Loading the essential datasets

In [4]:

```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
import glob
from sklearn import datasets
from PIL import Image
from tensorflow.keras.utils import image_dataset_from_directory
```

Loading the data

In [3]:

```
import zipfile

# Specify the path to your ZIP file
zip_file_path = '/content/Brain tumor.zip'

# Specify the directory where you want to extract the contents
extract_dir = '/content/BTE'

# Unzip the file
with zipfile.ZipFile(zip_file_path, 'r') as zip_ref:
    zip_ref.extractall(extract_dir)
```

In [5]:

```
image_list = []

for img_path in glob.iglob("/content/BTE/Brain Tumor Data Set/Brain Tumor Data Set/*/*.jpg"):
    img = Image.open(img_path)
    image_list.append(np.asarray(img))

image_array = np.asarray(image_list, dtype="object")
```

In [6]:

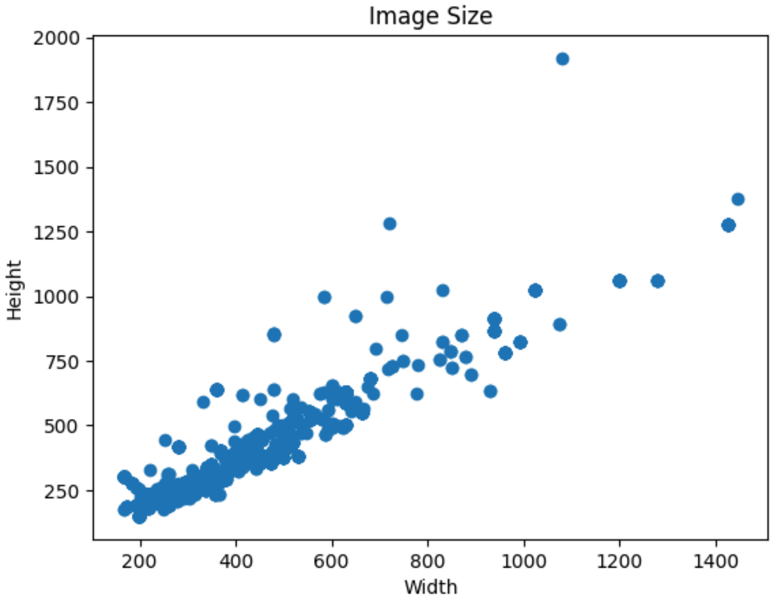
```
import numpy as np
import matplotlib.pyplot as plt

image_sizes_X = []
image_sizes_Y = []

for i in range(image_array.shape[0]):
    image_sizes_X.append(image_array[i].shape[0])
    image_sizes_Y.append(image_array[i].shape[1])

image_sizes_X = np.asarray(image_sizes_X)
image_sizes_Y = np.asarray(image_sizes_Y)

plt.scatter(image_sizes_X, image_sizes_Y)
plt.title("Image Size")
plt.xlabel("Width")
plt.ylabel("Height")
plt.show()
```



In [7]:

```
avg_width = np.mean(image_sizes_X).astype("int32")
avg_height = np.mean(image_sizes_Y).astype("int32")
image_size = (avg_width, avg_height)
image_size
```

Out[7]:

```
(381, 362)
```

In [8]:

```
from tensorflow.keras.preprocessing import image_dataset_from_directory

train_dataset = image_dataset_from_directory(
    "/content/BTE/Brain Tumor Data Set/Brain Tumor Data Set/",
    labels="inferred",
    image_size=image_size,
    color_mode="rgb",
    shuffle=True,
    batch_size=32,
    validation_split=0.3,
    subset="training",
    seed=16
)

validation_dataset = image_dataset_from_directory(
    "/content/BTE/Brain Tumor Data Set/Brain Tumor Data Set/",
    labels="inferred",
    image_size=image_size,
    color_mode="rgb",
    shuffle=True,
    batch_size=32,
    validation_split=0.3,
    subset="validation",
    seed=16
)
```

```
Found 4514 files belonging to 2 classes.
Using 3160 files for training.
Found 4514 files belonging to 2 classes.
Using 1354 files for validation.
```

In [9]:

```
classes = train_dataset.class_names
classes
```

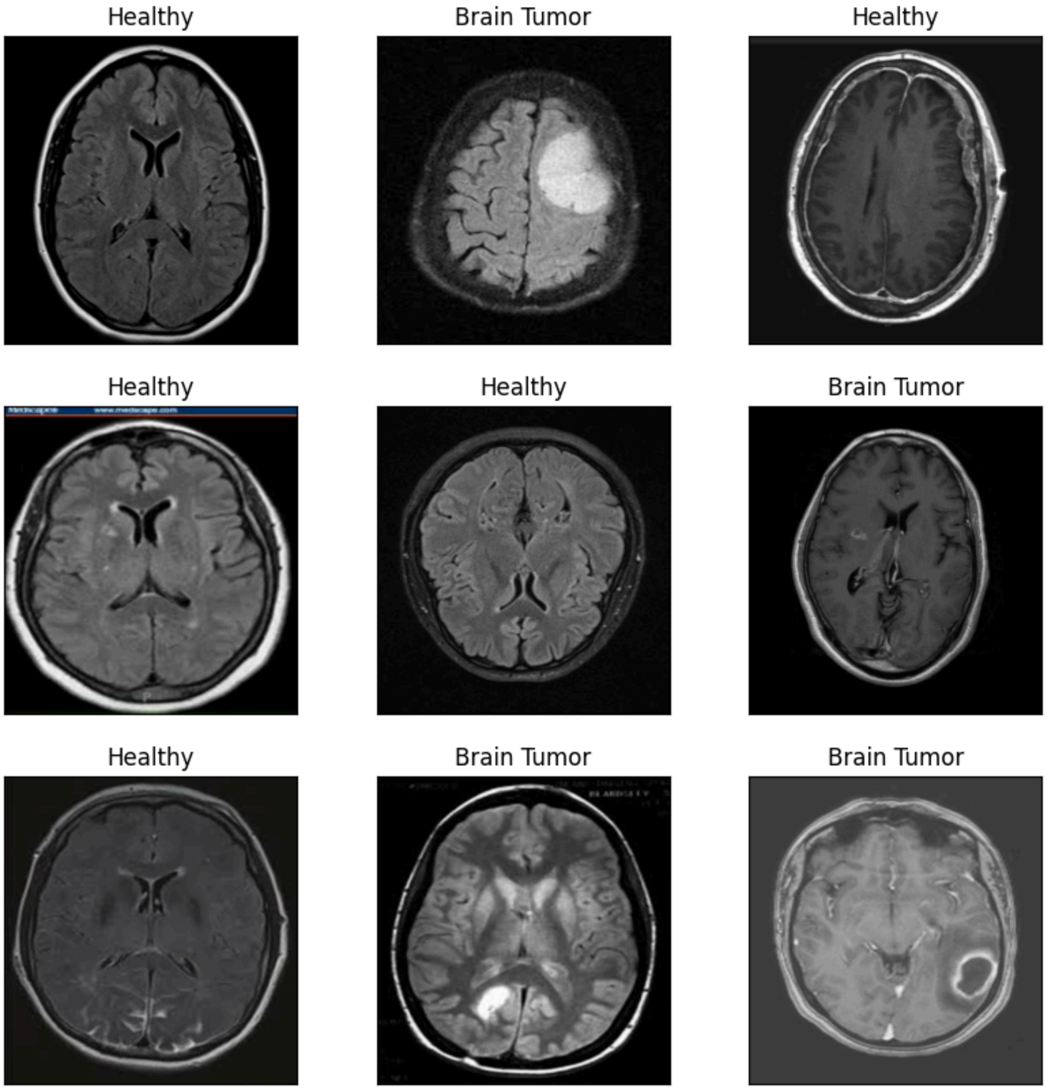
Out[9]:

```
['Brain Tumor', 'Healthy']
```

