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In [196...]: from google.colab import drive
drive.mount('/content/gdrive/')

Drive already mounted at /content/gdrive/; to attempt to forcibly remount, call drive.mount("/content/gdrive/", force_remount=True).

In [197...]: %cd /content/gdrive/MyDrive
/ccontent/gdrive/MyDrive

In [ ]: import numpy as np
import pandas as pd
import time
import shutil
import pathlib
import itertools
import cv2
import seaborn as sns
import matplotlib.pyplot as plt
import tensorflow as tf

from PIL import Image
from imblearn.over_sampling import RandomOverSampler
from sklearn.preprocessing import LabelEncoder
from tensorflow import keras
from tensorflow.keras.models import Sequential
from tensorflow.keras.optimizers import Adam, Adamax
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.layers import Conv2D, MaxPooling2D,
                                         Flatten, Dense, Activation, Dropout,
                                         BatchNormalization
from tensorflow.keras import regularizers
from tensorflow.keras import layers, models
from tensorflow.keras.callbacks import EarlyStopping, ModelCheckpoint
from tensorflow.keras.applications import VGG16
from tensorflow.keras.models import Model
from tensorflow.keras.layers import (GlobalAveragePooling2D, Dense, Dropout,
                                         BatchNormalization,
                                         GaussianNoise, Input, MultiHeadAttention,
                                         Reshape)
from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix, classification_report
from tensorflow.keras.applications import VGG19
from tensorflow.keras.models import Model
from tensorflow.keras.layers import GlobalAveragePooling2D, Dense,
                                         Dropout, BatchNormalization, GaussianNoise,
                                         Input, MultiHeadAttention, Reshape
from tensorflow.keras.applications import MobileNet, ResNet50, DenseNet121,
                                         InceptionV3
from tensorflow.keras.layers import GlobalAveragePooling2D, Dense, Dropout,
                                         BatchNormalization, GaussianNoise, Input,
                                         MultiHeadAttention, Reshape
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.applications import Xception
from tensorflow.keras.models import Model
from tensorflow.keras.layers import GlobalAveragePooling2D, Dense, Dropout,
                                         BatchNormalization, GaussianNoise,
                                         Input, MultiHeadAttention, Reshape
from tensorflow.keras.applications import InceptionV3
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from tensorflow.keras.layers import GlobalAveragePooling2D, Dense, Dropout,
    BatchNormalization, GaussianNoise, Input,
    MultiHeadAttention, Reshape
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In [ ]: import os
for dirname, _, filenames in os.walk('Brain_Tumor_Classification and Object_Dete
    for filename in filenames:
        print(os.path.join(dirname, filename))
```

Streaming output truncated to the last 5000 lines.

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g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1064.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0996.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0999.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0963.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0984.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0987.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0971.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0939.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1056.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1035.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1009.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1026.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0968.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0985.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1007.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1044.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1004.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0992.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1045.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0997.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0946.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0969.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1062.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1046.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0943.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0979.jp

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Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1257.jp
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Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1324.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1232.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1245.jp
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Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1314.jp
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Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1270.jp
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Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1344.jp
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Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1222.jp
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Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1298.jp
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Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1322.jp
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Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1306.jp
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Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1263.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1319.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1240.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1274.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1293.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1216.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1295.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1233.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1335.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1266.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1332.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1320.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1253.jp
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Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1258.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1225.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1239.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1264.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1311.jp
g
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/1292.jp


```
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0280.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0351.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0231.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0346.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0287.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0256.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0340.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0356.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0241.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0324.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0326.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0313.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0305.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0354.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0339.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0248.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0357.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0283.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0350.jp  
g  
Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train/glioma/0276.jp  
g
```

```
In [ ]: base_path = "Brain_Tumor_Classification and Object_Detection/BrainTumor_1/Train"  
categories = ["glioma", "meningioma", "notumor", "pituitary"]
```

```
In [ ]: image_paths = []  
labels = []  
  
for category in categories:  
    category_path = os.path.join(base_path, category)  
    for image_name in os.listdir(category_path):  
        image_path = os.path.join(category_path, image_name)  
        image_paths.append(image_path)  
        labels.append(category)  
  
df = pd.DataFrame({  
    "image_path": image_paths,  
    "label": labels  
})
```

```
In [ ]: df.head()
```

Out[]:

		image_path	label
0	Brain_Tumor_Classification and Object_Detectio...	glioma	
1	Brain_Tumor_Classification and Object_Detectio...	glioma	
2	Brain_Tumor_Classification and Object_Detectio...	glioma	
3	Brain_Tumor_Classification and Object_Detectio...	glioma	
4	Brain_Tumor_Classification and Object_Detectio...	glioma	

```
In [ ]: df.tail()
```

Out[]:

		image_path	label
22852	Brain_Tumor_Classification and Object_Detectio...	pituitary	
22853	Brain_Tumor_Classification and Object_Detectio...	pituitary	
22854	Brain_Tumor_Classification and Object_Detectio...	pituitary	
22855	Brain_Tumor_Classification and Object_Detectio...	pituitary	
22856	Brain_Tumor_Classification and Object_Detectio...	pituitary	

```
In [ ]: df.shape
```

Out[]: (22857, 2)

```
In [ ]: df.columns
```

Out[]: Index(['image_path', 'label'], dtype='object')

```
In [ ]: df['label'].unique()
```

Out[]: array(['glioma', 'meningioma', 'notumor', 'pituitary'], dtype=object)

```
In [ ]: df['label'].value_counts()
```

Out[]:

	count
label	
notumor	6389
pituitary	5828
meningioma	5356
glioma	5284

dtype: int64

```
In [ ]: df.describe
```

Out[]: **pandas.core.generic.NDFrame.describe**
def describe(percentiles=None, include=None, exclude=None) -> Self

Generate descriptive statistics.

Descriptive statistics include those that summarize the central tendency, dispersion and shape of a dataset's distribution, excluding ``NaN`` values.

```
In [ ]: plt.figure(figsize=(8, 6))
sns.countplot(data=df, x="label", palette="viridis")
plt.title("Distribution of Labels - Count Plot")
plt.xlabel("Tumor Type")
plt.ylabel("Count")

for p in plt.gca().patches:
    plt.gca().annotate(f'{int(p.get_height())}', 
                       (p.get_x() + p.get_width() / 2., p.get_height()),
                       ha='center', va='center', fontsize=11, color='black',
                       xytext=(0, 5),
                       textcoords='offset points')

plt.show()

