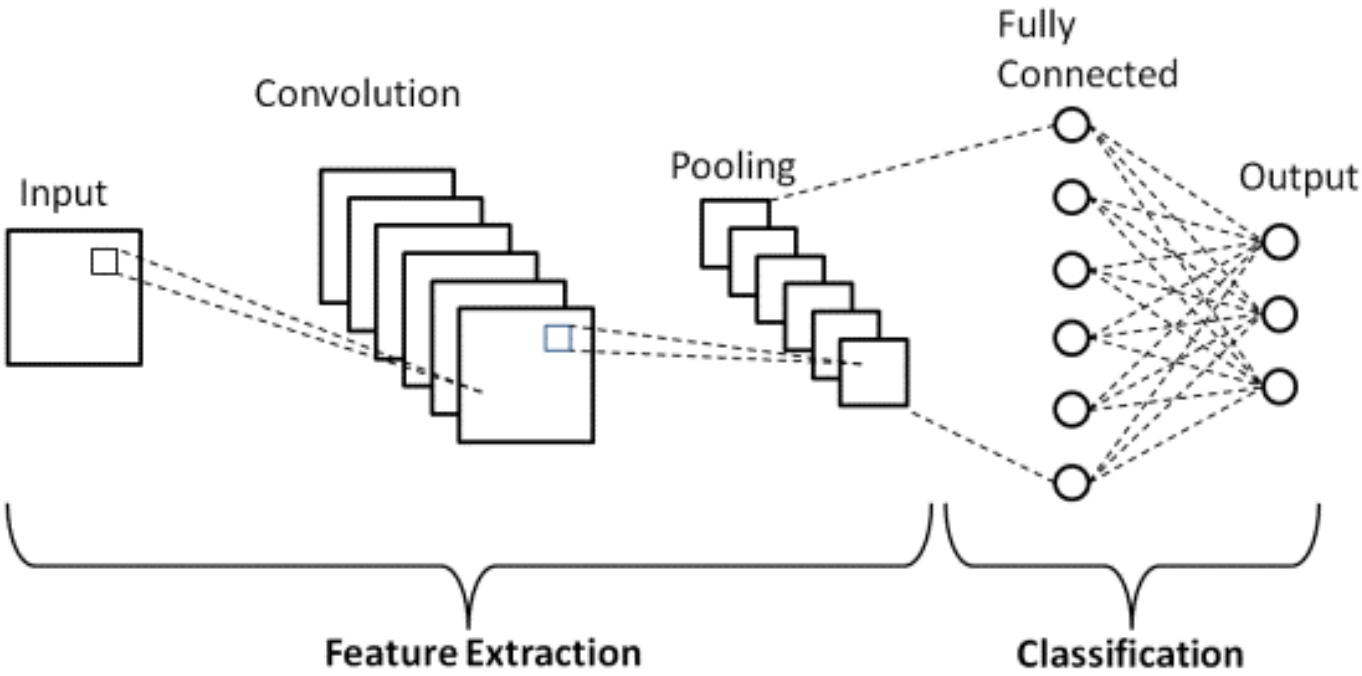
80 percent for training.