DATA VISUALIZATION

In [10]:

```
for images, labels in train_dataset.take(1):
    figs, axs = plt.subplots(3, 3, figsize=(10,10))
    for i in range(3):
        temp = 3*i
        for j in range(3):
            index = temp + j
            axs[i][j].imshow(images[index].numpy().astype("int32"))
            axs[i][j].set_title(classes[labels[index]])
            axs[i][j].set_xticks(ticks=[])
            axs[i][j].set_yticks(ticks=[])
```



Healthy Brain Tumor Healthy

Healthy Healthy Brain Tumor

Healthy Brain Tumor Brain Tumor

In [11]:

```
AUTOTUNE = tf.data.experimental.AUTOTUNE

train_dataset = train_dataset.prefetch(buffer_size=AUTOTUNE)
validation_dataset = validation_dataset.prefetch(buffer_size=AUTOTUNE)
```

In [ ]:

MODEL WE SELECTED APRE-TRAINED MODEL OF VGG16

In [12]:

```
image_shape = image_size + (3,)
```

In [13]:

```python
base_model = tf.keras.applications.vgg16.VGG16(include_top=False,
                                               weights="imagenet",
                                               input_shape=image_shape)
base_model.summary()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/vgg16/vgg16_weights_tf_dim_ordering
_tf_kernels_notop.h5 (https://storage.googleapis.com/tensorflow/keras-applications/vgg16/vgg16_weights_tf_dim_ordering
_tf_kernels_notop.h5)
58889256/58889256 [==============================] - 0s 0us/step
Model: "vgg16"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 input_1 (InputLayer)        [(None, 381, 362, 3)]     0         
                                                                 
 block1_conv1 (Conv2D)       (None, 381, 362, 64)      1792      
                                                                 
 block1_conv2 (Conv2D)       (None, 381, 362, 64)      36928     
                                                                 
 block1_pool (MaxPooling2D)  (None, 190, 181, 64)      0         
                                                                 
 block2_conv1 (Conv2D)       (None, 190, 181, 128)     73856     
                                                                 
 block2_conv2 (Conv2D)       (None, 190, 181, 128)     147584    
                                                                 
 block2_pool (MaxPooling2D)  (None, 95, 90, 128)       0         
                                                                 
 block3_conv1 (Conv2D)       (None, 95, 90, 256)       295168    
                                                                 
 block3_conv2 (Conv2D)       (None, 95, 90, 256)       590080    
                                                                 
 block3_conv3 (Conv2D)       (None, 95, 90, 256)       590080    
                                                                 
 block3_pool (MaxPooling2D)  (None, 47, 45, 256)       0         
                                                                 
 block4_conv1 (Conv2D)       (None, 47, 45, 512)       1180160   
                                                                 
 block4_conv2 (Conv2D)       (None, 47, 45, 512)       2359808   
                                                                 
 block4_conv3 (Conv2D)       (None, 47, 45, 512)       2359808   
                                                                 
 block4_pool (MaxPooling2D)  (None, 23, 22, 512)       0         
                                                                 
 block5_conv1 (Conv2D)       (None, 23, 22, 512)       2359808   
                                                                 
 block5_conv2 (Conv2D)       (None, 23, 22, 512)       2359808   
                                                                 
 block5_conv3 (Conv2D)       (None, 23, 22, 512)       2359808   
                                                                 
 block5_pool (MaxPooling2D)  (None, 11, 11, 512)       0         
                                                                 
=================================================================
Total params: 14714688 (56.13 MB)
Trainable params: 14714688 (56.13 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

In [14]:

```python
def tumor_classifier(input_shape):
    base_model = tf.keras.applications.vgg16.VGG16(include_top=False,
                                                   weights="imagenet",
                                                   input_shape=input_shape)
    base_model.trainable = False

    inputs = tf.keras.layers.Input(shape=input_shape)
    x = tf.keras.layers.Rescaling(1./255)(inputs)
    x = tf.keras.applications.vgg16.preprocess_input(x)
    x = base_model(x, training=False)
    x = tf.keras.layers.Flatten()(x)
    outputs = tf.keras.layers.Dense(1)(x)

    model = tf.keras.Model(inputs, outputs)
    return model
```

```
In [15]:  model = tumor_classifier(input_shape=image_shape)
          model.summary()
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 input_3 (InputLayer)        [(None, 381, 362, 3)]     0         
                                                                 
 rescaling (Rescaling)       (None, 381, 362, 3)       0         
                                                                 
 tf.__operators__.getitem (  (None, 381, 362, 3)       0         
 SlicingOpLambda)                                                
                                                                 
 tf.nn.bias_add (TFOpLambda  (None, 381, 362, 3)       0         
 )                                                               
                                                                 
 vgg16 (Functional)          (None, 11, 11, 512)       14714688  
                                                                 
 flatten (Flatten)           (None, 61952)             0         
                                                                 
 dense (Dense)               (None, 1)                 61953     
                                                                 
=================================================================
Total params: 14776641 (56.37 MB)
Trainable params: 61953 (242.00 KB)
Non-trainable params: 14714688 (56.13 MB)
_________________________________________________________________
```

Training the model

```
In [16]:  model.compile(optimizer=tf.keras.optimizers.Adam(1e-3),
                        loss=tf.keras.losses.BinaryCrossentropy(from_logits=True),
                        metrics=["accuracy"])

          epochs = 10
          history = model.fit(train_dataset, batch_size=32, validation_data=validation_dataset, epochs=epochs)
```