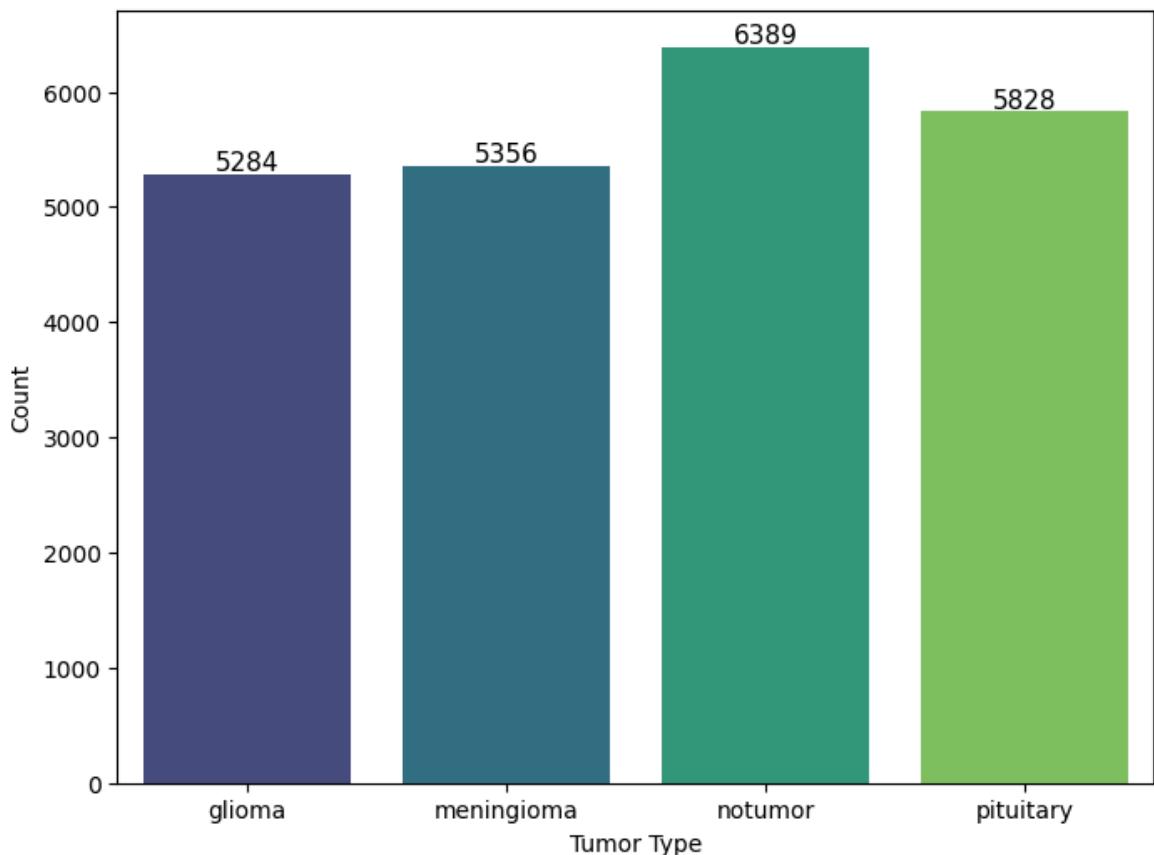
label_counts = df['label'].value_counts()
plt.figure(figsize=(8, 6))
plt.pie(label_counts, labels=label_counts.index, autopct='%1.1f%%', startangle=1
        colors=sns.color_palette("viridis"))
plt.title("Distribution of Labels - Pie Chart")
plt.show()
```

<ipython-input-60-061097bff8e3>:2: FutureWarning:

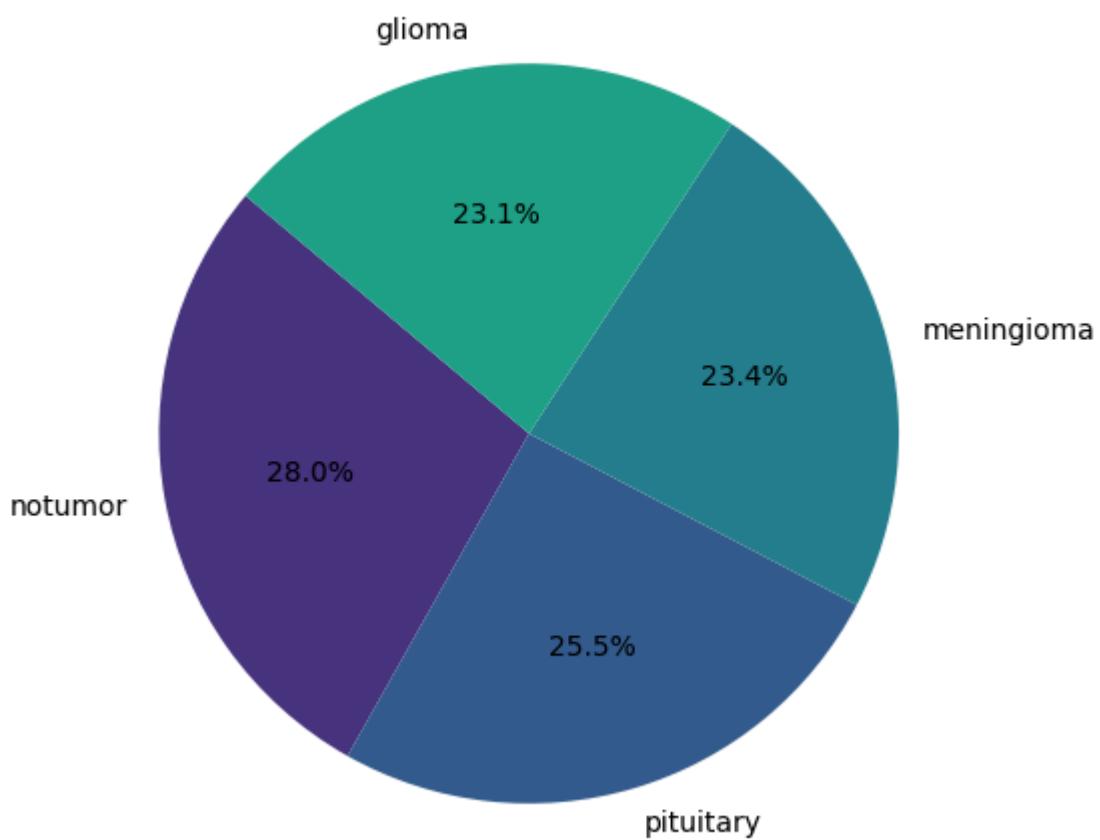
Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend=False` for the same effect.

```
sns.countplot(data=df, x="label", palette="viridis")
```

Distribution of Labels - Count Plot



Distribution of Labels - Pie Chart



In []: num_images = 5

```

plt.figure(figsize=(15, 12))

for i, category in enumerate(categories):
    category_images = df[df['label'] == category]['image_path'].iloc[:num_images]

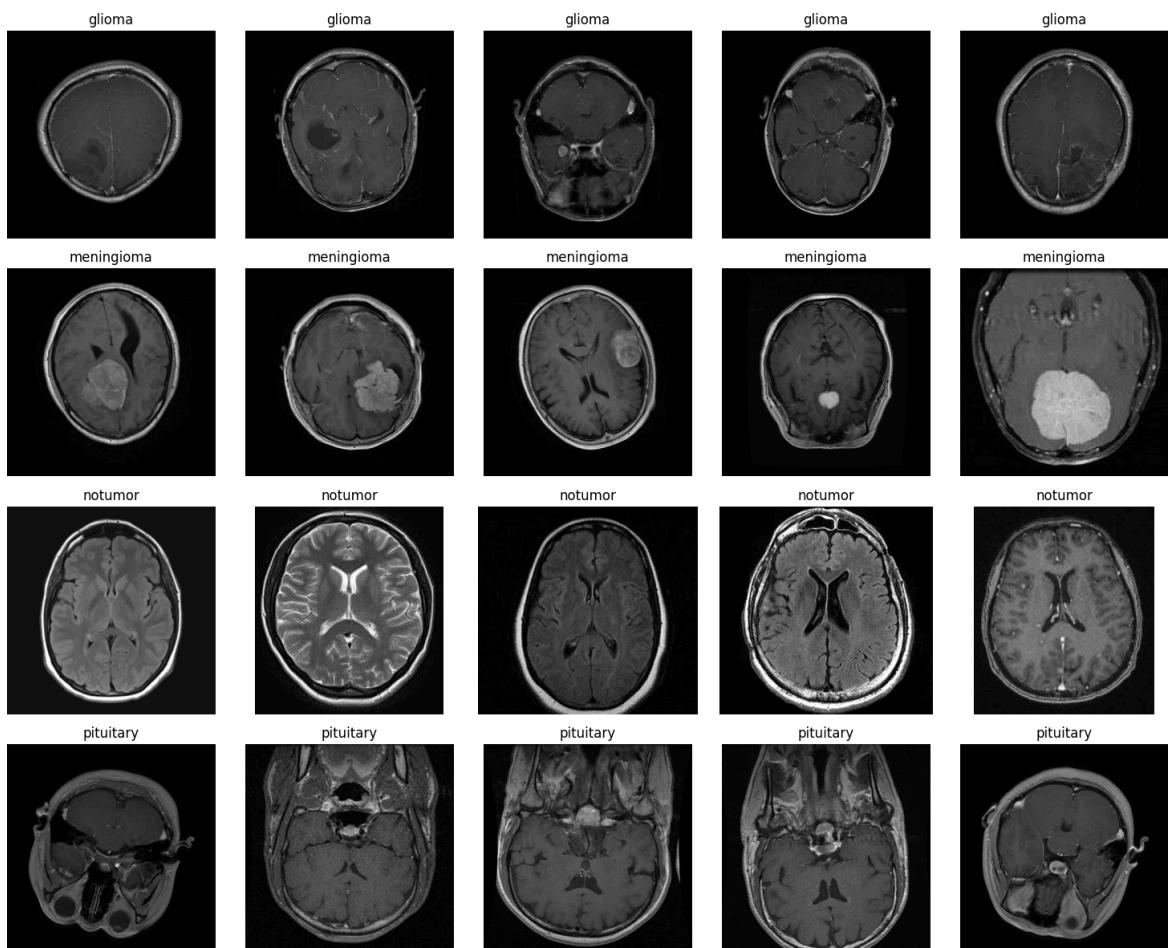
    for j, img_path in enumerate(category_images):

        img = cv2.imread(img_path)
        img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)

        plt.subplot(len(categories), num_images, i * num_images + j + 1)
        plt.imshow(img)
        plt.axis('off')
        plt.title(category)

plt.tight_layout()
plt.show()

```



```

In [ ]: label_encoder = LabelEncoder()

df['category_encoded'] = label_encoder.fit_transform(df['label'])

In [ ]: df = df[['image_path', 'category_encoded']]

In [ ]: ros = RandomOverSampler(random_state=42)
X_resampled, y_resampled = ros.fit_resample(df[['image_path']], df['category_encoded'])

In [ ]: df_resampled = pd.DataFrame(X_resampled, columns=['image_path'])
df_resampled['category_encoded'] = y_resampled

```

```
In [ ]: print("\nClass distribution after oversampling => ")
print(df_resampled['category_encoded'].value_counts())
```

```
Class distribution after oversampling =>
category_encoded
0    6389
1    6389
2    6389
3    6389
Name: count, dtype: int64
```

```
In [ ]: df_resampled
```

```
Out[ ]:
```

	image_path	category_encoded
0	Brain_Tumor_Classification and Object_Detectio...	0
1	Brain_Tumor_Classification and Object_Detectio...	0
2	Brain_Tumor_Classification and Object_Detectio...	0
3	Brain_Tumor_Classification and Object_Detectio...	0
4	Brain_Tumor_Classification and Object_Detectio...	0
...
25551	Brain_Tumor_Classification and Object_Detectio...	3
25552	Brain_Tumor_Classification and Object_Detectio...	3
25553	Brain_Tumor_Classification and Object_Detectio...	3
25554	Brain_Tumor_Classification and Object_Detectio...	3
25555	Brain_Tumor_Classification and Object_Detectio...	3

25556 rows × 2 columns

```
In [ ]: sns.set_style('darkgrid')
```

```
In [ ]: import warnings
warnings.filterwarnings("ignore")

print ('Check.....')
```

Check.....