20 percent for testing

- To have 1,697 images for training and 425 for testing

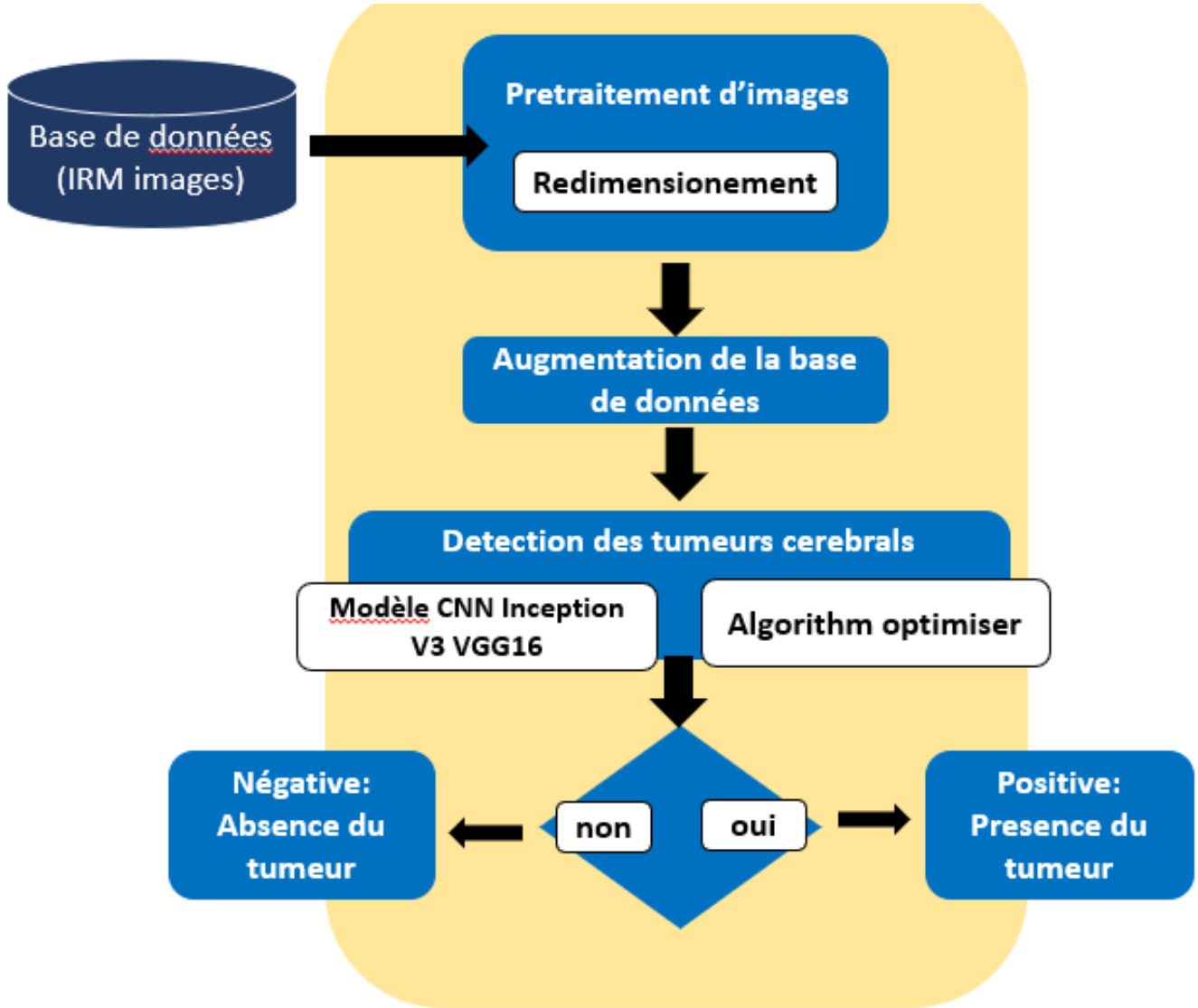

CNN :

The CNN (Convolutional Neural Network) is one of the most efficient algorithms in deep learning used for object detection or image processing




CNN :

- **The main architecture of our project, part 1, is as follows. :**



Simple CNN :

