```
!pip install kaggle
```

```
Requirement already satisfied: kaggle in /usr/local/lib/python3.10/dist-packages (1.6.17)
Requirement already satisfied: six>=1.10 in /usr/local/lib/python3.10/dist-packages (from kaggle) (1.16.0)
Requirement already satisfied: certifi>=2023.7.22 in /usr/local/lib/python3.10/dist-packages (from kaggle) (2024.8.30)
Requirement already satisfied: python-dateutil in /usr/local/lib/python3.10/dist-packages (from kaggle) (2.8.2)
Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-packages (from kaggle) (2.32.3)
Requirement already satisfied: tqdm in /usr/local/lib/python3.10/dist-packages (from kaggle) (4.66.5)
Requirement already satisfied: python-slugify in /usr/local/lib/python3.10/dist-packages (from kaggle) (8.0.4)
Requirement already satisfied: urllib3 in /usr/local/lib/python3.10/dist-packages (from kaggle) (2.0.7)
Requirement already satisfied: bleach in /usr/local/lib/python3.10/dist-packages (from kaggle) (6.1.0)
Requirement already satisfied: webencodings in /usr/local/lib/python3.10/dist-packages (from bleach->kaggle) (0.5.1)
Requirement already satisfied: text-unidecode>=1.3 in /usr/local/lib/python3.10/dist-packages (from python-slugify->kaggle) (1.3)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.10/dist-packages (from requests->kaggle) (3.3.2)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests->kaggle) (3.8)
```

```
!mkdir ~/.kaggle
```

```
!cp kaggle.json ~/.kaggle
```

DOWNLOAD THE DATASET WITH API

```
!kaggle datasets download -d masoudnickparvar/brain-tumor-mri-dataset
```

```
Warning: Your Kaggle API key is readable by other users on this system! To fix this, you can run 'chmod 600 /root/.kaggle/kaggle.json
Dataset URL: https://www.kaggle.com/datasets/masoudnickparvar/brain-tumor-mri-dataset
License(s): CC0-1.0
Downloading brain-tumor-mri-dataset.zip to /content
100% 149M/149M [00:07<00:00, 20.8MB/s]
100% 149M/149M [00:07<00:00, 21.4MB/s]
```

```
!unzip -qq brain-tumor-mri-dataset.zip
```

LIBRARIES AND PREPROCESSING

```
import os
import os.path
```

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from PIL import Image
#FOR NN
from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix,classification_report

import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.layers import Conv2D,MaxPooling2D,Flatten,Dense,Dropout
from tensorflow.keras.optimizers import Adamax

print ('modules loaded')
```

```
modules loaded
```

PREPROCESSING

```
train_path = "/content/Training"
labels=[]
filepaths=[]
folds = os.listdir(train_path)
for fold in folds:
  foldpath=os.path.join(train_path,fold)
  foldlist=os.listdir(foldpath)
  for file in foldlist:
    filepath=os.path.join(foldpath,file)
    labels.append(fold)
    filepaths.append(filepath)

  l=pd.Series(labels,name="labels")
  f=pd.Series(filepaths,name="filepaths")
  tr_df = pd.concat([f,l],axis=1)


tr_df
```

	filepaths	labels
0	/content/Training/glioma/Tr-gl_0497.jpg	glioma
1	/content/Training/glioma/Tr-gl_0048.jpg	glioma
2	/content/Training/glioma/Tr-gl_1228.jpg	glioma
3	/content/Training/glioma/Tr-gl_0659.jpg	glioma
4	/content/Training/glioma/Tr-gl_0268.jpg	glioma
...	...	...
5707	/content/Training/meningioma/Tr-me_0050.jpg	meningioma
5708	/content/Training/meningioma/Tr-me_0460.jpg	meningioma
5709	/content/Training/meningioma/Tr-me_0023.jpg	meningioma
5710	/content/Training/meningioma/Tr-me_0708.jpg	meningioma
5711	/content/Training/meningioma/Tr-me_1045.jpg	meningioma

5712 rows × 2 columns