```
In [ ]: df_resampled['category_encoded'] = df_resampled['category_encoded'].astype(str)
```

```
In [ ]: train_df_new, temp_df_new = train_test_split(
        df_resampled,
        train_size=0.8,
        shuffle=True,
        random_state=42,
        stratify=df_resampled['category_encoded']
)

valid_df_new, test_df_new = train_test_split(
        temp_df_new,
```

```
    test_size=0.5,
    shuffle=True,
    random_state=42,
    stratify=temp_df_new['category_encoded']
)
```

```
In [ ]: batch_size = 16
img_size = (224, 224)
channels = 3
img_shape = (img_size[0], img_size[1], channels)

tr_gen = ImageDataGenerator(rescale=1./255)
ts_gen = ImageDataGenerator(rescale=1./255)

train_gen_new = tr_gen.flow_from_dataframe(
    train_df_new,
    x_col='image_path',
    y_col='category_encoded',
    target_size=img_size,
    class_mode='sparse',
    color_mode='rgb',
    shuffle=True,
    batch_size=batch_size
)

valid_gen_new = ts_gen.flow_from_dataframe(
    valid_df_new,
    x_col='image_path',
    y_col='category_encoded',
    target_size=img_size,
    class_mode='sparse',
    color_mode='rgb',
    shuffle=True,
    batch_size=batch_size
)

test_gen_new = ts_gen.flow_from_dataframe(
    test_df_new,
    x_col='image_path',
    y_col='category_encoded',
    target_size=img_size,
    class_mode='sparse',
    color_mode='rgb',
    shuffle=False,
    batch_size=batch_size
)
```

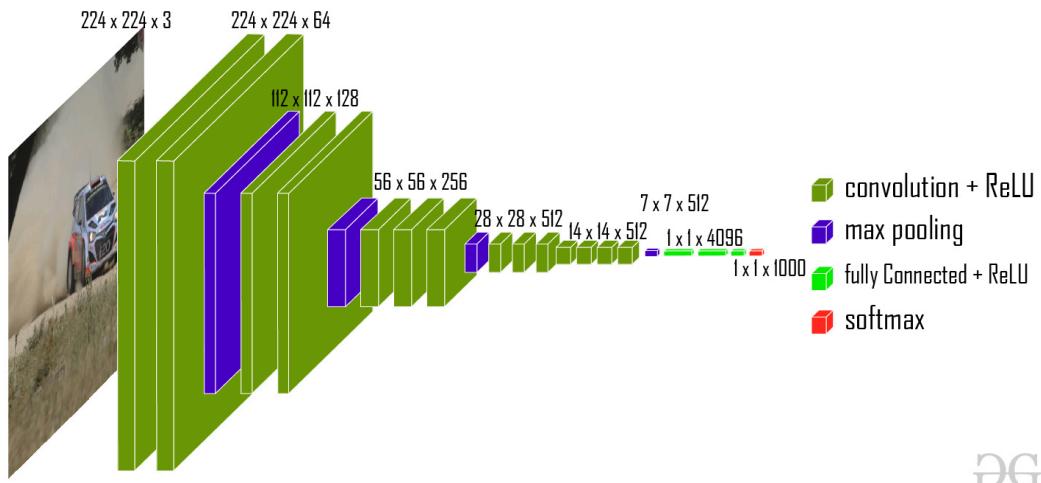
```
Found 20444 validated image filenames belonging to 4 classes.
Found 2556 validated image filenames belonging to 4 classes.
Found 2556 validated image filenames belonging to 4 classes.
```

```
In [ ]: physical_devices = tf.config.list_physical_devices('GPU')
if physical_devices:
    print("Using GPU")
else:
    print("Using CPU")
```

```
Using GPU
```

```
In [ ]: early_stopping = EarlyStopping(monitor='val_loss', patience=5,  
                                     restore_best_weights=True)
```

VGG_16 Architecture



DEG

```
In [ ]: def create_vgg16_model(input_shape):  
  
    inputs = Input(shape=input_shape)  
  
    base_model = VGG16(weights='imagenet', input_tensor=inputs, include_top=False)  
  
    for layer in base_model.layers:  
        layer.trainable = False  
  
    x = base_model.output  
  
    height, width, channels = 7, 7, 512  
    x = Reshape((height * width, channels))(x)  
  
    attention_output = MultiHeadAttention(num_heads=8, key_dim=channels)(x, x)  
    attention_output = Reshape((height, width, channels))(attention_output)  
  
    x = GaussianNoise(0.25)(attention_output)  
  
    x = GlobalAveragePooling2D()(x)  
  
    x = Dense(512, activation='relu')(x)  
    x = BatchNormalization()(x)  
    x = GaussianNoise(0.25)(x)  
    x = Dropout(0.25)(x)  
  
    outputs = Dense(4, activation='softmax')(x)  
  
    model = Model(inputs=inputs, outputs=outputs)  
  
    return model  
  
input_shape = (224, 224, 3)  
  
cnn_model = create_vgg16_model(input_shape)  
  
cnn_model.compile(optimizer=Adam(learning_rate=0.0001),
```

```
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy'])
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/vgg16/vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5
58889256/58889256 ━━━━━━━━━━━━━━━━ 4s 0us/step
```