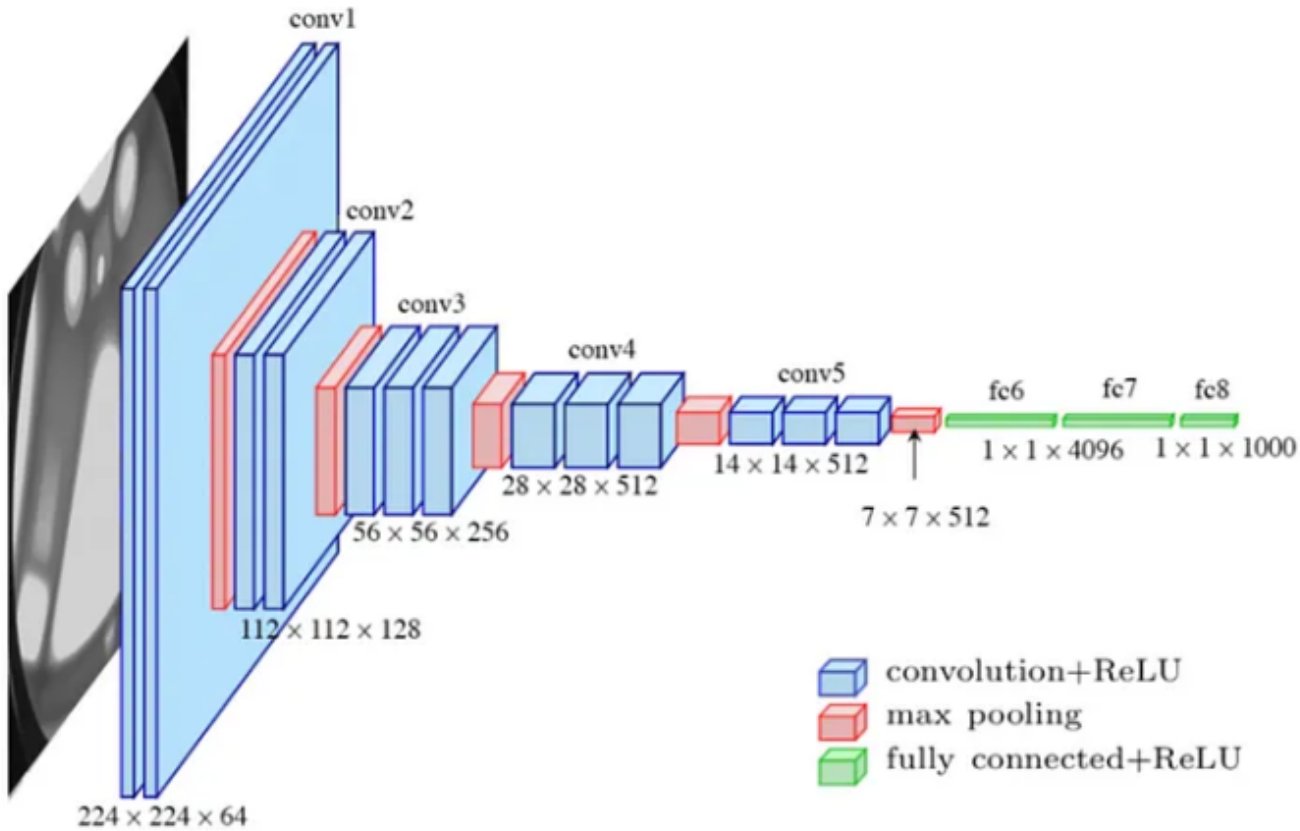
- **Result :**

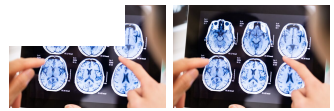
```
[ ]  1  from sklearn.metrics import classification_report
     2  print(classification_report(y_test_bin, y_pred_bin))
```

```
                precision    recall  f1-score   support

             0       0.97      0.76      0.85       126
             1       0.86      0.98      0.92       187

      accuracy                           0.89       313
     macro avg       0.91      0.87      0.89       313
  weighted avg       0.90      0.89      0.89       313
```


VGG 16 :

VGG is a simple yet powerful convolutional neural network architecture used to extract visual features from images.





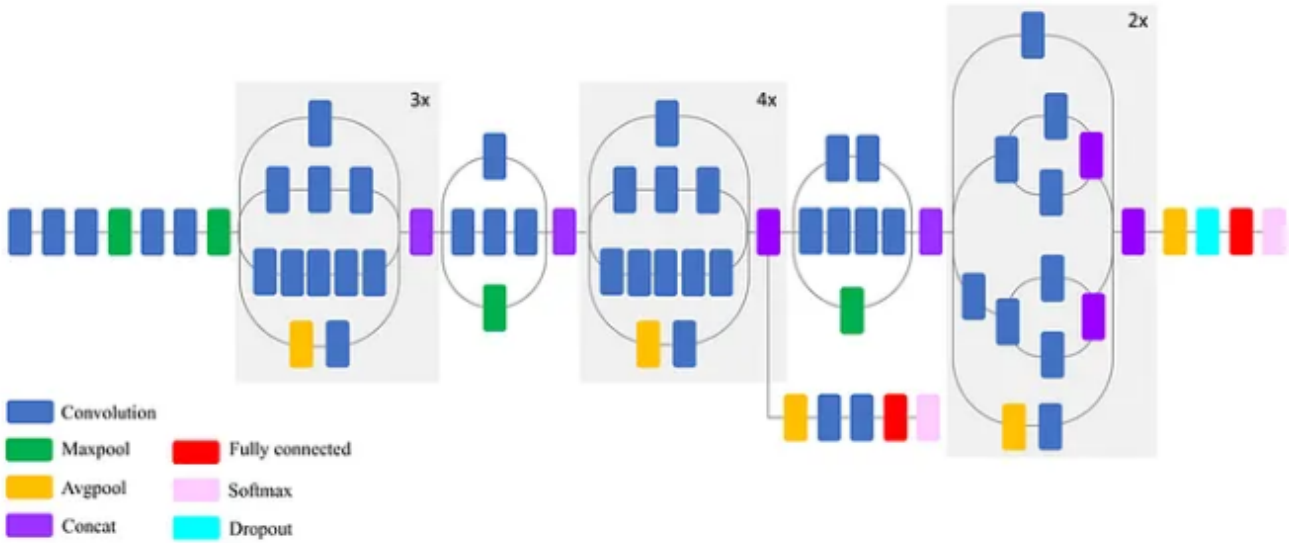
VGG 16 :

- **Result :**

	precision	recall	f1-score	support
0	0.92	0.76	0.83	102
1	0.89	0.97	0.93	211
accuracy			0.90	313
macro avg	0.91	0.87	0.88	313
weighted avg	0.90	0.90	0.90	313


Inception V3 :

Inception V3 is a CNN architecture. It uses convolution and pooling operations to extract meaningful features and has achieved excellent results in various computer vision tasks.