```
test_path = "/content/Testing"
labels=[]
filepaths=[]
folds = os.listdir(test_path)
for fold in folds:
  foldpath=os.path.join(test_path,fold)
  foldlist=os.listdir(foldpath)
  for file in foldlist:
    filepath=os.path.join(foldpath,file)
    labels.append(fold)
    filepaths.append(filepath)

  l=pd.Series(labels,name="labels")
  f=pd.Series(filepaths,name="filepaths")
  ts_df = pd.concat([f,l],axis=1)


ts_df
```

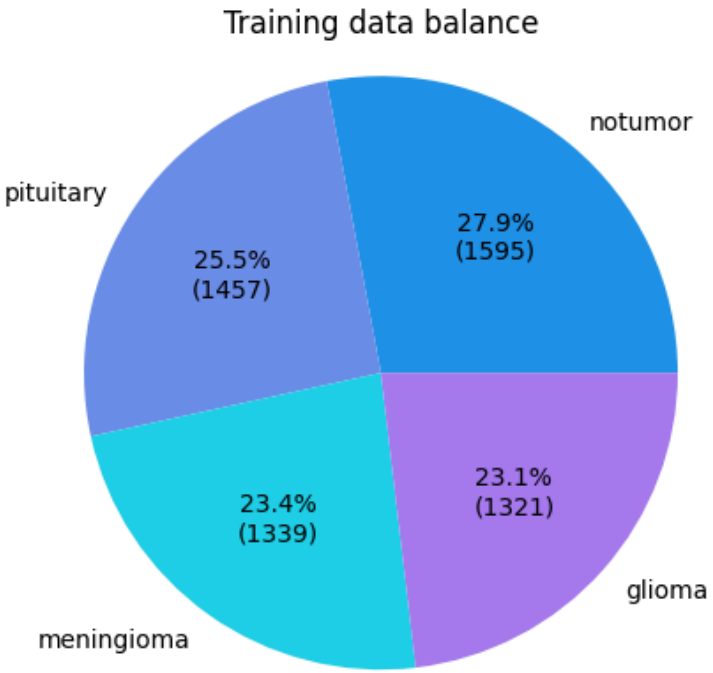
	filepaths	labels
0	/content/Testing/glioma/Te-gl_0286.jpg	glioma
1	/content/Testing/glioma/Te-gl_0090.jpg	glioma
2	/content/Testing/glioma/Te-gl_0226.jpg	glioma
3	/content/Testing/glioma/Te-gl_0218.jpg	glioma
4	/content/Testing/glioma/Te-gl_0181.jpg	glioma
...	...	...
1306	/content/Testing/meningioma/Te-me_0047.jpg	meningioma
1307	/content/Testing/meningioma/Te-me_0230.jpg	meningioma
1308	/content/Testing/meningioma/Te-me_0274.jpg	meningioma
1309	/content/Testing/meningioma/Te-me_0294.jpg	meningioma
1310	/content/Testing/meningioma/Te-me_0212.jpg	meningioma

1311 rows × 2 columns

```
data_balance = tr_df.labels.value_counts()


def custom_autopct(pct):
    total = sum(data_balance)
    val = int(round(pct*total/100.0))
    return "{:.1f}%\n({:d})".format(pct, val)


# pie chart for data balance
plt.pie(data_balance, labels = data_balance.index, autopct=custom_autopct,
        colors = ["#2092E8","#6D8CE6","#20D0E6","#A579EB"])
plt.title("Training data balance")
plt.axis("equal")
plt.show()
data_balance
```



labels	count
notumor	1595
pituitary	1457
meningioma	1339
glioma	1321

dtype: int64

```
valid_df,tst_df=train_test_split(ts_df,test_size=0.5,random_state=50,stratify=ts_df["labels"])
print(f"ts_df shape: {ts_df.shape}")
print("---"*10)
print(f"valid data shape: {valid_df.shape}")
print(f"test data shape: {tst_df.shape}")
```

```
ts_df shape: (1311, 2)
------------------------------
valid data shape: (655, 2)
test data shape: (656, 2)
```