```
Epoch 1/10
99/99 [==============================] - 81s 643ms/step - loss: 0.6684 - accuracy: 0.6272 - val_loss: 0.5773 - val_acc
uracy: 0.6617
Epoch 2/10
99/99 [==============================] - 49s 490ms/step - loss: 0.6066 - accuracy: 0.6693 - val_loss: 0.5926 - val_acc
uracy: 0.6573
Epoch 3/10
99/99 [==============================] - 50s 497ms/step - loss: 0.5470 - accuracy: 0.6994 - val_loss: 0.5792 - val_acc
uracy: 0.6603
Epoch 4/10
99/99 [==============================] - 50s 504ms/step - loss: 0.5407 - accuracy: 0.7019 - val_loss: 0.5337 - val_acc
uracy: 0.6869
Epoch 5/10
99/99 [==============================] - 50s 504ms/step - loss: 0.5082 - accuracy: 0.7225 - val_loss: 0.5314 - val_acc
uracy: 0.7075
Epoch 6/10
99/99 [==============================] - 49s 492ms/step - loss: 0.5590 - accuracy: 0.6981 - val_loss: 0.5223 - val_acc
uracy: 0.6839
Epoch 7/10
99/99 [==============================] - 49s 489ms/step - loss: 0.4931 - accuracy: 0.7297 - val_loss: 0.5181 - val_acc
uracy: 0.6809
Epoch 8/10
99/99 [==============================] - 55s 554ms/step - loss: 0.4818 - accuracy: 0.7396 - val_loss: 0.5107 - val_acc
uracy: 0.7326
Epoch 9/10
99/99 [==============================] - 50s 501ms/step - loss: 0.4908 - accuracy: 0.7383 - val_loss: 0.5637 - val_acc
uracy: 0.7703
Epoch 10/10
99/99 [==============================] - 51s 512ms/step - loss: 0.4659 - accuracy: 0.7547 - val_loss: 0.4995 - val_acc
uracy: 0.7378
```

```
In [17]:  len(base_model.layers)

Out[17]:  19
```

In [18]:

```
def fine_tuned_model(input_shape, num_frozen_layers):
    base_model = tf.keras.applications.vgg16.VGG16(input_shape=input_shape,
                                                   weights="imagenet",
                                                   include_top=False)
    base_model.trainable = True
    for layer in base_model.layers[:num_frozen_layers]:
        layer.trainable = False

    inputs = tf.keras.layers.Input(shape=input_shape)
    x = tf.keras.layers.Rescaling(1./255)(inputs)
    x = tf.keras.applications.vgg16.preprocess_input(x)
    x = base_model(x)
    x = tf.keras.layers.Conv2D(filters=1024, kernel_size=(3,3), padding="same", strides=1)(x)
    x = tf.keras.layers.BatchNormalization()(x)
    x = tf.keras.layers.Conv2D(filters=1024, kernel_size=(3,3), padding="same", strides=1)(x)
    x = tf.keras.layers.BatchNormalization()(x)
    x = tf.keras.layers.Conv2D(filters=1024, kernel_size=(3,3), padding="same", strides=1)(x)
    x = tf.keras.layers.BatchNormalization()(x)
    x = tf.keras.layers.MaxPooling2D()(x)
    x = tf.keras.layers.BatchNormalization()(x)
    x = tf.keras.layers.Flatten()(x)
    outputs = tf.keras.layers.Dense(1)(x)

    model = tf.keras.Model(inputs, outputs)
    return model
```

In [21]:

```
num_frozen_layers = 7
model = fine_tuned_model(input_shape=image_shape, num_frozen_layers=num_frozen_layers)
model.summary()
```

```
Model: "model_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 input_9 (InputLayer)        [(None, 381, 362, 3)]     0         
                                                                 
 rescaling_3 (Rescaling)     (None, 381, 362, 3)       0         
                                                                 
 tf.__operators__.getitem_3  (None, 381, 362, 3)       0         
  (SlicingOpLambda)                                              
                                                                 
 tf.nn.bias_add_3 (TFOpLamb  (None, 381, 362, 3)       0         
 da)                                                             
                                                                 
 vgg16 (Functional)          (None, 11, 11, 512)       14714688  
                                                                 
 conv2d_6 (Conv2D)           (None, 11, 11, 1024)      4719616   
                                                                 
 batch_normalization_8 (Bat  (None, 11, 11, 1024)      4096      
 chNormalization)                                                
                                                                 
 conv2d_7 (Conv2D)           (None, 11, 11, 1024)      9438208   
                                                                 
 batch_normalization_9 (Bat  (None, 11, 11, 1024)      4096      
 chNormalization)                                                
                                                                 
 conv2d_8 (Conv2D)           (None, 11, 11, 1024)      9438208   
                                                                 
 batch_normalization_10 (Ba  (None, 11, 11, 1024)      4096      
 tchNormalization)                                               
                                                                 
 max_pooling2d_2 (MaxPoolin  (None, 5, 5, 1024)        0         
 g2D)                                                            
                                                                 
 batch_normalization_11 (Ba  (None, 5, 5, 1024)        4096      
 tchNormalization)                                               
                                                                 
 flatten_3 (Flatten)         (None, 25600)             0         
                                                                 
 dense_3 (Dense)             (None, 1)                 25601     
                                                                 
=================================================================
Total params: 38352705 (146.30 MB)
Trainable params: 38084353 (145.28 MB)
Non-trainable params: 268352 (1.02 MB)
_________________________________________________________________
```

In [22]:

```
model.compile(optimizer=tf.keras.optimizers.Adam(1e-3),
              loss=tf.keras.losses.BinaryCrossentropy(from_logits=True),
              metrics=["accuracy"])

epochs = 10
history = model.fit(train_dataset, batch_size=32, validation_data=validation_dataset, epochs=epochs)
```

```
Epoch 1/10
99/99 [==============================] - 130s 1s/step - loss: 1.5992 - accuracy: 0.5864 - val_loss: 124.1439 - val_acc
uracy: 0.4586
Epoch 2/10
99/99 [==============================] - 93s 930ms/step - loss: 0.9581 - accuracy: 0.6522 - val_loss: 27.1999 - val_ac
curacy: 0.4586
Epoch 3/10
99/99 [==============================] - 96s 964ms/step - loss: 1.0208 - accuracy: 0.6247 - val_loss: 81.9209 - val_ac
curacy: 0.4586
Epoch 4/10
99/99 [==============================] - 91s 916ms/step - loss: 0.7207 - accuracy: 0.6956 - val_loss: 72.1323 - val_ac
curacy: 0.4586
Epoch 5/10
99/99 [==============================] - 89s 896ms/step - loss: 0.7081 - accuracy: 0.7127 - val_loss: 10.4022 - val_ac
curacy: 0.4586
Epoch 6/10
99/99 [==============================] - 90s 909ms/step - loss: 0.5988 - accuracy: 0.7370 - val_loss: 6.0522 - val_acc
uracy: 0.4586
Epoch 7/10
99/99 [==============================] - 90s 904ms/step - loss: 0.4973 - accuracy: 0.7687 - val_loss: 5.2556 - val_acc
uracy: 0.5414
Epoch 8/10
99/99 [==============================] - 90s 906ms/step - loss: 0.4783 - accuracy: 0.7842 - val_loss: 10.2883 - val_ac
curacy: 0.5414
Epoch 9/10
99/99 [==============================] - 90s 905ms/step - loss: 0.5461 - accuracy: 0.7712 - val_loss: 9.9714 - val_acc
uracy: 0.4586
Epoch 10/10
99/99 [==============================] - 95s 959ms/step - loss: 0.7334 - accuracy: 0.7475 - val_loss: 6.4082 - val_acc
uracy: 0.4594
```

In [23]:

```
epochs = 20
history2 = model.fit(train_dataset, batch_size=32, validation_data=validation_dataset, epochs=epochs, initial_epoch=his
```

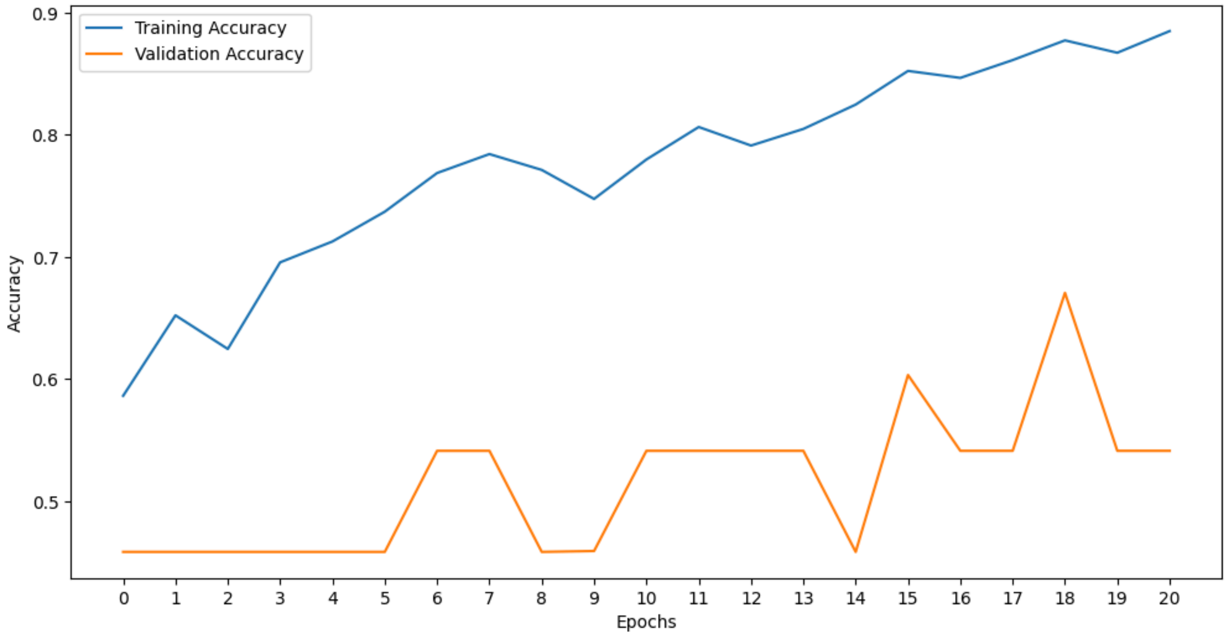
```
Epoch 10/20
99/99 [==============================] - 90s 905ms/step - loss: 0.5751 - accuracy: 0.7797 - val_loss: 51.5746 - val_ac
curacy: 0.5414
Epoch 11/20
99/99 [==============================] - 90s 902ms/step - loss: 0.5159 - accuracy: 0.8063 - val_loss: 13.0680 - val_ac
curacy: 0.5414
Epoch 12/20
99/99 [==============================] - 90s 903ms/step - loss: 0.5968 - accuracy: 0.7911 - val_loss: 33.8107 - val_ac
curacy: 0.5414
Epoch 13/20
99/99 [==============================] - 93s 930ms/step - loss: 0.5655 - accuracy: 0.8047 - val_loss: 42.5975 - val_ac
curacy: 0.5414
Epoch 14/20
99/99 [==============================] - 96s 964ms/step - loss: 0.4754 - accuracy: 0.8247 - val_loss: 19.1672 - val_ac
curacy: 0.4586
Epoch 15/20
99/99 [==============================] - 96s 963ms/step - loss: 0.3682 - accuracy: 0.8522 - val_loss: 2.4342 - val_acc
uracy: 0.6034
Epoch 16/20
99/99 [==============================] - 96s 964ms/step - loss: 0.3911 - accuracy: 0.8465 - val_loss: 23.1410 - val_ac
curacy: 0.5414
Epoch 17/20
99/99 [==============================] - 96s 962ms/step - loss: 0.3611 - accuracy: 0.8611 - val_loss: 17.8802 - val_ac
curacy: 0.5414
Epoch 18/20
99/99 [==============================] - 91s 918ms/step - loss: 0.3036 - accuracy: 0.8772 - val_loss: 1.1551 - val_acc
uracy: 0.6706
Epoch 19/20
99/99 [==============================] - 91s 914ms/step - loss: 0.3551 - accuracy: 0.8671 - val_loss: 30.5873 - val_ac
curacy: 0.5414
Epoch 20/20
99/99 [==============================] - 92s 916ms/step - loss: 0.2823 - accuracy: 0.8848 - val_loss: 17.6090 - val_ac
curacy: 0.5414
```

ERROR ANALYSIS

In [24]:

```
acc = history.history["accuracy"] + history2.history["accuracy"]
val_acc = history.history["val_accuracy"] + history2.history["val_accuracy"]

plt.figure(figsize=(12,6))
plt.plot(range(epochs+1), acc, label="Training Accuracy")
plt.plot(range(epochs+1), val_acc, label="Validation Accuracy")
plt.legend(loc="upper left")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.xticks(list(range(epochs+1)))
plt.show()
```



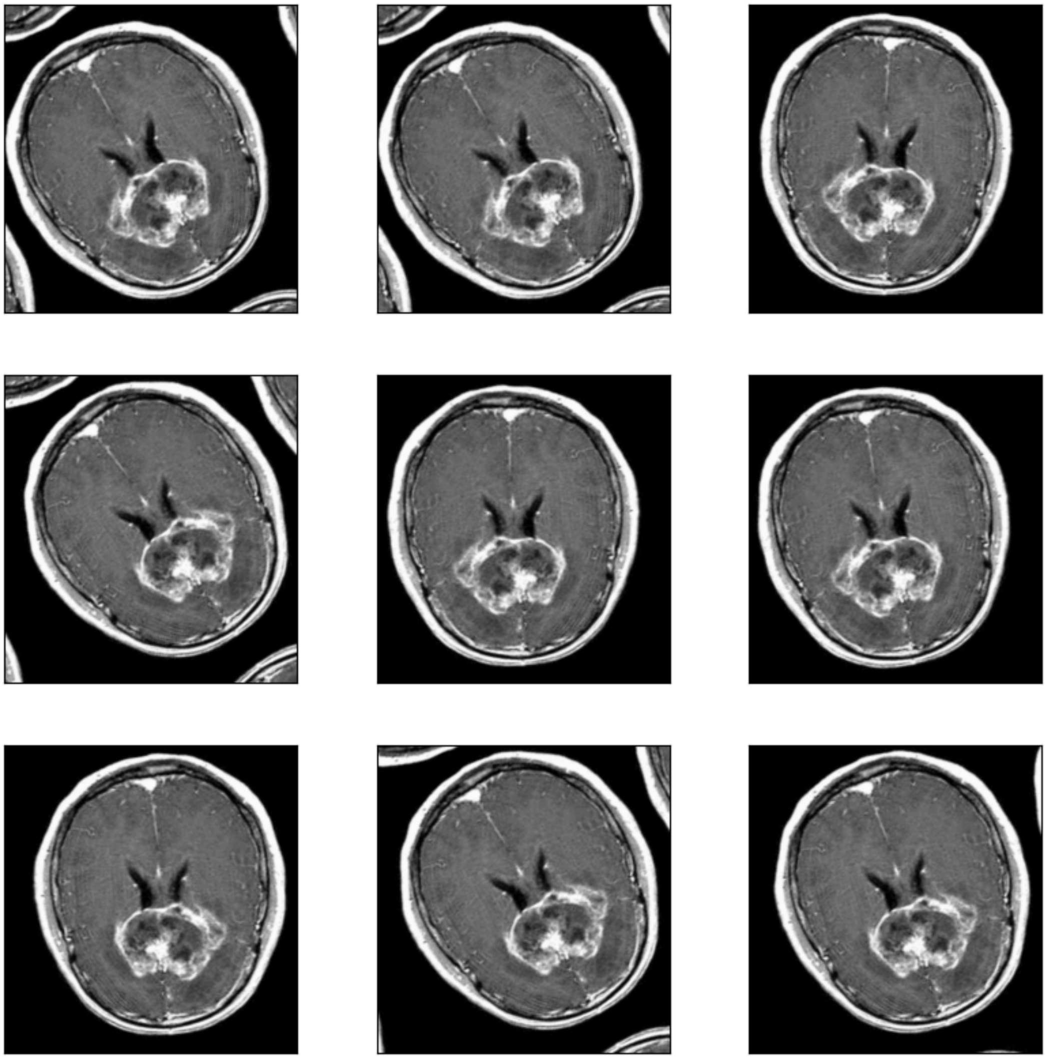
In [25]:

```
def augment_data(input):
    x = tf.keras.layers.RandomFlip("horizontal")(input)
    output = tf.keras.layers.RandomRotation(0.1)(x)

    return output
```

In [26]:

```
for images, labels in train_dataset.take(1):
    img = images[0]
    figs, axs = plt.subplots(3, 3, figsize=(10,10))
    for i in range(3):
        for j in range(3):
            augmented_img = augment_data(img)
            axs[i][j].imshow(augmented_img.numpy().astype("int32"))
            axs[i][j].set_xticks(ticks=[])
            axs[i][j].set_yticks(ticks=[])
```



In [27]:

```
def data_augmented_regularized_model(input_shape, num_freezed_layers):
    base_model = tf.keras.applications.vgg16.VGG16(input_shape=input_shape, include_top=False, weights="imagenet")

    base_model.trainable = True
    for layer in base_model.layers[:num_freezed_layers]:
        layer.trainable = False

    inputs = tf.keras.layers.Input(shape=input_shape)
    x = augment_data(inputs)
    x = tf.keras.layers.Rescaling(1./255)(x)
    x = tf.keras.applications.vgg16.preprocess_input(x)
    x = base_model(x)
    x = tf.keras.layers.Conv2D(filters=1024, kernel_size=(3,3), padding="same", strides=1)(x)
    x = tf.keras.layers.BatchNormalization()(x)
    x = tf.keras.layers.Conv2D(filters=1024, kernel_size=(3,3), padding="same", strides=1)(x)
    x = tf.keras.layers.BatchNormalization()(x)
    x = tf.keras.layers.Conv2D(filters=1024, kernel_size=(3,3), padding="same", strides=1)(x)
    x = tf.keras.layers.BatchNormalization()(x)
    x = tf.keras.layers.MaxPooling2D()(x)
    x = tf.keras.layers.BatchNormalization()(x)
    x = tf.keras.layers.Dropout(0.2)(x)
    x = tf.keras.layers.Flatten()(x)
    outputs = tf.keras.layers.Dense(1)(x)

    model = tf.keras.Model(inputs, outputs)
    return model
```

In [28]:

```
num_frozen_layers = 7
model = data_augmented_regularized_model(input_shape=image_shape, num_freezed_layers=num_frozen_layers)

model.compile(optimizer=tf.keras.optimizers.Adam(1e-3),
              loss=tf.keras.losses.BinaryCrossentropy(from_logits=True),
              metrics=["accuracy"])

epochs = 20
history = model.fit(train_dataset, batch_size=32, validation_data=validation_dataset, epochs=epochs)
```

```
Epoch 1/20
99/99 [==============================] - 111s 1s/step - loss: 1.8527 - accuracy: 0.5165 - val_loss: 13.6772 - val_accu
racy: 0.4586
Epoch 2/20
99/99 [==============================] - 109s 1s/step - loss: 0.8617 - accuracy: 0.5687 - val_loss: 34.9234 - val_accu
racy: 0.4586
Epoch 3/20
99/99 [==============================] - 105s 1s/step - loss: 0.8703 - accuracy: 0.6484 - val_loss: 84.2635 - val_accu
racy: 0.4586
Epoch 4/20
99/99 [==============================] - 105s 1s/step - loss: 0.8410 - accuracy: 0.6646 - val_loss: 42.5906 - val_accu
racy: 0.4586
Epoch 5/20
99/99 [==============================] - 105s 1s/step - loss: 0.9565 - accuracy: 0.6402 - val_loss: 22.8999 - val_accu
racy: 0.4586
Epoch 6/20
99/99 [==============================] - 104s 1s/step - loss: 0.7074 - accuracy: 0.6880 - val_loss: 3.0703 - val_accur
acy: 0.4778
Epoch 7/20
99/99 [==============================] - 104s 1s/step - loss: 0.8588 - accuracy: 0.6766 - val_loss: 49.4450 - val_accu
racy: 0.4586
Epoch 8/20
99/99 [==============================] - 105s 1s/step - loss: 0.6760 - accuracy: 0.7165 - val_loss: 1.6748 - val_accur
acy: 0.5554
Epoch 9/20
99/99 [==============================] - 104s 1s/step - loss: 0.6351 - accuracy: 0.7275 - val_loss: 2.2253 - val_accur
acy: 0.5510
Epoch 10/20
99/99 [==============================] - 108s 1s/step - loss: 0.8314 - accuracy: 0.7165 - val_loss: 212.9399 - val_acc
uracy: 0.4586
Epoch 11/20
99/99 [==============================] - 106s 1s/step - loss: 0.6071 - accuracy: 0.7392 - val_loss: 8.0272 - val_accur
acy: 0.5414
Epoch 12/20
99/99 [==============================] - 103s 1s/step - loss: 0.5251 - accuracy: 0.7566 - val_loss: 0.3999 - val_accur
acy: 0.8205
Epoch 13/20
99/99 [==============================] - 107s 1s/step - loss: 0.6406 - accuracy: 0.7468 - val_loss: 8.9735 - val_accur
acy: 0.4586
Epoch 14/20
99/99 [==============================] - 107s 1s/step - loss: 0.6137 - accuracy: 0.7652 - val_loss: 31.7377 - val_accu
racy: 0.4586
Epoch 15/20
99/99 [==============================] - 103s 1s/step - loss: 0.5482 - accuracy: 0.7769 - val_loss: 3.4996 - val_accur
acy: 0.5421
Epoch 16/20
99/99 [==============================] - 104s 1s/step - loss: 0.5054 - accuracy: 0.7921 - val_loss: 49.7994 - val_accu
racy: 0.4586
Epoch 17/20
99/99 [==============================] - 108s 1s/step - loss: 0.4968 - accuracy: 0.7934 - val_loss: 18.1423 - val_accu
racy: 0.4586
Epoch 18/20
99/99 [==============================] - 109s 1s/step - loss: 0.6261 - accuracy: 0.7744 - val_loss: 64.9189 - val_accu
racy: 0.4586
Epoch 19/20
99/99 [==============================] - 109s 1s/step - loss: 0.4718 - accuracy: 0.8089 - val_loss: 25.4782 - val_accu
racy: 0.5414
Epoch 20/20
99/99 [==============================] - 109s 1s/step - loss: 0.4444 - accuracy: 0.8095 - val_loss: 5.1169 - val_accur
acy: 0.5414
```

After the regularization and data augmentation. The validation accuracy doesnot increase. So as the VGG16 Model has toomany layers we tried building model with few layers

In [29]:

```
def Modfinal_model(input_shape):
    inputs = tf.keras.layers.Input(shape=input_shape)
    x = tf.keras.layers.Rescaling(1./255)(inputs)
    x = augment_data(x)
    x = tf.keras.layers.Conv2D(16, (3,3), padding="same", activation="relu")(x)
    x = tf.keras.layers.MaxPooling2D()(x)
    x = tf.keras.layers.Conv2D(32, (3,3), padding="same", activation="relu")(x)
    x = tf.keras.layers.MaxPooling2D()(x)
    x = tf.keras.layers.Conv2D(64, (3,3), padding="same", activation="relu")(x)
    x = tf.keras.layers.MaxPooling2D()(x)
    x = tf.keras.layers.Conv2D(128, (3,3), padding="same", activation="relu")(x)
    x = tf.keras.layers.MaxPooling2D()(x)
    x = tf.keras.layers.Conv2D(256, (3,3), padding="same", activation="relu")(x)
    x = tf.keras.layers.MaxPooling2D()(x)
    x = tf.keras.layers.Dropout(0.2)(x)
    x = tf.keras.layers.Flatten()(x)
    x = tf.keras.layers.Dense(1024, activation="relu")(x)
    outputs = tf.keras.layers.Dense(1)(x)

    model = tf.keras.Model(inputs, outputs)
    return model
```

In [30]:

```
model = Modfinal_model(input_shape=image_shape)
model.summary()
```

```
Model: "model_5"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_12 (InputLayer)       [(None, 381, 362, 3)]     0

 rescaling_5 (Rescaling)     (None, 381, 362, 3)       0

 random_flip_10 (RandomFlip  (None, 381, 362, 3)       0
 )

 random_rotation_10 (Random  (None, 381, 362, 3)       0
 Rotation)

 conv2d_12 (Conv2D)          (None, 381, 362, 16)      448

 max_pooling2d_4 (MaxPoolin  (None, 190, 181, 16)      0
 g2D)

 conv2d_13 (Conv2D)          (None, 190, 181, 32)      4640

 max_pooling2d_5 (MaxPoolin  (None, 95, 90, 32)        0
 g2D)

 conv2d_14 (Conv2D)          (None, 95, 90, 64)        18496

 max_pooling2d_6 (MaxPoolin  (None, 47, 45, 64)        0
 g2D)

 conv2d_15 (Conv2D)          (None, 47, 45, 128)       73856

 max_pooling2d_7 (MaxPoolin  (None, 23, 22, 128)       0
 g2D)

 conv2d_16 (Conv2D)          (None, 23, 22, 256)       295168

 max_pooling2d_8 (MaxPoolin  (None, 11, 11, 256)       0
 g2D)

 dropout_1 (Dropout)         (None, 11, 11, 256)       0

 flatten_5 (Flatten)         (None, 30976)             0

 dense_5 (Dense)             (None, 1024)              31720448

 dense_6 (Dense)             (None, 1)                 1025

=================================================================
Total params: 32114081 (122.51 MB)
Trainable params: 32114081 (122.51 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

In [31]:

```
model.compile(optimizer=tf.keras.optimizers.Adam(1e-3),
              loss=tf.keras.losses.BinaryCrossentropy(from_logits=True),
              metrics=["accuracy"])

epochs = 20
history = model.fit(train_dataset, batch_size=32, validation_data=validation_dataset, epochs=epochs)
```

```
Epoch 1/20
99/99 [==============================] - 28s 213ms/step - loss: 0.6398 - accuracy: 0.6152 - val_loss: 0.5534 - val_acc
uracy: 0.7142
Epoch 2/20
99/99 [==============================] - 19s 185ms/step - loss: 0.4683 - accuracy: 0.7585 - val_loss: 0.4348 - val_acc
uracy: 0.7614
Epoch 3/20
99/99 [==============================] - 18s 180ms/step - loss: 0.4049 - accuracy: 0.8066 - val_loss: 0.4159 - val_acc
uracy: 0.8235
Epoch 4/20
99/99 [==============================] - 20s 200ms/step - loss: 0.3477 - accuracy: 0.8329 - val_loss: 0.3244 - val_acc
uracy: 0.8508
Epoch 5/20
99/99 [==============================] - 19s 191ms/step - loss: 0.3129 - accuracy: 0.8563 - val_loss: 0.2604 - val_acc
uracy: 0.8892
Epoch 6/20
99/99 [==============================] - 19s 186ms/step - loss: 0.2800 - accuracy: 0.8756 - val_loss: 0.2530 - val_acc
uracy: 0.8700
Epoch 7/20
99/99 [==============================] - 20s 194ms/step - loss: 0.2278 - accuracy: 0.9060 - val_loss: 0.2344 - val_acc
uracy: 0.9055
Epoch 8/20
99/99 [==============================] - 18s 173ms/step - loss: 0.2054 - accuracy: 0.9120 - val_loss: 0.1854 - val_acc
uracy: 0.9350
Epoch 9/20
99/99 [==============================] - 18s 179ms/step - loss: 0.1911 - accuracy: 0.9215 - val_loss: 0.1884 - val_acc
uracy: 0.9313
Epoch 10/20
99/99 [==============================] - 18s 181ms/step - loss: 0.1692 - accuracy: 0.9332 - val_loss: 0.1595 - val_acc
uracy: 0.9483
Epoch 11/20
99/99 [==============================] - 19s 183ms/step - loss: 0.1470 - accuracy: 0.9377 - val_loss: 0.1420 - val_acc
uracy: 0.9498
Epoch 12/20
99/99 [==============================] - 17s 171ms/step - loss: 0.1529 - accuracy: 0.9411 - val_loss: 0.1429 - val_acc
uracy: 0.9476
Epoch 13/20
99/99 [==============================] - 17s 171ms/step - loss: 0.1230 - accuracy: 0.9528 - val_loss: 0.1316 - val_acc
uracy: 0.9535
Epoch 14/20
99/99 [==============================] - 20s 194ms/step - loss: 0.1084 - accuracy: 0.9598 - val_loss: 0.1592 - val_acc
uracy: 0.9446
Epoch 15/20
99/99 [==============================] - 18s 177ms/step - loss: 0.1004 - accuracy: 0.9608 - val_loss: 0.1715 - val_acc
uracy: 0.9335
Epoch 16/20
99/99 [==============================] - 18s 181ms/step - loss: 0.0959 - accuracy: 0.9639 - val_loss: 0.0770 - val_acc
uracy: 0.9734
Epoch 17/20
99/99 [==============================] - 17s 171ms/step - loss: 0.0832 - accuracy: 0.9684 - val_loss: 0.0736 - val_acc
uracy: 0.9749
Epoch 18/20
99/99 [==============================] - 18s 175ms/step - loss: 0.0788 - accuracy: 0.9712 - val_loss: 0.1035 - val_acc
uracy: 0.9586
Epoch 19/20
99/99 [==============================] - 18s 173ms/step - loss: 0.0723 - accuracy: 0.9712 - val_loss: 0.1042 - val_acc
uracy: 0.9638
Epoch 20/20
99/99 [==============================] - 17s 170ms/step - loss: 0.0727 - accuracy: 0.9725 - val_loss: 0.0828 - val_acc
uracy: 0.9675
```