Inception V3 :

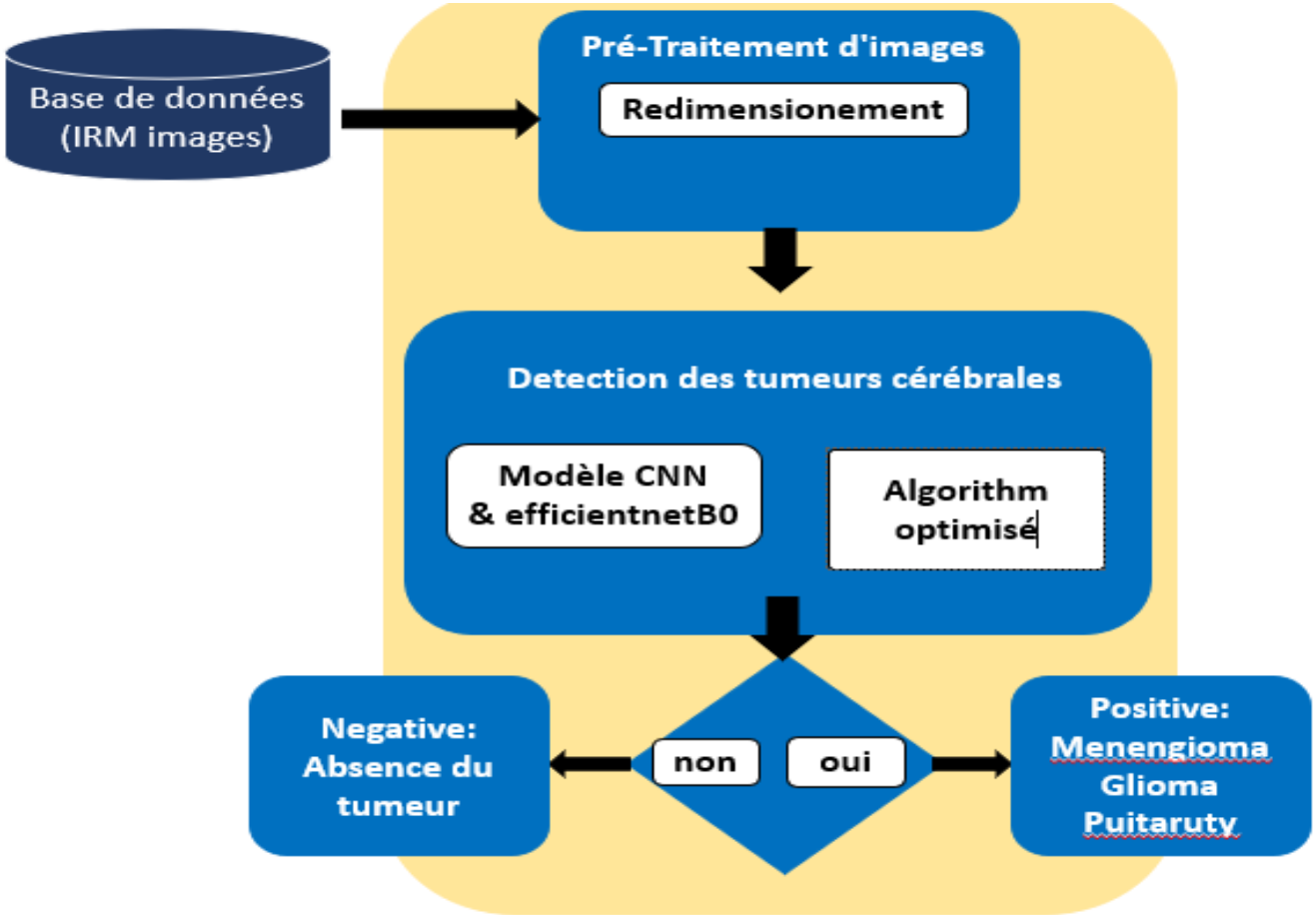
- **Result :**

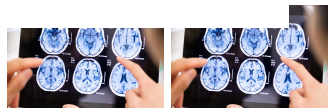
```
print(classification_report(y_test_bin, y_pred_bin))
```

	precision	recall	f1-score	support
0	0.91	0.74	0.82	116
1	0.86	0.96	0.91	197
accuracy			0.88	313
macro avg	0.89	0.85	0.86	313
weighted avg	0.88	0.88	0.88	313


CNN :