```
img_size=(224,224)

tr=ImageDataGenerator()
ts=ImageDataGenerator()

train_gen=tr.flow_from_dataframe(tr_df,x_col="filepaths",y_col="labels",
                                 target_size=img_size,
                                 batch_size=16,shuffle=True,
                                 class_mode='categorical',color_mode="rgb")


valid_gen=ts.flow_from_dataframe(ts_df,x_col='filepaths',y_col='labels',
                                target_size=img_size,
                                 class_mode="categorical",color_mode="rgb",
                                 shuffle=True,batch_size=16,)


test_gen=ts.flow_from_dataframe(ts_df, x_col='filepaths', y_col='labels',
                                 target_size=img_size,
                                 batch_size=16, shuffle=False,
                                 color_mode="rgb", class_mode="categorical")
```

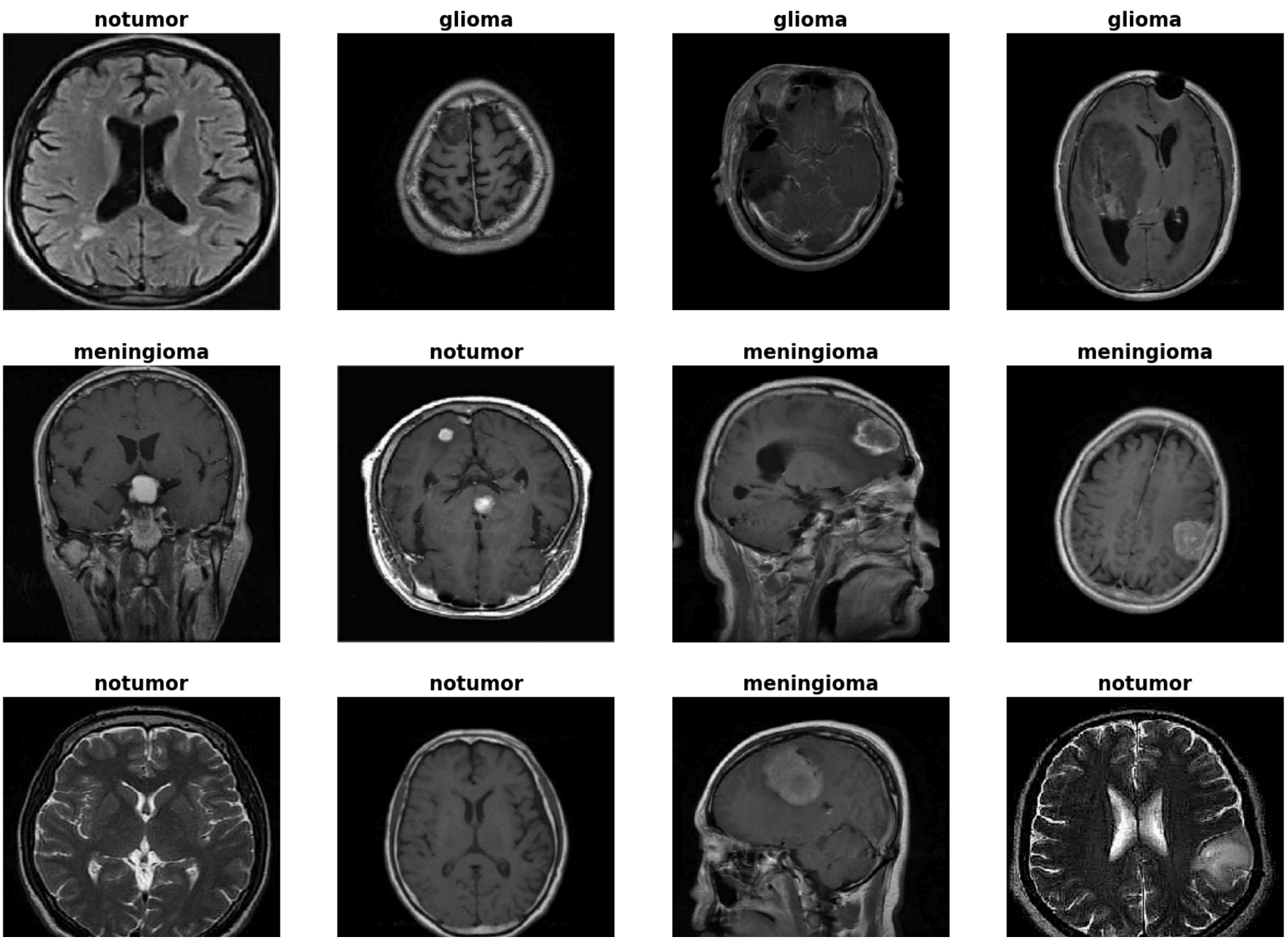
```
Found 5712 validated image filenames belonging to 4 classes.
Found 1311 validated image filenames belonging to 4 classes.
Found 1311 validated image filenames belonging to 4 classes.
```