```
In [ ]: cnn_model.summary()
```

```
Model: "functional"
```

Layer (type)	Output Shape	Param #	Co
input_layer (InputLayer)	(None, 224, 224, 3)	0	-
block1_conv1 (Conv2D)	(None, 224, 224, 64)	1,792	in
block1_conv2 (Conv2D)	(None, 224, 224, 64)	36,928	bl
block1_pool (MaxPooling2D)	(None, 112, 112, 64)	0	bl
block2_conv1 (Conv2D)	(None, 112, 112, 128)	73,856	bl
block2_conv2 (Conv2D)	(None, 112, 112, 128)	147,584	bl
block2_pool (MaxPooling2D)	(None, 56, 56, 128)	0	bl
block3_conv1 (Conv2D)	(None, 56, 56, 256)	295,168	bl
block3_conv2 (Conv2D)	(None, 56, 56, 256)	590,080	bl
block3_conv3 (Conv2D)	(None, 56, 56, 256)	590,080	bl
block3_pool (MaxPooling2D)	(None, 28, 28, 256)	0	bl
block4_conv1 (Conv2D)	(None, 28, 28, 512)	1,180,160	bl
block4_conv2 (Conv2D)	(None, 28, 28, 512)	2,359,808	bl
block4_conv3 (Conv2D)	(None, 28, 28, 512)	2,359,808	bl
block4_pool (MaxPooling2D)	(None, 14, 14, 512)	0	bl
block5_conv1 (Conv2D)	(None, 14, 14, 512)	2,359,808	bl
block5_conv2 (Conv2D)	(None, 14, 14, 512)	2,359,808	bl
block5_conv3 (Conv2D)	(None, 14, 14, 512)	2,359,808	bl
block5_pool (MaxPooling2D)	(None, 7, 7, 512)	0	bl
reshape (Reshape)	(None, 49, 512)	0	bl
multi_head_attention (MultiHeadAttention)	(None, 49, 512)	8,401,408	re re
reshape_1 (Reshape)	(None, 7, 7, 512)	0	mu
gaussian_noise (GaussianNoise)	(None, 7, 7, 512)	0	re
global_average_pooling2d (GlobalAveragePooling2D)	(None, 512)	0	ga
dense (Dense)	(None, 512)	262,656	gl

batch_normalization (BatchNormalization)	(None, 512)	2,048	de
gaussian_noise_1 (GaussianNoise)	(None, 512)	0	ba
dropout_1 (Dropout)	(None, 512)	0	ga
dense_1 (Dense)	(None, 4)	2,052	dr

Total params: 23,382,852 (89.20 MB)

Trainable params: 8,667,140 (33.06 MB)

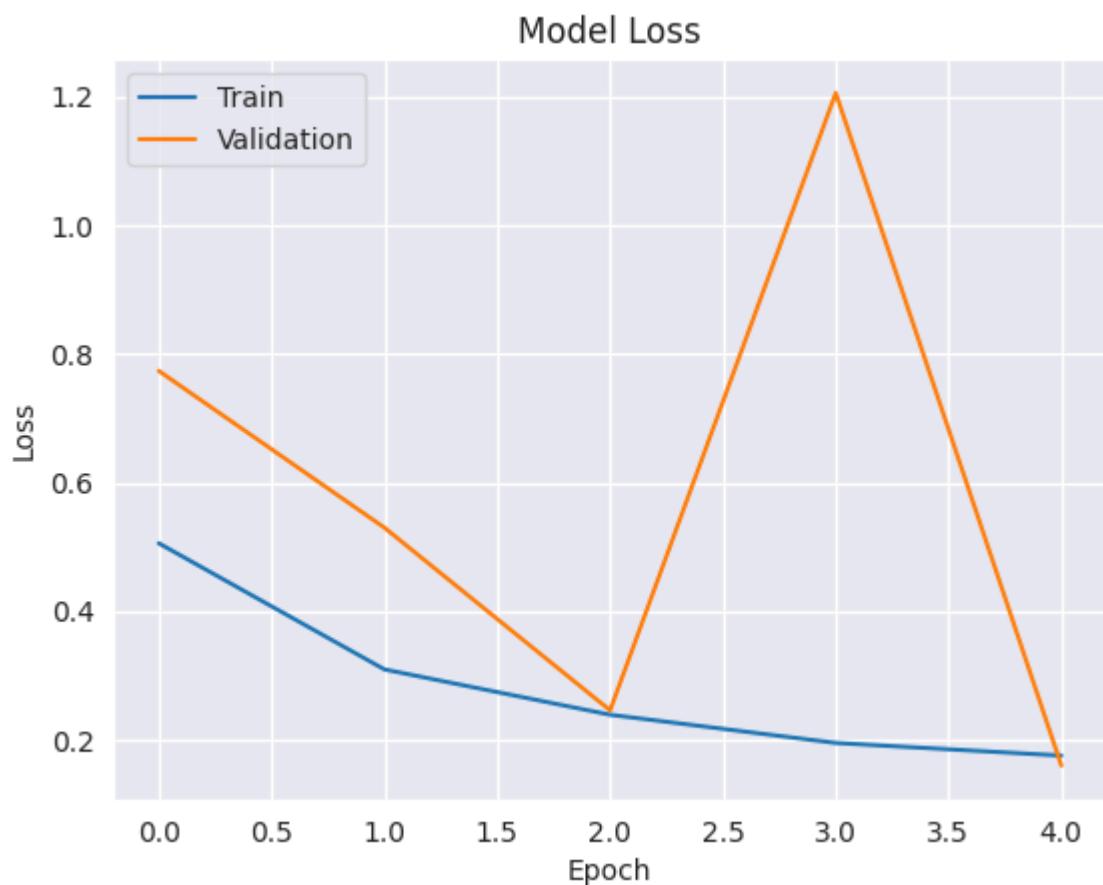
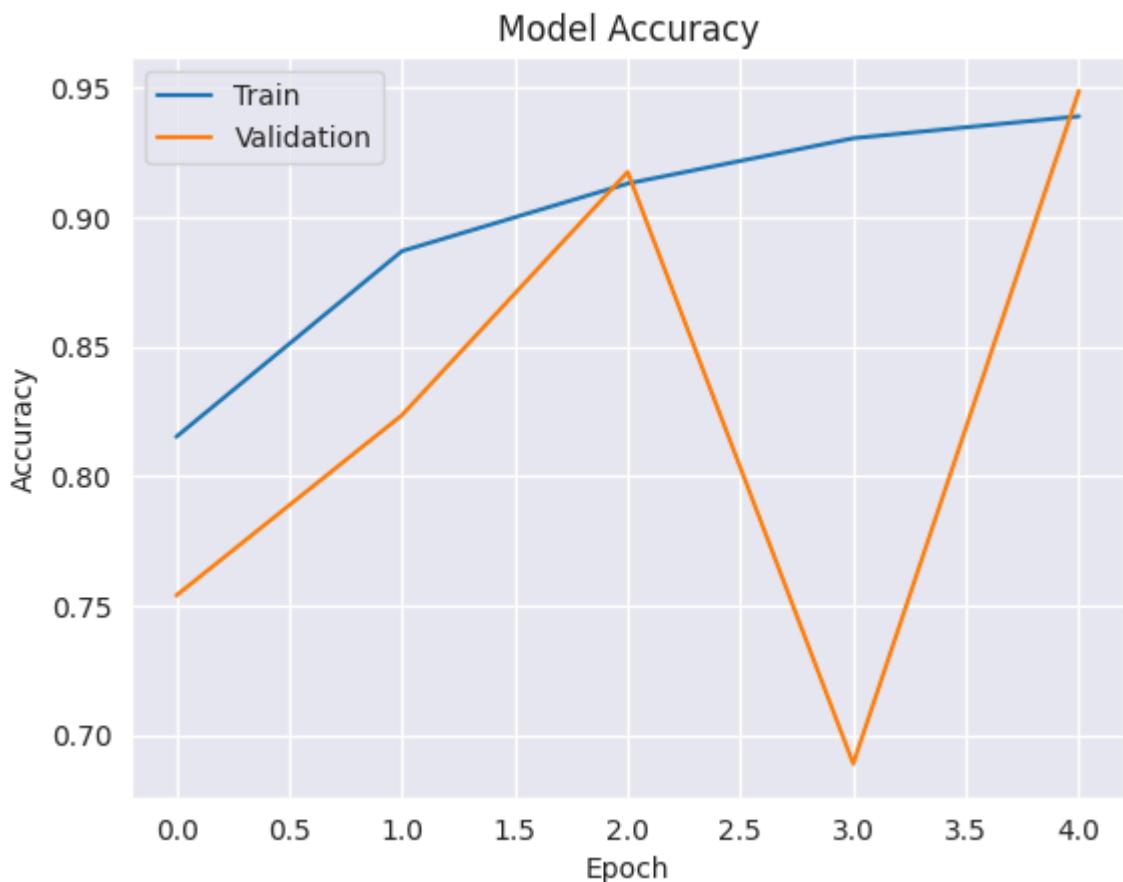
Non-trainable params: 14,715,712 (56.14 MB)

```
In [ ]: history = cnn_model.fit(
    train_gen_new,
    validation_data=valid_gen_new,
    epochs=5,
    callbacks=[early_stopping],
    verbose=1
)
```

```
Epoch 1/5
1278/1278 16718s 13s/step - accuracy: 0.7607 - loss: 0.6321
- val_accuracy: 0.7539 - val_loss: 0.7736
Epoch 2/5
1278/1278 118s 92ms/step - accuracy: 0.8799 - loss: 0.3240 -
val_accuracy: 0.8236 - val_loss: 0.5298
Epoch 3/5
1278/1278 116s 90ms/step - accuracy: 0.9136 - loss: 0.2369 -
val_accuracy: 0.9174 - val_loss: 0.2459
Epoch 4/5
1278/1278 116s 90ms/step - accuracy: 0.9276 - loss: 0.2049 -
val_accuracy: 0.6890 - val_loss: 1.2055
Epoch 5/5
1278/1278 116s 90ms/step - accuracy: 0.9399 - loss: 0.1725 -
val_accuracy: 0.9487 - val_loss: 0.1599
```

```
In [ ]: plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()

plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model Loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()
```



```
In [ ]: test_labels = test_gen_new.classes  
predictions = cnn_model.predict(test_gen_new)  
predicted_classes = np.argmax(predictions, axis=1)
```

160/160 ━━━━━━ 1317s 8s/step