- **The main architecture of our project, part 2, is as follows**





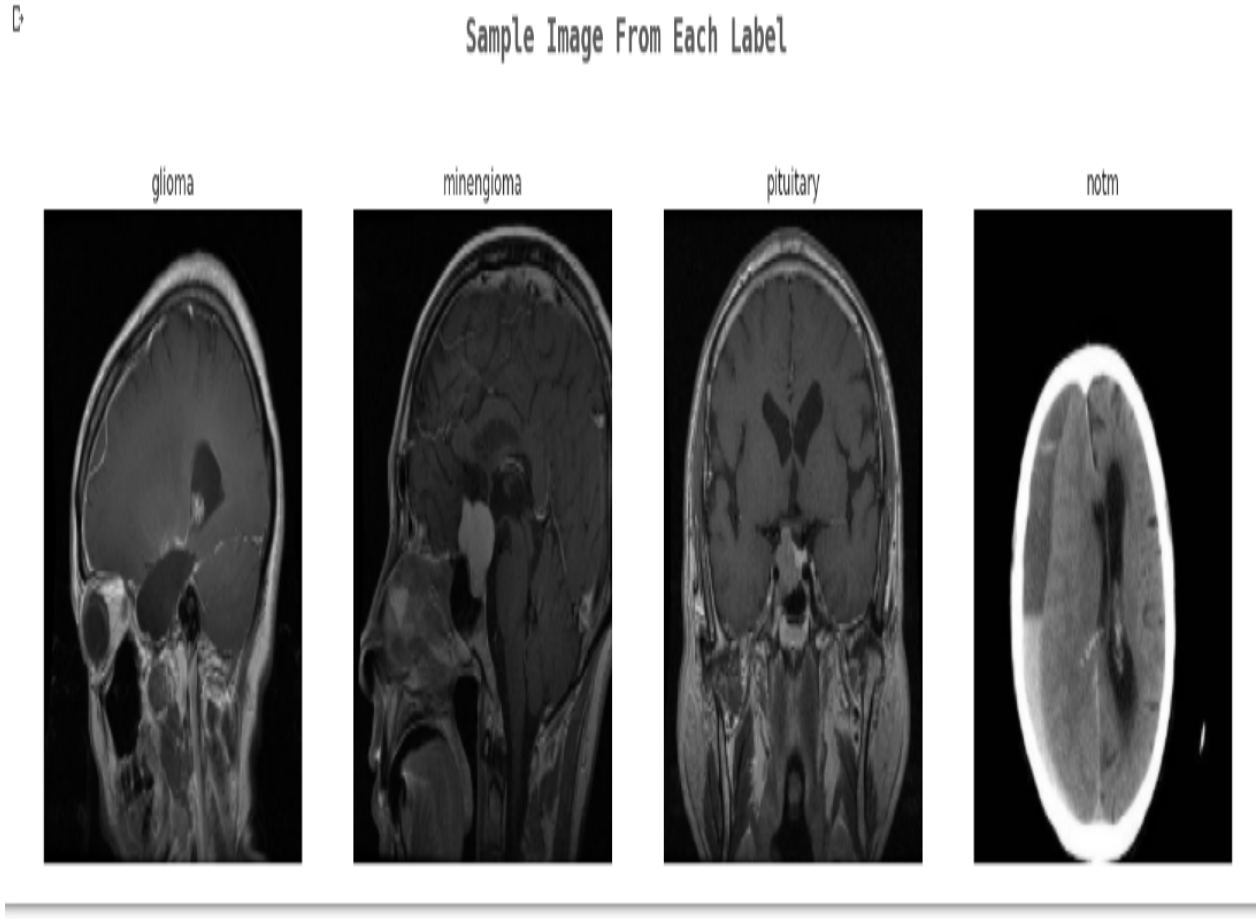
CNN :

- **Division of DATASET :**

In this part, we focus on the classification of brain tumor types (glioma, meningioma, pituitary, and non-tumor) using data divided into 80 percent for training and 20 percent for testing, as well as two improved versions of CNN and a pretrained EfficientNetB0 model

CNN :

- **Display of images for each type of tumor :**




CNN :

- **Result :**

```
1  pred = model.predict(X_test)
2  pred = np.argmax(pred,axis=1)
3  y_test_new = np.argmax(y_test,axis=1)
4
```

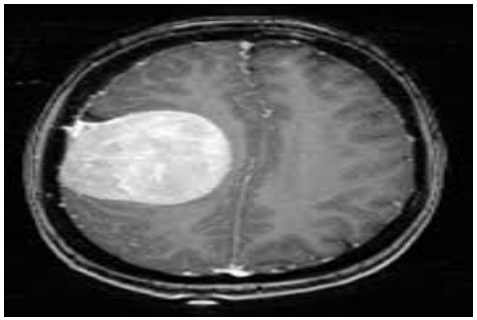
```
12/12 [==============================] - 2s 87ms/step
```

```
[ ]  1  print(classification_report(y_test_new,pred))
     2
```

	precision	recall	f1-score	support
0	0.97	0.96	0.97	110
1	0.97	0.93	0.95	108
2	0.97	1.00	0.99	104
3	0.94	1.00	0.97	46
accuracy			0.97	368
macro avg	0.96	0.97	0.97	368
weighted avg	0.97	0.97	0.97	368


CNN :

- **Result :**



Upload (1)