```
gen_dict = train_gen.class_indices
classes = list(gen_dict.keys())
images , labels = next(train_gen)

plt.figure(figsize= (20,20))

for i in range(16):
    plt.subplot(4,4,i+1)
    image = images[i] / 255
    plt.imshow(image)
```

```
        index = np.argmax(labels[i])
        class_name = classes[index]
        plt.title(class_name , color = 'black' , fontsize= 17,weight="bold")
        plt.axis('off')
    plt.show()
```


notumor
glioma
glioma
glioma
meningioma
notumor
meningioma
meningioma
notumor
notumor
meningioma
notumor


```
img_shape=(224,224,3)
base_Model = tf.keras.applications.Xception(include_top= False,weights= "imagenet",
                                            input_shape= img_shape, pooling= 'max')

Model = Sequential([
    base_Model,
    Dropout(rate= 0.5),
    Dense(128, activation= 'relu'),
    Dropout(rate= 0.25),
    Dense(4, activation= 'softmax')
])

Model.compile(Adamax(learning_rate= 0.001),
              loss= 'categorical_crossentropy',
              metrics= ['accuracy'])

Model.summary()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/xception/xception_weights_tf_dim_ordering_tf_kerne
83683744/83683744 ━━━━━━━━━━━━━━━━━━━━ 5s 0us/step
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-15-760c5cc73e88> in <cell line: 17>()
     15               metrics= ['accuracy'])
     16
---> 17 Model.summary()

 ──────────────────────────────────── 1 frames ────────────────────────────────────
/usr/local/lib/python3.10/dist-packages/optree/ops.py in tree_map(func, tree, is_leaf, none_is_leaf, namespace, *rests)
    745     leaves, treespec = _C.flatten(tree, is_leaf, none_is_leaf, namespace)
    746     flat_args = [leaves] + [treespec.flatten_up_to(r) for r in rests]
--> 747     return treespec.unflatten(map(func, *flat_args))
    748
    749

ValueError: Undefined shapes are not supported.
```

```
import tensorflow as tf
from tensorflow.keras.layers import Dense, Dropout, Input
from tensorflow.keras.models import Model
from tensorflow.keras.optimizers import Adamax

img_shape = (224, 224, 3)

# Define the input layer
input_layer = Input(shape=img_shape)

# Load the base model (Xception) without the top layer
base_model = tf.keras.applications.Xception(include_top=False, weights="imagenet",
                                            input_tensor=input_layer, pooling='max')

# Add custom layers on top of the base model
x = Dropout(rate=0.5)(base_model.output)
x = Dense(128, activation='relu')(x)
x = Dropout(rate=0.25)(x)
output_layer = Dense(4, activation='softmax')(x)

# Create the model
```

```
Model = Model(inputs=input_layer, outputs=output_layer)

# Compile the model
Model.compile(Adamax(learning_rate=0.001),
              loss='categorical_crossentropy',
              metrics=['accuracy'])