```
In [ ]: report = classification_report(test_labels, predicted_classes,
                                         target_names=list(test_gen_new.class_indices.keys())
                                         print("Report for VGG16 =>")
                                         print(report)
```

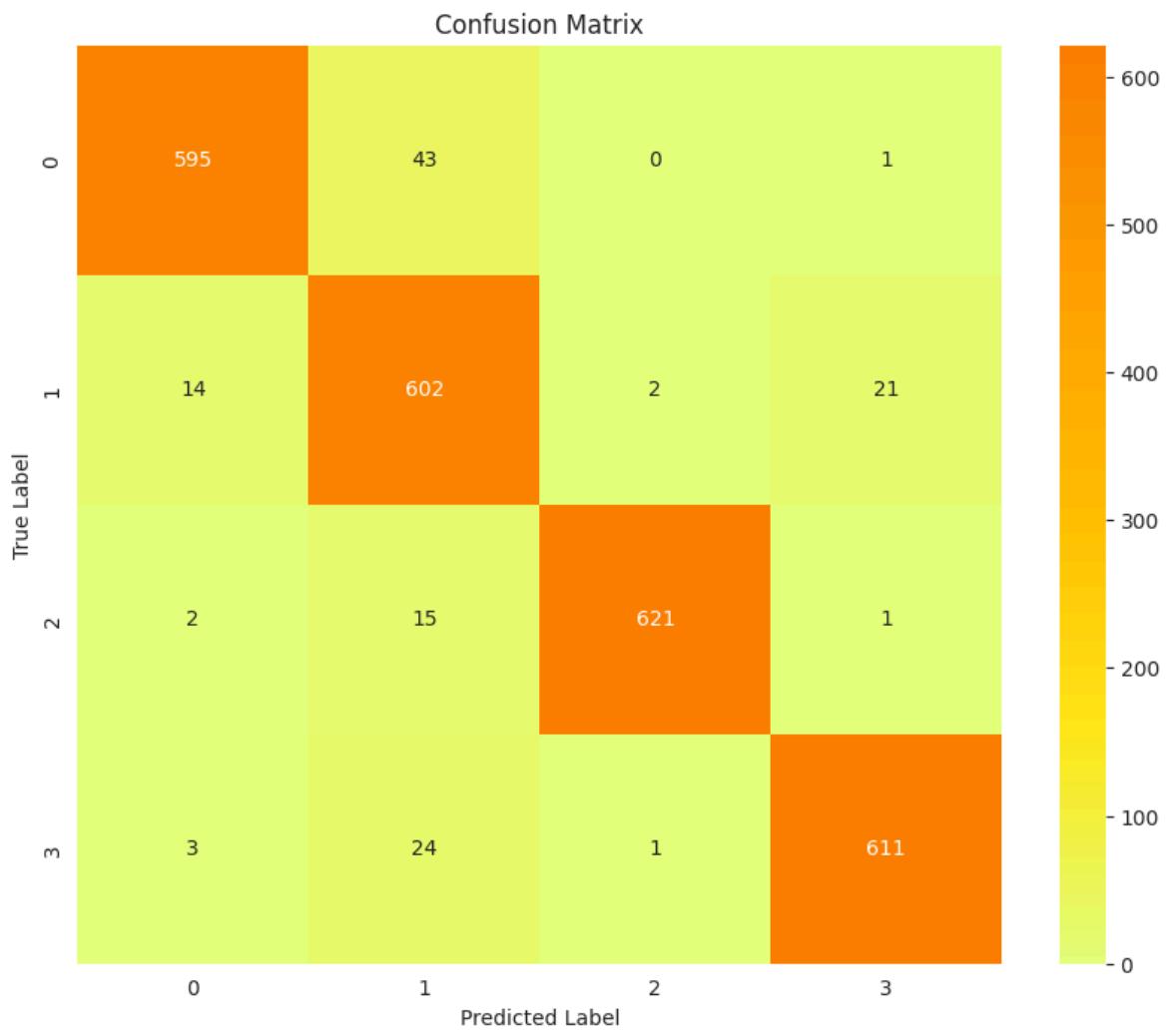
```
Report for VGG16 =>
      precision    recall  f1-score   support

          0       0.97     0.93     0.95      639
          1       0.88     0.94     0.91      639
          2       1.00     0.97     0.98      639
          3       0.96     0.96     0.96      639

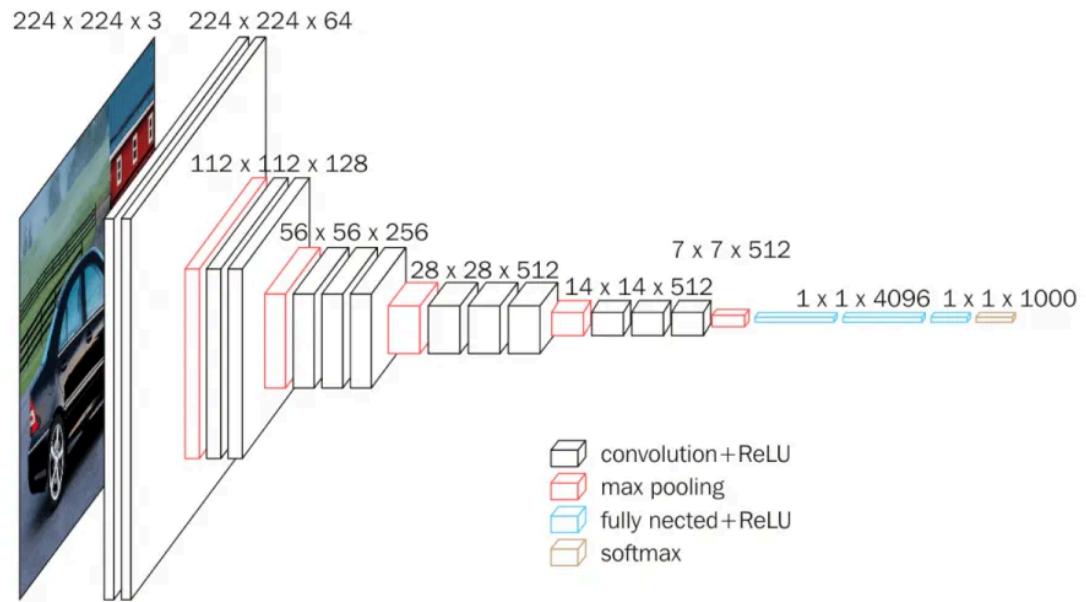
   accuracy                           0.95      2556
macro avg       0.95     0.95     0.95      2556
weighted avg    0.95     0.95     0.95      2556
```

```
In [ ]: conf_matrix = confusion_matrix(test_labels, predicted_classes)
```

```
In [ ]: plt.figure(figsize=(10, 8))
sns.heatmap(conf_matrix, annot=True, fmt='d', cmap='Wistia',
            xticklabels=list(test_gen_new.class_indices.keys()),
            yticklabels=list(test_gen_new.class_indices.keys()))
plt.title('Confusion Matrix')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```



VGG19 Architecture



```
In [ ]: def create_vgg19_model(input_shape):
    inputs = Input(shape=input_shape)
```

```

base_model = VGG19(weights='imagenet',
                    input_tensor=inputs, include_top=False)

for layer in base_model.layers:
    layer.trainable = False

x = base_model.output

height, width, channels = 7, 7, 512
x = Reshape((height * width, channels))(x)

attention_output = MultiHeadAttention(num_heads=8, key_dim=channels)(x, x)

attention_output = Reshape((height, width, channels))(attention_output)

x = GaussianNoise(0.25)(attention_output)

x = GlobalAveragePooling2D()(x)

x = Dense(512, activation='relu')(x)
x = BatchNormalization()(x)
x = GaussianNoise(0.25)(x)
x = Dropout(0.25)(x)

outputs = Dense(4, activation='softmax')(x)

model = Model(inputs=inputs, outputs=outputs)

return model

```

input_shape = (224, 224, 3)

cnn_model = create_vgg19_model(input_shape)

cnn_model.compile(optimizer=Adam(learning_rate=0.0001),
 loss='sparse_categorical_crossentropy',
 metrics=['accuracy'])

Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/vgg19/vgg19_weights_tf_dim_ordering_tf_kernels_notop.h5
80134624/80134624 ————— 4s 0us/step

In []: `cnn_model.summary()`

Model: "functional_1"

Layer (type)	Output Shape	Param #	Co
input_layer_1 (InputLayer)	(None, 224, 224, 3)	0	-
block1_conv1 (Conv2D)	(None, 224, 224, 64)	1,792	in
block1_conv2 (Conv2D)	(None, 224, 224, 64)	36,928	bl
block1_pool (MaxPooling2D)	(None, 112, 112, 64)	0	bl
block2_conv1 (Conv2D)	(None, 112, 112, 128)	73,856	bl
block2_conv2 (Conv2D)	(None, 112, 112, 128)	147,584	bl
block2_pool (MaxPooling2D)	(None, 56, 56, 128)	0	bl
block3_conv1 (Conv2D)	(None, 56, 56, 256)	295,168	bl
block3_conv2 (Conv2D)	(None, 56, 56, 256)	590,080	bl
block3_conv3 (Conv2D)	(None, 56, 56, 256)	590,080	bl
block3_conv4 (Conv2D)	(None, 56, 56, 256)	590,080	bl
block3_pool (MaxPooling2D)	(None, 28, 28, 256)	0	bl
block4_conv1 (Conv2D)	(None, 28, 28, 512)	1,180,160	bl
block4_conv2 (Conv2D)	(None, 28, 28, 512)	2,359,808	bl
block4_conv3 (Conv2D)	(None, 28, 28, 512)	2,359,808	bl
block4_conv4 (Conv2D)	(None, 28, 28, 512)	2,359,808	bl
block4_pool (MaxPooling2D)	(None, 14, 14, 512)	0	bl
block5_conv1 (Conv2D)	(None, 14, 14, 512)	2,359,808	bl
block5_conv2 (Conv2D)	(None, 14, 14, 512)	2,359,808	bl
block5_conv3 (Conv2D)	(None, 14, 14, 512)	2,359,808	bl
block5_conv4 (Conv2D)	(None, 14, 14, 512)	2,359,808	bl
block5_pool (MaxPooling2D)	(None, 7, 7, 512)	0	bl
reshape_2 (Reshape)	(None, 49, 512)	0	bl
multi_head_attention_1 (MultiHeadAttention)	(None, 49, 512)	8,401,408	re re
reshape_3 (Reshape)	(None, 7, 7, 512)	0	mu

gaussian_noise_2 (GaussianNoise)	(None, 7, 7, 512)	0	re
global_average_pooling2d... (GlobalAveragePooling2D)	(None, 512)	0	ga
dense_2 (Dense)	(None, 512)	262,656	gl
batch_normalization_1 (BatchNormalization)	(None, 512)	2,048	de
gaussian_noise_3 (GaussianNoise)	(None, 512)	0	ba
dropout_3 (Dropout)	(None, 512)	0	ga
dense_3 (Dense)	(None, 4)	2,052	dr

Total params: 28,692,548 (109.45 MB)