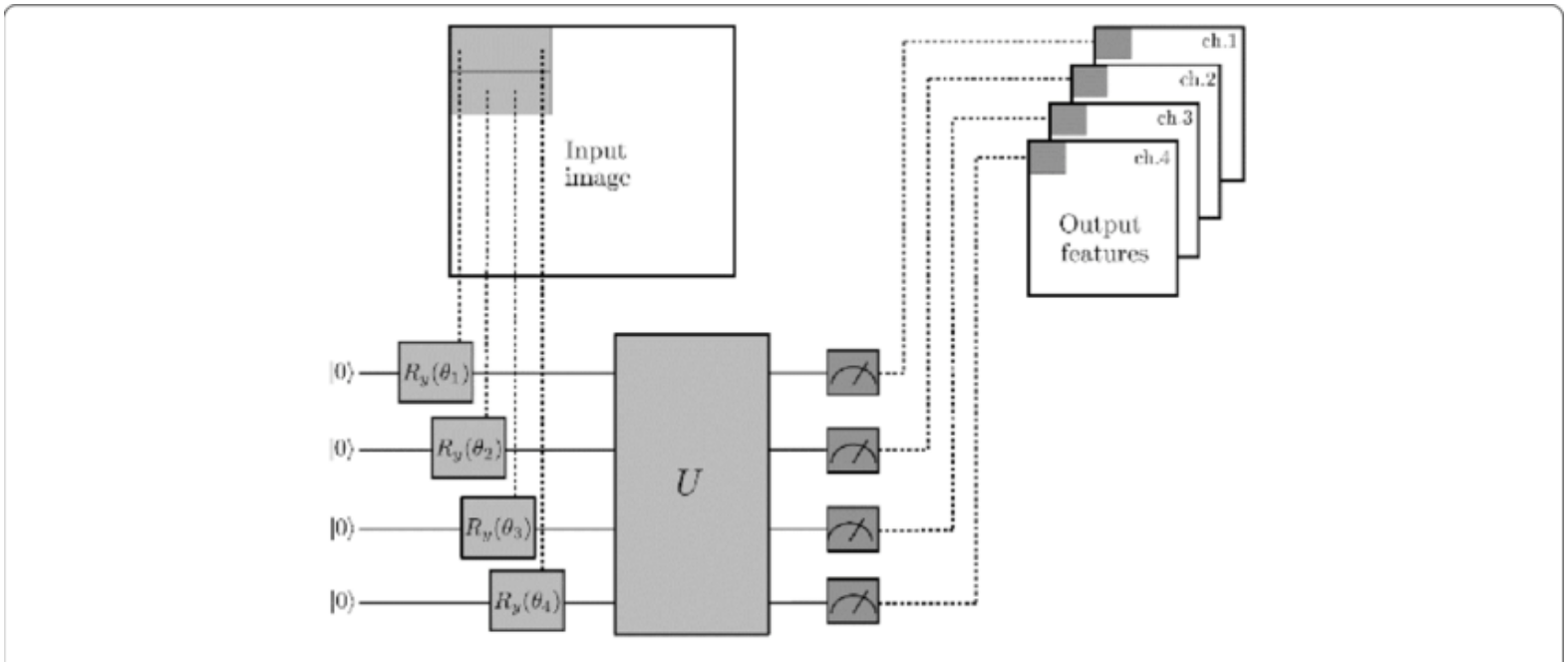
Predict

```
1/1 [==============================] - ETA: 0s
1/1 [==============================] - 0s 26ms/step
The Model predicts that it is a Minengioma
```