# Print the model summary
Model.summary()
```

Model: "functional_1"

Layer (type)	Output Shape	Param #	Connected to
input_layer_3 (InputLayer)	(None, 224, 224, 3)	0	–
block1_conv1 (Conv2D)	(None, 111, 111, 32)	864	input_layer_3[0][0]
block1_conv1_bn (BatchNormalization)	(None, 111, 111, 32)	128	block1_conv1[0][0]
block1_conv1_act (Activation)	(None, 111, 111, 32)	0	block1_conv1_bn[0][0]
block1_conv2 (Conv2D)	(None, 109, 109, 64)	18,432	block1_conv1_act[0][0]
block1_conv2_bn (BatchNormalization)	(None, 109, 109, 64)	256	block1_conv2[0][0]
block1_conv2_act (Activation)	(None, 109, 109, 64)	0	block1_conv2_bn[0][0]
block2_sepconv1 (SeparableConv2D)	(None, 109, 109, 128)	8,768	block1_conv2_act[0][0]
block2_sepconv1_bn (BatchNormalization)	(None, 109, 109, 128)	512	block2_sepconv1[0][0]
block2_sepconv2_act (Activation)	(None, 109, 109, 128)	0	block2_sepconv1_bn[0]…
block2_sepconv2 (SeparableConv2D)	(None, 109, 109, 128)	17,536	block2_sepconv2_act[0…
block2_sepconv2_bn (BatchNormalization)	(None, 109, 109, 128)	512	block2_sepconv2[0][0]
conv2d_12 (Conv2D)	(None, 55, 55, 128)	8,192	block1_conv2_act[0][0]
block2_pool (MaxPooling2D)	(None, 55, 55, 128)	0	block2_sepconv2_bn[0]…
batch_normalization_12 (BatchNormalization)	(None, 55, 55, 128)	512	conv2d_12[0][0]
add_36 (Add)	(None, 55, 55, 128)	0	block2_pool[0][0], batch_normalization_1…
block3_sepconv1_act (Activation)	(None, 55, 55, 128)	0	add_36[0][0]

(Activation)			
block3_sepconv1 (SeparableConv2D)	(None, 55, 55, 256)	33,920	block3_sepconv1_act[0…
block3_sepconv1_bn (BatchNormalization)	(None, 55, 55, 256)	1,024	block3_sepconv1[0][0]
block3_sepconv2_act (Activation)	(None, 55, 55, 256)	0	block3_sepconv1_bn[0]…
block3_sepconv2 (SeparableConv2D)	(None, 55, 55, 256)	67,840	block3_sepconv2_act[0…
block3_sepconv2_bn (BatchNormalization)	(None, 55, 55, 256)	1,024	block3_sepconv2[0][0]
conv2d_13 (Conv2D)	(None, 28, 28, 256)	32,768	add_36[0][0]
block3_pool (MaxPooling2D)	(None, 28, 28, 256)	0	block3_sepconv2_bn[0]…
batch_normalization_13 (BatchNormalization)	(None, 28, 28, 256)	1,024	conv2d_13[0][0]
add_37 (Add)	(None, 28, 28, 256)	0	block3_pool[0][0], batch_normalization_1…
block4_sepconv1_act (Activation)	(None, 28, 28, 256)	0	add_37[0][0]
block4_sepconv1 (SeparableConv2D)	(None, 28, 28, 728)	188,672	block4_sepconv1_act[0…
block4_sepconv1_bn (BatchNormalization)	(None, 28, 28, 728)	2,912	block4_sepconv1[0][0]
block4_sepconv2_act (Activation)	(None, 28, 28, 728)	0	block4_sepconv1_bn[0]…
block4_sepconv2 (SeparableConv2D)	(None, 28, 28, 728)	536,536	block4_sepconv2_act[0…
block4_sepconv2_bn (BatchNormalization)	(None, 28, 28, 728)	2,912	block4_sepconv2[0][0]
conv2d_14 (Conv2D)	(None, 14, 14, 728)	186,368	add_37[0][0]
block4_pool (MaxPooling2D)	(None, 14, 14, 728)	0	block4_sepconv2_bn[0]…
batch_normalization_14	(None, 14, 14, 728)	2,912	conv2d_14[0][0]

```
tf.keras.utils.plot_model(Model,show_shapes=True)
```

```
historyy=Model.fit(train_gen,epochs=10,
                   validation_data=valid_gen,
                   shuffle=False)
```