Trainable params: 8,667,140 (33.06 MB)

Non-trainable params: 20,025,408 (76.39 MB)

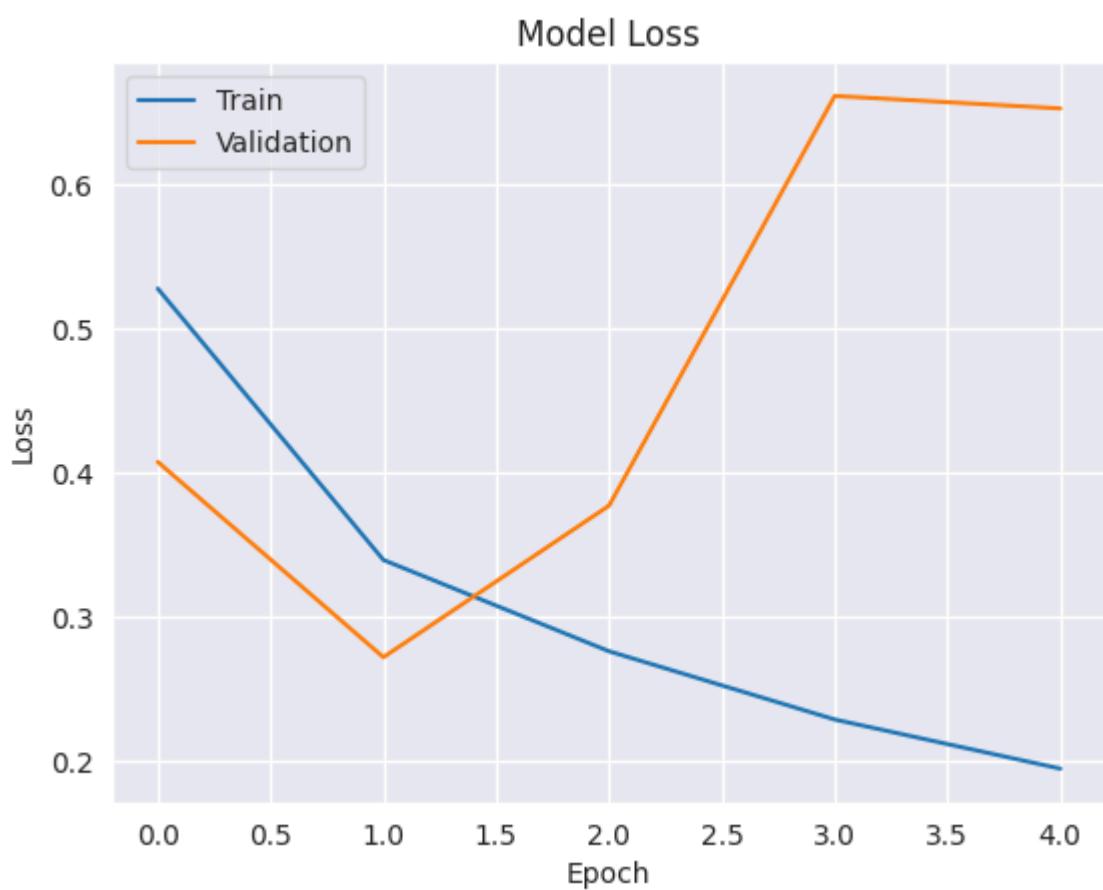
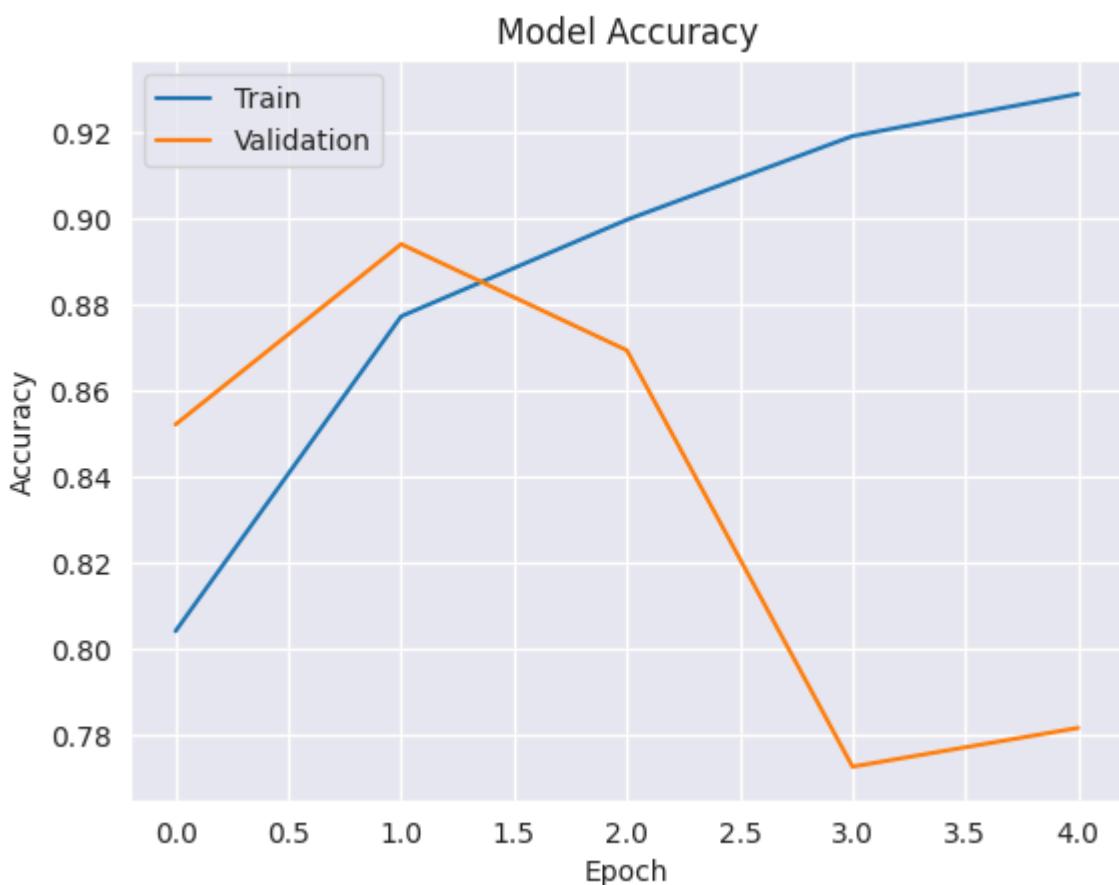
```
In [ ]: history = cnn_model.fit(
    train_gen_new,
    validation_data=valid_gen_new,
    epochs=5,
    callbacks=[early_stopping],
    verbose=1
)
```

```
Epoch 1/5
1278/1278 147s 110ms/step - accuracy: 0.7494 - loss: 0.6612
- val_accuracy: 0.8521 - val_loss: 0.4078
Epoch 2/5
1278/1278 139s 109ms/step - accuracy: 0.8724 - loss: 0.3593
- val_accuracy: 0.8940 - val_loss: 0.2722
Epoch 3/5
1278/1278 140s 109ms/step - accuracy: 0.8969 - loss: 0.2841
- val_accuracy: 0.8693 - val_loss: 0.3774
Epoch 4/5
1278/1278 139s 108ms/step - accuracy: 0.9174 - loss: 0.2328
- val_accuracy: 0.7727 - val_loss: 0.6618
Epoch 5/5
1278/1278 139s 109ms/step - accuracy: 0.9316 - loss: 0.1853
- val_accuracy: 0.7817 - val_loss: 0.6531
```

```
In [ ]: plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()

plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model Loss')
```

```
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()
```



```
In [ ]: test_labels = test_gen_new.classes
         predictions = cnn_model.predict(test_gen_new)
         predicted_classes = np.argmax(predictions, axis=1)

160/160 ━━━━━━━━ 16s 93ms/step
```

```
In [ ]: report = classification_report(test_labels, predicted_classes,
                                         target_names=list(test_gen_new.class_indices.keys()))
print("Report for VGG19 =>")
print(report)
```