In [33]:

```
model = Modfinal_model(image_shape)

model.compile(optimizer=tf.keras.optimizers.Adam(1e-3),
              loss=tf.keras.losses.BinaryCrossentropy(from_logits=True),
              metrics=["accuracy"])

epochs = 30
history = model.fit(train_dataset, batch_size=32, validation_data=validation_dataset, epochs=epochs)
```

```
Epoch 1/30
99/99 [==============================] - 22s 181ms/step - loss: 0.6609 - accuracy: 0.6019 - val_loss: 0.5782 - val_acc
uracy: 0.6935
Epoch 2/30
99/99 [==============================] - 20s 195ms/step - loss: 0.5192 - accuracy: 0.7335 - val_loss: 0.4321 - val_acc
uracy: 0.8168
Epoch 3/30
99/99 [==============================] - 19s 188ms/step - loss: 0.4051 - accuracy: 0.7918 - val_loss: 0.3431 - val_acc
uracy: 0.8368
Epoch 4/30
99/99 [==============================] - 20s 194ms/step - loss: 0.3732 - accuracy: 0.8187 - val_loss: 0.3082 - val_acc
uracy: 0.8752
Epoch 5/30
99/99 [==============================] - 17s 172ms/step - loss: 0.3294 - accuracy: 0.8475 - val_loss: 0.2791 - val_acc
uracy: 0.8959
Epoch 6/30
99/99 [==============================] - 19s 184ms/step - loss: 0.3029 - accuracy: 0.8557 - val_loss: 0.2383 - val_acc
uracy: 0.9010
Epoch 7/30
99/99 [==============================] - 18s 179ms/step - loss: 0.2541 - accuracy: 0.8839 - val_loss: 0.2714 - val_acc
uracy: 0.8744
Epoch 8/30
99/99 [==============================] - 19s 182ms/step - loss: 0.2407 - accuracy: 0.8943 - val_loss: 0.1897 - val_acc
uracy: 0.9202
Epoch 9/30
99/99 [==============================] - 20s 196ms/step - loss: 0.2065 - accuracy: 0.9082 - val_loss: 0.2029 - val_acc
uracy: 0.9313
Epoch 10/30
99/99 [==============================] - 20s 196ms/step - loss: 0.1784 - accuracy: 0.9275 - val_loss: 0.1686 - val_acc
uracy: 0.9284
Epoch 11/30
99/99 [==============================] - 19s 184ms/step - loss: 0.1683 - accuracy: 0.9288 - val_loss: 0.1590 - val_acc
uracy: 0.9335
Epoch 12/30
99/99 [==============================] - 19s 182ms/step - loss: 0.1373 - accuracy: 0.9434 - val_loss: 0.1469 - val_acc
uracy: 0.9446
Epoch 13/30
99/99 [==============================] - 19s 186ms/step - loss: 0.1355 - accuracy: 0.9484 - val_loss: 0.1595 - val_acc
uracy: 0.9291
Epoch 14/30
99/99 [==============================] - 18s 179ms/step - loss: 0.1100 - accuracy: 0.9573 - val_loss: 0.1408 - val_acc
uracy: 0.9380
Epoch 15/30
99/99 [==============================] - 19s 187ms/step - loss: 0.0987 - accuracy: 0.9636 - val_loss: 0.0966 - val_acc
uracy: 0.9638
Epoch 16/30
99/99 [==============================] - 19s 183ms/step - loss: 0.0966 - accuracy: 0.9639 - val_loss: 0.0988 - val_acc
uracy: 0.9653
Epoch 17/30
99/99 [==============================] - 18s 175ms/step - loss: 0.0797 - accuracy: 0.9693 - val_loss: 0.0998 - val_acc
uracy: 0.9668
Epoch 18/30
99/99 [==============================] - 19s 189ms/step - loss: 0.0764 - accuracy: 0.9703 - val_loss: 0.1049 - val_acc
uracy: 0.9668
Epoch 19/30
99/99 [==============================] - 18s 174ms/step - loss: 0.0716 - accuracy: 0.9734 - val_loss: 0.1256 - val_acc
uracy: 0.9513
Epoch 20/30
99/99 [==============================] - 19s 182ms/step - loss: 0.0630 - accuracy: 0.9753 - val_loss: 0.0967 - val_acc
uracy: 0.9742
Epoch 21/30
99/99 [==============================] - 18s 178ms/step - loss: 0.0642 - accuracy: 0.9766 - val_loss: 0.0863 - val_acc
uracy: 0.9697
Epoch 22/30
99/99 [==============================] - 19s 183ms/step - loss: 0.0450 - accuracy: 0.9813 - val_loss: 0.1107 - val_acc
uracy: 0.9742
Epoch 23/30
99/99 [==============================] - 19s 191ms/step - loss: 0.0632 - accuracy: 0.9750 - val_loss: 0.0753 - val_acc
uracy: 0.9719
Epoch 24/30
99/99 [==============================] - 18s 180ms/step - loss: 0.0325 - accuracy: 0.9889 - val_loss: 0.1144 - val_acc
uracy: 0.9690
Epoch 25/30
99/99 [==============================] - 19s 190ms/step - loss: 0.0401 - accuracy: 0.9858 - val_loss: 0.1144 - val_acc
uracy: 0.9749
Epoch 26/30
99/99 [==============================] - 18s 173ms/step - loss: 0.0430 - accuracy: 0.9854 - val_loss: 0.1473 - val_acc
uracy: 0.9520
Epoch 27/30
99/99 [==============================] - 19s 188ms/step - loss: 0.0474 - accuracy: 0.9839 - val_loss: 0.1582 - val_acc
uracy: 0.9645
Epoch 28/30
99/99 [==============================] - 17s 171ms/step - loss: 0.0413 - accuracy: 0.9858 - val_loss: 0.0992 - val_acc
uracy: 0.9786
```

```
Epoch 29/30
99/99 [==============================] - 19s 189ms/step - loss: 0.0443 - accuracy: 0.9826 - val_loss: 0.1097 - val_acc
uracy: 0.9690
Epoch 30/30
99/99 [==============================] - 17s 171ms/step - loss: 0.0503 - accuracy: 0.9810 - val_loss: 0.1118 - val_acc
uracy: 0.9734
```