```
Epoch 1/10
/usr/local/lib/python3.10/dist-packages/keras/src/trainers/data_adapters/py_dataset_adapter.py:121: UserWarning: Your `PyDataset` cla
  self._warn_if_super_not_called()
357/357 ━━━━━━━━━━━━━━━━━━━━ 143s 260ms/step - accuracy: 0.7823 - loss: 0.5917 - val_accuracy: 0.8818 - val_loss: 0.4283
Epoch 2/10
357/357 ━━━━━━━━━━━━━━━━━━━━ 85s 238ms/step - accuracy: 0.9639 - loss: 0.1170 - val_accuracy: 0.9641 - val_loss: 0.3489
Epoch 3/10
357/357 ━━━━━━━━━━━━━━━━━━━━ 85s 239ms/step - accuracy: 0.9874 - loss: 0.0444 - val_accuracy: 0.9519 - val_loss: 0.2254
Epoch 4/10
357/357 ━━━━━━━━━━━━━━━━━━━━ 85s 239ms/step - accuracy: 0.9922 - loss: 0.0328 - val_accuracy: 0.9634 - val_loss: 0.1051
Epoch 5/10
357/357 ━━━━━━━━━━━━━━━━━━━━ 85s 239ms/step - accuracy: 0.9925 - loss: 0.0249 - val_accuracy: 0.9855 - val_loss: 0.0465
Epoch 6/10
357/357 ━━━━━━━━━━━━━━━━━━━━ 85s 238ms/step - accuracy: 0.9923 - loss: 0.0293 - val_accuracy: 0.9901 - val_loss: 0.0423
Epoch 7/10
357/357 ━━━━━━━━━━━━━━━━━━━━ 85s 239ms/step - accuracy: 0.9976 - loss: 0.0119 - val_accuracy: 0.9924 - val_loss: 0.0445
Epoch 8/10
357/357 ━━━━━━━━━━━━━━━━━━━━ 90s 253ms/step - accuracy: 0.9963 - loss: 0.0123 - val_accuracy: 0.9764 - val_loss: 0.1155
Epoch 9/10
357/357 ━━━━━━━━━━━━━━━━━━━━ 90s 253ms/step - accuracy: 0.9969 - loss: 0.0111 - val_accuracy: 0.9901 - val_loss: 0.0426
Epoch 10/10
357/357 ━━━━━━━━━━━━━━━━━━━━ 85s 239ms/step - accuracy: 0.9984 - loss: 0.0053 - val_accuracy: 0.9855 - val_loss: 0.0693
```

```
model_json = Model.to_json()

with open("model.json", "w") as json_file:
    json_file.write(model_json)

# serialize weights to HDF5
Model.save_weights("model.weights.h5")
print("Saved model to disk")
```

```
Saved model to disk
```

```
historyy.history.keys()
```

```
dict_keys(['accuracy', 'loss', 'val_accuracy', 'val_loss'])
```

```
    | (Activation)              |                           |                 |                              |
```

```
plt.figure(figsize=(20, 8))
tr_loss=historyy.history["loss"]
val_loss=historyy.history["val_loss"]
index_loss=np.argmin(val_loss)
loss_lowest=val_loss[index_loss]
l_label=f"best epoch {index_loss+1}"

tr_accuracy=historyy.history["accuracy"]
val_accuracy=historyy.history["val_accuracy"]
index_acc=np.argmax(val_accuracy)
acc_highest=tr_accuracy[index_acc]
c_label=f"best epoch {index_acc+1}"

epochs=[i+1 for i in range (len(tr_accuracy))]


plt.figure(figsize=(20,10))
plt.style.use('fivethirtyeight')

plt.subplot(1, 2, 1)
plt.plot(epochs,tr_loss,"r",label="train loss")
plt.plot(epochs,val_loss,"g",label="valid loss")
plt.scatter(index_loss+1,loss_lowest,c="b",s=150,label=l_label)
plt.title('Training and Validation loss')
plt.xlabel("epochs")
plt.ylabel("loss")
plt.legend()


plt.subplot(1, 2, 2)
plt.plot(epochs,tr_accuracy,"r",label="train accuracy")
plt.plot(epochs,val_accuracy,"g",label="valid accuracy")
plt.scatter(index_acc+1,acc_highest,c="b",s=150,label=c_label)
plt.title('Training and Validation Accuracy')
plt.xlabel("epochs")
plt.ylabel("accuracy")
plt.legend()
```

```
plt.suptitle('Model Training Metrics Over Epochs', fontsize=20);
```

```
<Figure size 2000x800 with 0 Axes>
```


```
train_score=Model.evaluate(train_gen)
valid_score=Model.evaluate(valid_gen)
test_score=Model.evaluate(test_gen)