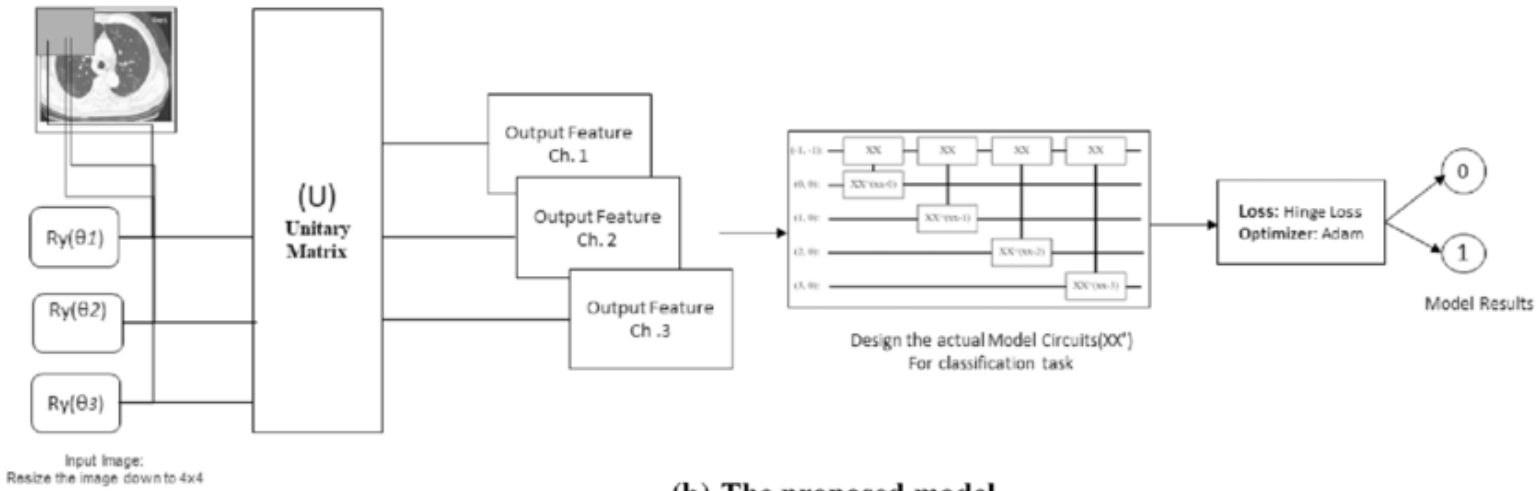

Quantum machine learning

In my research, I explored the application of Quantum Neural Networks (QNNs) in medical imaging, specifically for brain tumor detection.
What are QNNs ? QNNs are a type of neural network that principles from quantum computing to process and analyze data. They have the potential to perform complex computations more efficiently than classical neural networks

QNN-Architecture :

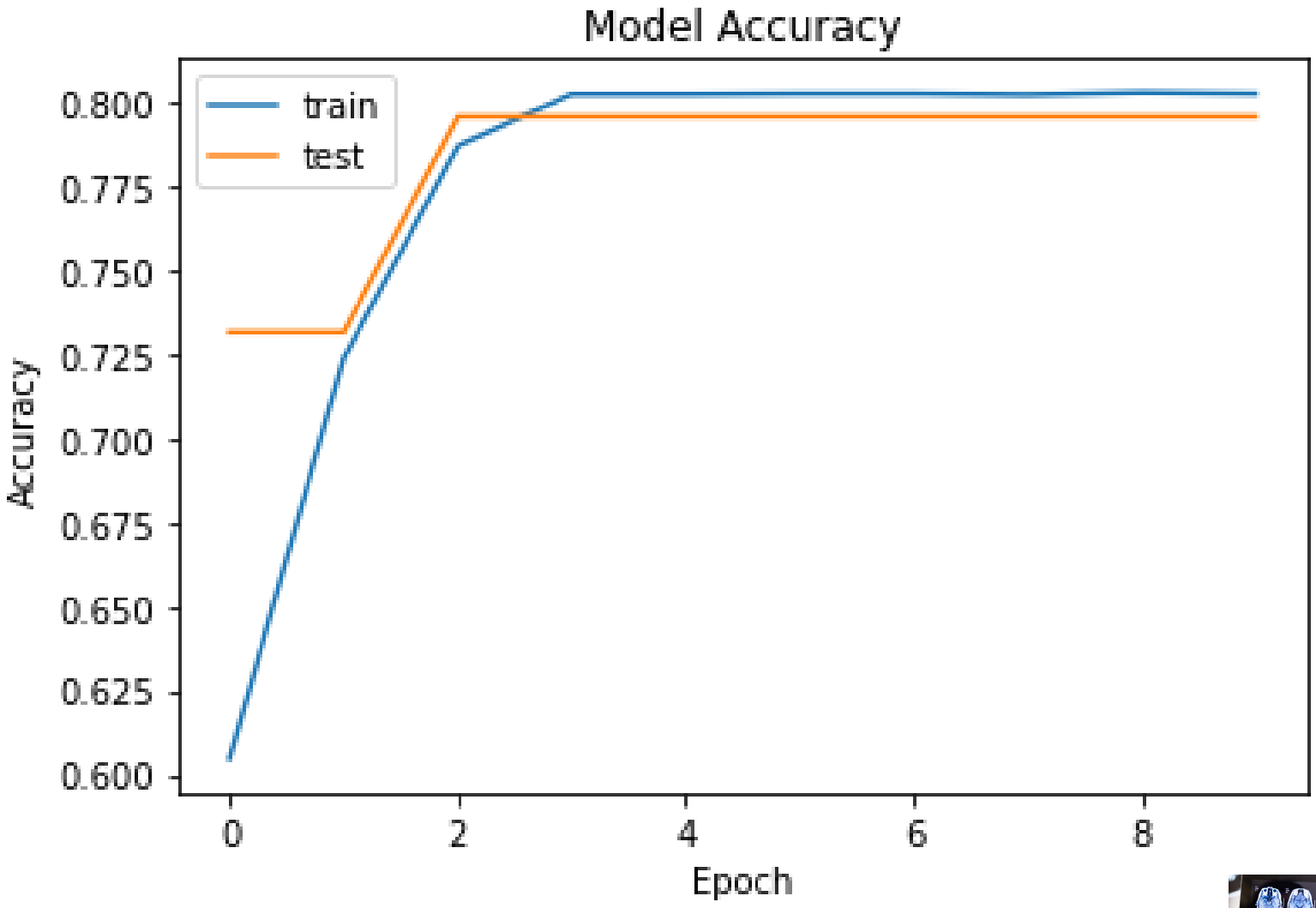


(a) QNN Architecture (Henderson et al., 2019)