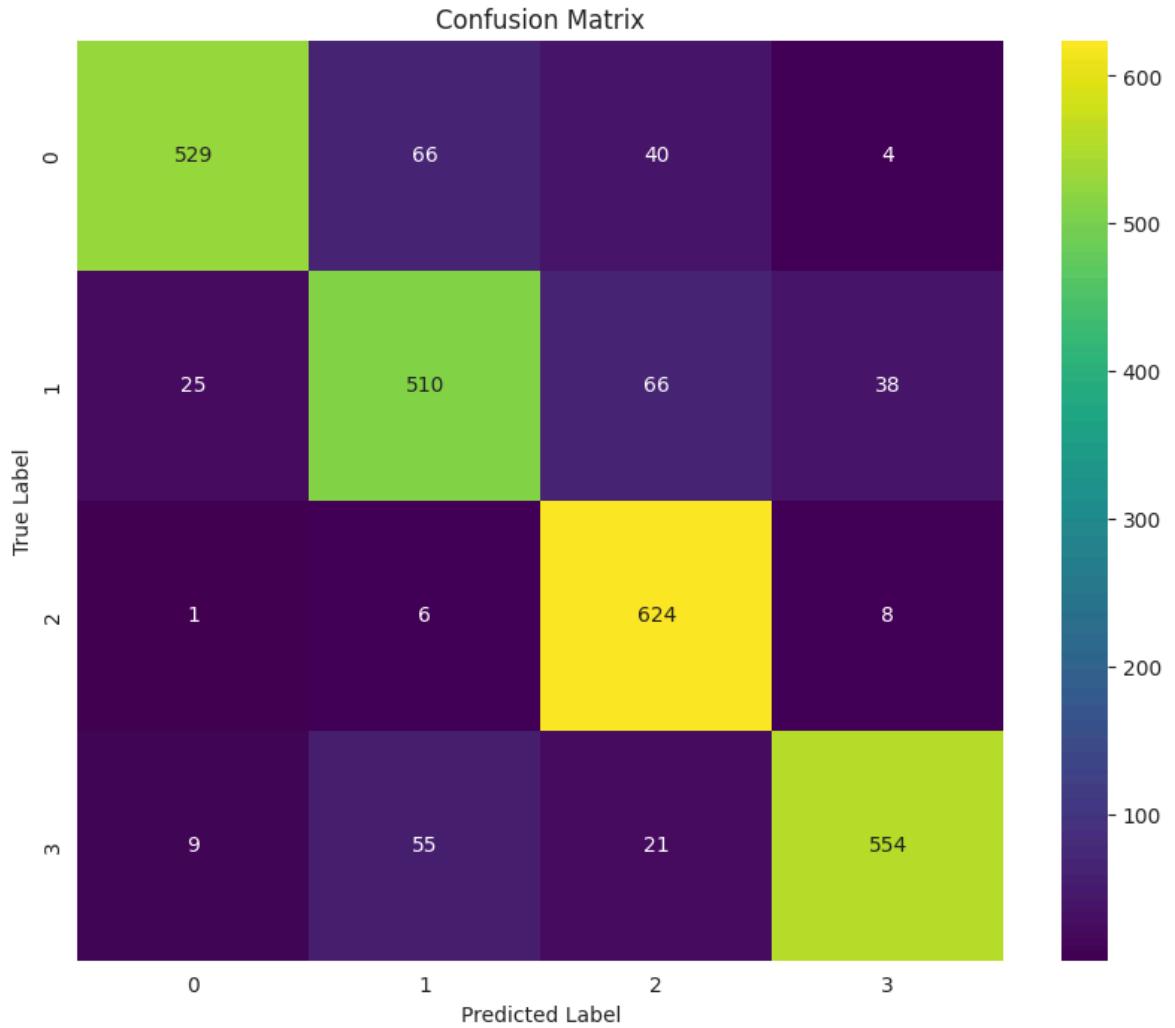
```
Report for VGG19 =>
      precision    recall  f1-score   support

          0       0.94     0.83     0.88     639
          1       0.80     0.80     0.80     639
          2       0.83     0.98     0.90     639
          3       0.92     0.87     0.89     639

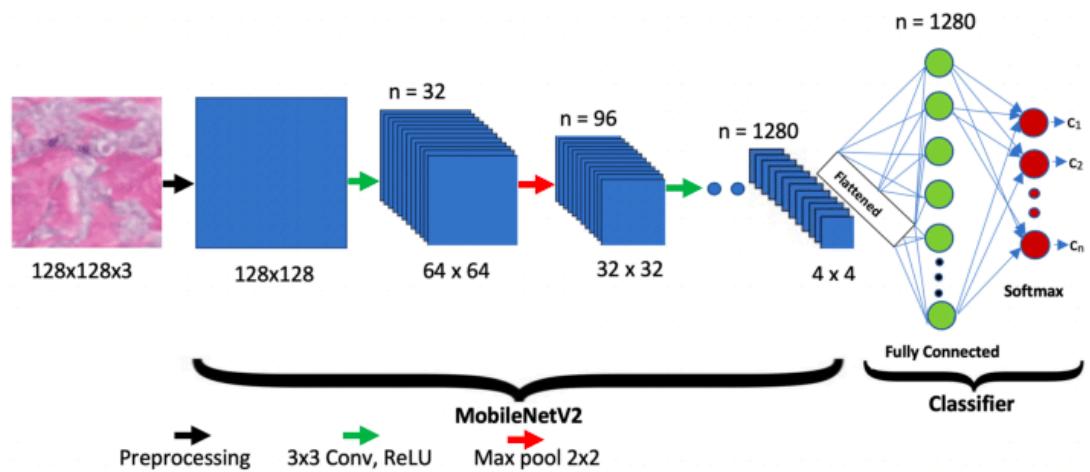
   accuracy                           0.87    2556
  macro avg       0.87     0.87     0.87    2556
weighted avg       0.87     0.87     0.87    2556
```

```
In [ ]: conf_matrix = confusion_matrix(test_labels, predicted_classes)
```

```
In [ ]: plt.figure(figsize=(10, 8))
sns.heatmap(conf_matrix, annot=True, fmt='d', cmap='viridis',
            xticklabels=list(test_gen_new.class_indices.keys()),
            yticklabels=list(test_gen_new.class_indices.keys()))
plt.title('Confusion Matrix')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```



MobileNetV3



```
In [ ]: def create_mobilenet_model(input_shape):

    inputs = Input(shape=input_shape)

    base_model = MobileNet(weights='imagenet',
                           input_tensor=inputs, include_top=False)

    for layer in base_model.layers:
        layer.trainable = False
```

```

x = base_model.output

height, width, channels = 7, 7, 1024
x = Reshape((height * width, channels))(x)

attention_output = MultiHeadAttention(num_heads=8, key_dim=channels)(x, x)

attention_output = Reshape((height, width, channels))(attention_output)

x = GaussianNoise(0.25)(attention_output)

x = GlobalAveragePooling2D()(x)

x = Dense(512, activation='relu')(x)
x = BatchNormalization()(x)
x = GaussianNoise(0.25)(x)
x = Dropout(0.25)(x)

outputs = Dense(4, activation='softmax')(x)

model = Model(inputs=inputs, outputs=outputs)

return model

input_shape = (224, 224, 3)

cnn_model = create_mobilenet_model(input_shape)