print(f"Train Loss : {train_score[0]:.3f}")
print(f"Train Accuracy : {train_score[1]*100:.2f}%")
print("-"*20)
print(f"Validation Loss : {valid_score[0]:.3f}")
print(f"Validation Accuracy : {valid_score[1]*100:.2f}%")
print("-"*20)
```

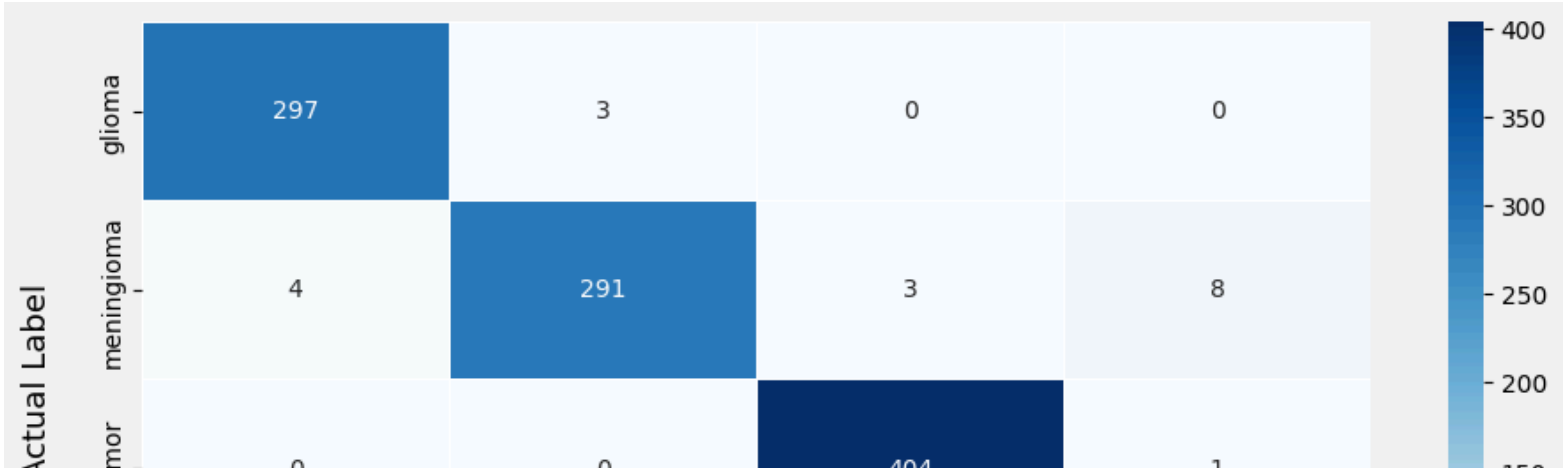
```
print(f"Test Loss: {test_score[0]:.3f}")
print(f"Test Accuracy: {test_score[1]*100:.2f}%")
```

```
357/357 ━━━━━━━━━━━━━━━━━━━━ 23s 63ms/step - accuracy: 0.9973 - loss: 0.0077
82/82 ━━━━━━━━━━━━━━━━━━━━ 5s 62ms/step - accuracy: 0.9859 - loss: 0.0615
 2/82 ━━━━━━━━━━━━━━━━━━━━ 6s 79ms/step - accuracy: 1.0000 - loss: 1.5534e-06  /usr/local/lib/python3.10/dist-packages/keras/src/trai
  self._warn_if_super_not_called()
82/82 ━━━━━━━━━━━━━━━━━━━━ 5s 61ms/step - accuracy: 0.9933 - loss: 0.0388
Train Loss : 0.005
Train Accuracy : 99.81%
--------------------
Validation Loss : 0.069
Validation Accuracy : 98.55%
--------------------
Test Loss: 0.069
Test Accuracy: 98.55%
| block10_sepconv2_bn (None, 14, 14, 728) | 2,912 | block10_sepconv2[0][0] |
```

```
preds=Model.predict(test_gen)
y_pred=np.argmax(preds,axis=1)
```

```
82/82 ━━━━━━━━━━━━━━━━━━━━ 9s 83ms/step
| (SeparableConv2D) | | | |
```

```
plt.figure(figsize=(10,5))
plt.style.use('default')
cm=confusion_matrix(test_gen.classes,y_pred)
labels = list(test_gen.class_indices.keys())
sns.heatmap(cm,annot=True,fmt="d",xticklabels=labels,yticklabels=labels,cmap="Blues", linewidths=.5)
plt.xlabel('\nPredicted Label',fontsize=13)
plt.ylabel('Actual Label\n',fontsize=13);
```




```
cr=classification_report(test_gen.classes,y_pred)
print(cr)
```

```
              precision    recall  f1-score   support
```