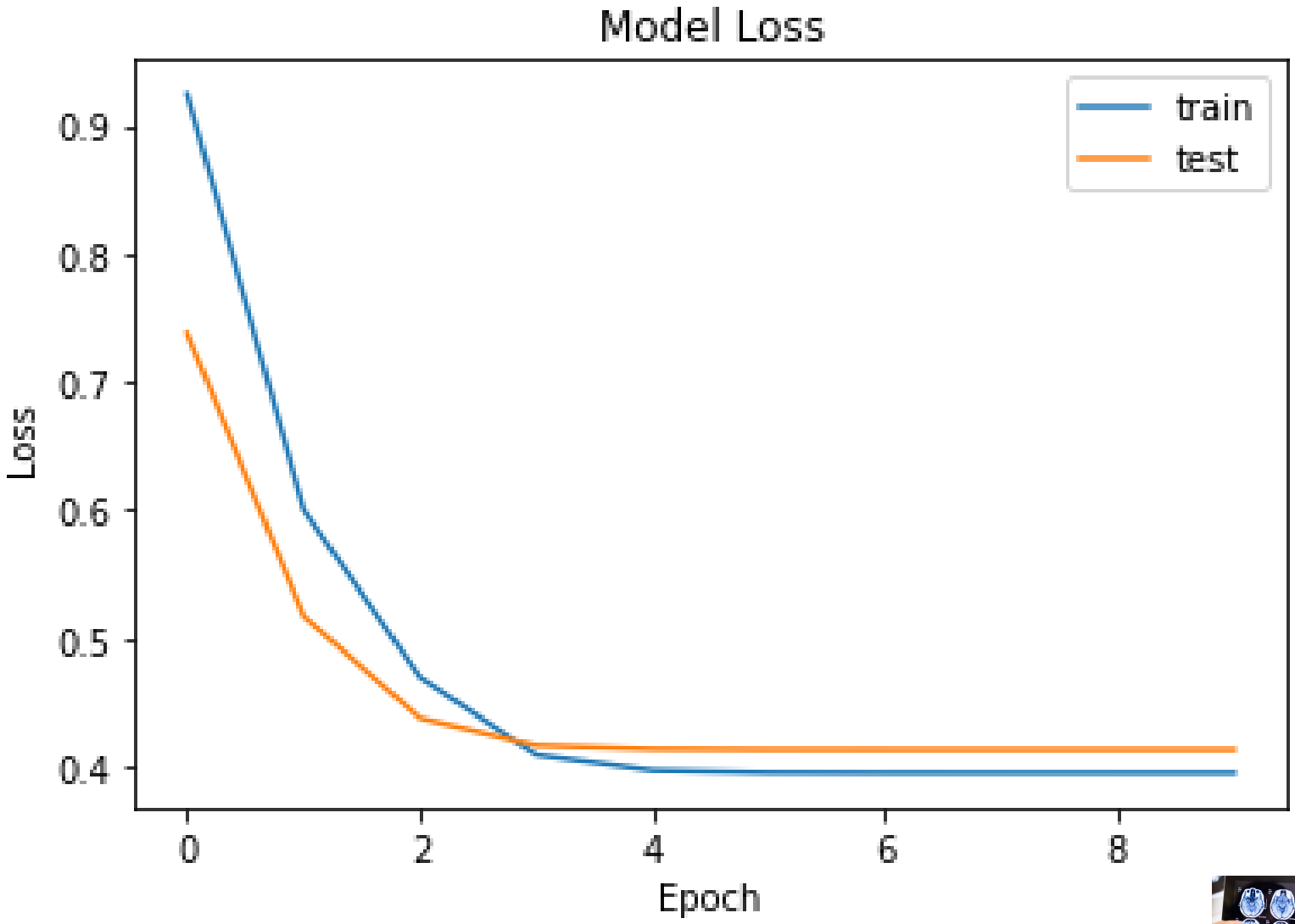


(b) The proposed model

Results


Model Accuracy
train
test
Accuracy
0.800
0.775
0.750
0.725
0.700
0.675
0.650
0.625
0.600
0
2
4
6
8
Epoch


Results



conclusion

We have developed a classification system for brain tumor images using a convolutional neural network (CNN) and transfer learning. Despite the small size of the data, the use of transfer learning with pretrained models has achieved a good classification accuracy of 97 percent.
Training a QNN is not much different from training a classical neural network ; it's just that instead of optimizing network weights, we optimize the parameters of a quantum circuit.
The impact of this study not only quantifies the ability of Quantum Machine Learning (QML) but also helps clinical scientists build diagnostic tools applied to drug discovery and disease identification problems with much faster analytical capability using quantum hardware. The study further provides prospects to evaluate quantum algorithms for more complex problems pertaining to image segmentation.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