In [56]:

```
history.history['val_accuracy']
```

Out[56]:

```
[0.6935007572174072,
 0.8168389797210693,
 0.8367798924446106,
 0.8751846551895142,
 0.8958641290664673,
 0.9010339975357056,
 0.8744460940361023,
 0.920236349105835,
 0.9313146471977234,
 0.9283604025840759,
 0.9335302710533142,
 0.9446085691452026,
 0.9290989637374878,
 0.9379615783691406,
 0.963810920715332,
 0.9652880430221558,
 0.9667651653289795,
 0.9667651653289795,
 0.9512555599212646,
 0.9741506576538086,
 0.9697193503379822,
 0.9741506576538086,
 0.9719350337982178,
 0.9689807891845703,
 0.9748892188072205,
 0.9519941210746765,
 0.9645494818687439,
 0.978581964969635,
 0.9689807891845703,
 0.9734120965003967]
```

In [57]:

```
history.history['accuracy']
```

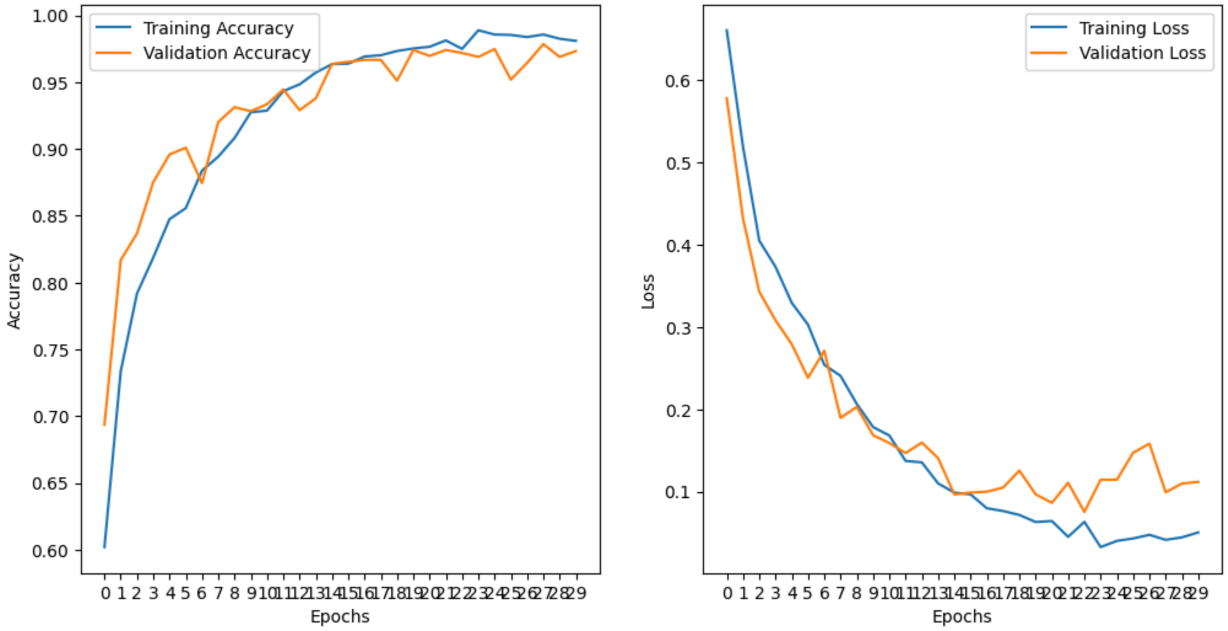
Out[57]:

```
[0.601898729801178,
 0.7335442900657654,
 0.7917721271514893,
 0.8186708688735962,
 0.847468376159668,
 0.8556962013244629,
 0.8838607668876648,
 0.8943037986755371,
 0.9082278609275818,
 0.9275316596031189,
 0.9287974834442139,
 0.9433544278144836,
 0.9484177231788635,
 0.9572784900665283,
 0.9636076092720032,
 0.9639240503311157,
 0.9693037867546082,
 0.9702531695365906,
 0.9734176993370056,
 0.9753164649009705,
 0.9765822887420654,
 0.9813291430473328,
 0.9750000238418579,
 0.9889240264892578,
 0.9857594966888428,
 0.9854430556297302,
 0.9838607311248779,
 0.9857594966888428,
 0.982594907283783,
 0.9810126423835754]
```

In [58]:

```
acc = history.history["accuracy"]
val_acc = history.history["val_accuracy"]
loss = history.history["loss"]
val_loss = history.history["val_loss"]

figs, axs = plt.subplots(1,2, figsize=(12,6))
axs[0].plot(range(epochs), acc, label="Training Accuracy")
axs[0].plot(range(epochs), val_acc, label="Validation Accuracy")
axs[0].legend(loc="upper left")
axs[0].set_xlabel("Epochs")
axs[0].set_xticks(list(range(epochs)))
axs[0].set_ylabel("Accuracy")
axs[1].plot(range(epochs), loss, label="Training Loss")
axs[1].plot(range(epochs), val_loss, label="Validation Loss")
axs[1].legend(loc="upper right")
axs[1].set_xlabel("Epochs")
axs[1].set_xticks(list(range(epochs)))
axs[1].set_ylabel("Loss")
plt.show()
```



In [59]:

```
img = tf.keras.utils.load_img("/content/scan.jpg", target_size=image_size)
img = np.asarray(img)
img = tf.expand_dims(img, 0)

prediction = model.predict(img)
score = tf.math.sigmoid(prediction)
result = 1 if score > 0.5 else 0
confidence = float(score * 100) if result else float((1 - score) * 100)
print(f"The image belongs to class '{classes[result]}' with {confidence:.6f}% confidence.")
```

```
1/1 [==============================] - 0s 18ms/step
The image belongs to class 'Brain Tumor' with 100.000000% confidence.
```

In [60]:

```
img = tf.keras.utils.load_img("/content/scan2.png", target_size=image_size)
img = np.asarray(img)
img = tf.expand_dims(img, 0)

prediction = model.predict(img)
score = tf.math.sigmoid(prediction)
result = 1 if score > 0.5 else 0
confidence = float(score * 100) if result else float((1 - score) * 100)
print(f"The image belongs to class '{classes[result]}' with {confidence:.6f}% confidence.")
```

```
1/1 [==============================] - 0s 28ms/step
The image belongs to class 'Healthy' with 100.000000% confidence.
```

In [61]:

```
model.save("brain_tumor_classifier.keras")
```