cnn_model.compile(optimizer=Adam(learning_rate=0.0001),
                  loss='sparse_categorical_crossentropy',
                  metrics=['accuracy'])

```

Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/mobilenet/mobilenet_1_0_224_tf_no_top.h5
17225924/17225924 ————— 2s 0us/step

In []: `cnn_model.summary()`

Model: "functional_2"

Layer (type)	Output Shape	Param #	Co
input_layer_2 (InputLayer)	(None, 224, 224, 3)	0	-
conv1 (Conv2D)	(None, 112, 112, 32)	864	in
conv1_bn (BatchNormalization)	(None, 112, 112, 32)	128	co
conv1_relu (ReLU)	(None, 112, 112, 32)	0	co
conv_dw_1 (DepthwiseConv2D)	(None, 112, 112, 32)	288	co
conv_dw_1_bn (BatchNormalization)	(None, 112, 112, 32)	128	co
conv_dw_1_relu (ReLU)	(None, 112, 112, 32)	0	co
conv_pw_1 (Conv2D)	(None, 112, 112, 64)	2,048	co
conv_pw_1_bn (BatchNormalization)	(None, 112, 112, 64)	256	co
conv_pw_1_relu (ReLU)	(None, 112, 112, 64)	0	co
conv_pad_2 (ZeroPadding2D)	(None, 113, 113, 64)	0	co
conv_dw_2 (DepthwiseConv2D)	(None, 56, 56, 64)	576	co
conv_dw_2_bn (BatchNormalization)	(None, 56, 56, 64)	256	co
conv_dw_2_relu (ReLU)	(None, 56, 56, 64)	0	co
conv_pw_2 (Conv2D)	(None, 56, 56, 128)	8,192	co
conv_pw_2_bn (BatchNormalization)	(None, 56, 56, 128)	512	co
conv_pw_2_relu (ReLU)	(None, 56, 56, 128)	0	co
conv_dw_3 (DepthwiseConv2D)	(None, 56, 56, 128)	1,152	co
conv_dw_3_bn (BatchNormalization)	(None, 56, 56, 128)	512	co
conv_dw_3_relu (ReLU)	(None, 56, 56, 128)	0	co
conv_pw_3 (Conv2D)	(None, 56, 56, 128)	16,384	co
conv_pw_3_bn (BatchNormalization)	(None, 56, 56, 128)	512	co
conv_pw_3_relu (ReLU)	(None, 56, 56, 128)	0	co

conv_pad_4 (ZeroPadding2D)	(None, 57, 57, 128)	0	co
conv_dw_4 (DepthwiseConv2D)	(None, 28, 28, 128)	1,152	co
conv_dw_4_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv_dw_4_relu (ReLU)	(None, 28, 28, 128)	0	co
conv_pw_4 (Conv2D)	(None, 28, 28, 256)	32,768	co
conv_pw_4_bn (BatchNormalization)	(None, 28, 28, 256)	1,024	co
conv_pw_4_relu (ReLU)	(None, 28, 28, 256)	0	co
conv_dw_5 (DepthwiseConv2D)	(None, 28, 28, 256)	2,304	co
conv_dw_5_bn (BatchNormalization)	(None, 28, 28, 256)	1,024	co
conv_dw_5_relu (ReLU)	(None, 28, 28, 256)	0	co
conv_pw_5 (Conv2D)	(None, 28, 28, 256)	65,536	co
conv_pw_5_bn (BatchNormalization)	(None, 28, 28, 256)	1,024	co
conv_pw_5_relu (ReLU)	(None, 28, 28, 256)	0	co
conv_pad_6 (ZeroPadding2D)	(None, 29, 29, 256)	0	co
conv_dw_6 (DepthwiseConv2D)	(None, 14, 14, 256)	2,304	co
conv_dw_6_bn (BatchNormalization)	(None, 14, 14, 256)	1,024	co
conv_dw_6_relu (ReLU)	(None, 14, 14, 256)	0	co
conv_pw_6 (Conv2D)	(None, 14, 14, 512)	131,072	co
conv_pw_6_bn (BatchNormalization)	(None, 14, 14, 512)	2,048	co
conv_pw_6_relu (ReLU)	(None, 14, 14, 512)	0	co
conv_dw_7 (DepthwiseConv2D)	(None, 14, 14, 512)	4,608	co
conv_dw_7_bn (BatchNormalization)	(None, 14, 14, 512)	2,048	co
conv_dw_7_relu (ReLU)	(None, 14, 14, 512)	0	co

conv_pw_7 (Conv2D)	(None, 14, 14, 512)	262,144	co
conv_pw_7_bn (BatchNormalization)	(None, 14, 14, 512)	2,048	co
conv_pw_7_relu (ReLU)	(None, 14, 14, 512)	0	co
conv_dw_8 (DepthwiseConv2D)	(None, 14, 14, 512)	4,608	co
conv_dw_8_bn (BatchNormalization)	(None, 14, 14, 512)	2,048	co
conv_dw_8_relu (ReLU)	(None, 14, 14, 512)	0	co
conv_pw_8 (Conv2D)	(None, 14, 14, 512)	262,144	co
conv_pw_8_bn (BatchNormalization)	(None, 14, 14, 512)	2,048	co
conv_pw_8_relu (ReLU)	(None, 14, 14, 512)	0	co
conv_dw_9 (DepthwiseConv2D)	(None, 14, 14, 512)	4,608	co
conv_dw_9_bn (BatchNormalization)	(None, 14, 14, 512)	2,048	co
conv_dw_9_relu (ReLU)	(None, 14, 14, 512)	0	co
conv_pw_9 (Conv2D)	(None, 14, 14, 512)	262,144	co
conv_pw_9_bn (BatchNormalization)	(None, 14, 14, 512)	2,048	co
conv_pw_9_relu (ReLU)	(None, 14, 14, 512)	0	co
conv_dw_10 (DepthwiseConv2D)	(None, 14, 14, 512)	4,608	co
conv_dw_10_bn (BatchNormalization)	(None, 14, 14, 512)	2,048	co
conv_dw_10_relu (ReLU)	(None, 14, 14, 512)	0	co
conv_pw_10 (Conv2D)	(None, 14, 14, 512)	262,144	co
conv_pw_10_bn (BatchNormalization)	(None, 14, 14, 512)	2,048	co
conv_pw_10_relu (ReLU)	(None, 14, 14, 512)	0	co
conv_dw_11 (DepthwiseConv2D)	(None, 14, 14, 512)	4,608	co
conv_dw_11_bn (BatchNormalization)	(None, 14, 14, 512)	2,048	co
conv_dw_11_relu (ReLU)	(None, 14, 14, 512)	0	co

conv_pw_11 (Conv2D)	(None, 14, 14, 512)	262,144	co
conv_pw_11_bn (BatchNormalization)	(None, 14, 14, 512)	2,048	co
conv_pw_11_relu (ReLU)	(None, 14, 14, 512)	0	co
conv_pad_12 (ZeroPadding2D)	(None, 15, 15, 512)	0	co
conv_dw_12 (DepthwiseConv2D)	(None, 7, 7, 512)	4,608	co
conv_dw_12_bn (BatchNormalization)	(None, 7, 7, 512)	2,048	co
conv_dw_12_relu (ReLU)	(None, 7, 7, 512)	0	co
conv_pw_12 (Conv2D)	(None, 7, 7, 1024)	524,288	co
conv_pw_12_bn (BatchNormalization)	(None, 7, 7, 1024)	4,096	co
conv_pw_12_relu (ReLU)	(None, 7, 7, 1024)	0	co
conv_dw_13 (DepthwiseConv2D)	(None, 7, 7, 1024)	9,216	co
conv_dw_13_bn (BatchNormalization)	(None, 7, 7, 1024)	4,096	co
conv_dw_13_relu (ReLU)	(None, 7, 7, 1024)	0	co
conv_pw_13 (Conv2D)	(None, 7, 7, 1024)	1,048,576	co
conv_pw_13_bn (BatchNormalization)	(None, 7, 7, 1024)	4,096	co
conv_pw_13_relu (ReLU)	(None, 7, 7, 1024)	0	co
reshape_4 (Reshape)	(None, 49, 1024)	0	co
multi_head_attention_2 (MultiHeadAttention)	(None, 49, 1024)	33,580,032	re re
reshape_5 (Reshape)	(None, 7, 7, 1024)	0	mu
gaussian_noise_4 (GaussianNoise)	(None, 7, 7, 1024)	0	re
global_average_pooling2d... (GlobalAveragePooling2D)	(None, 1024)	0	ga
dense_4 (Dense)	(None, 512)	524,800	gl
batch_normalization_2 (BatchNormalization)	(None, 512)	2,048	de
gaussian_noise_5 (GaussianNoise)	(None, 512)	0	ba

dropout_5 (Dropout)	(None, 512)	0	ga
dense_5 (Dense)	(None, 4)	2,052	dr

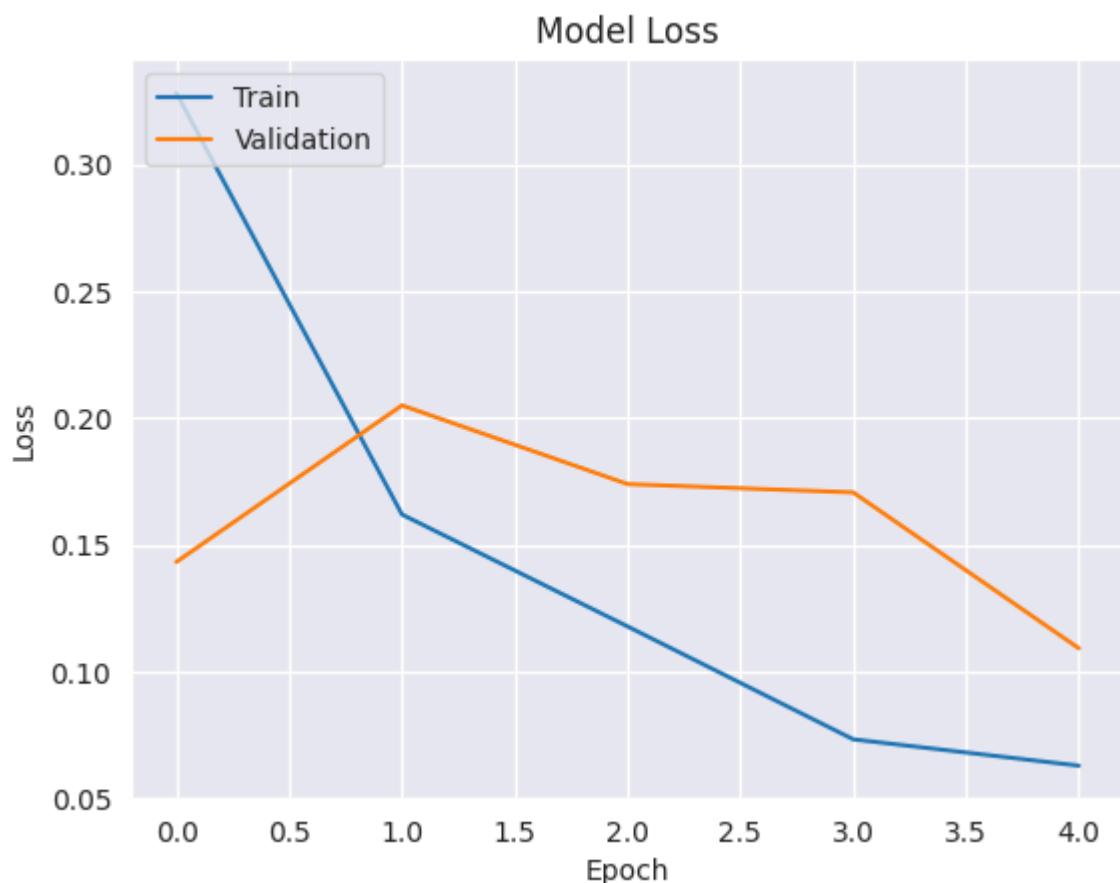
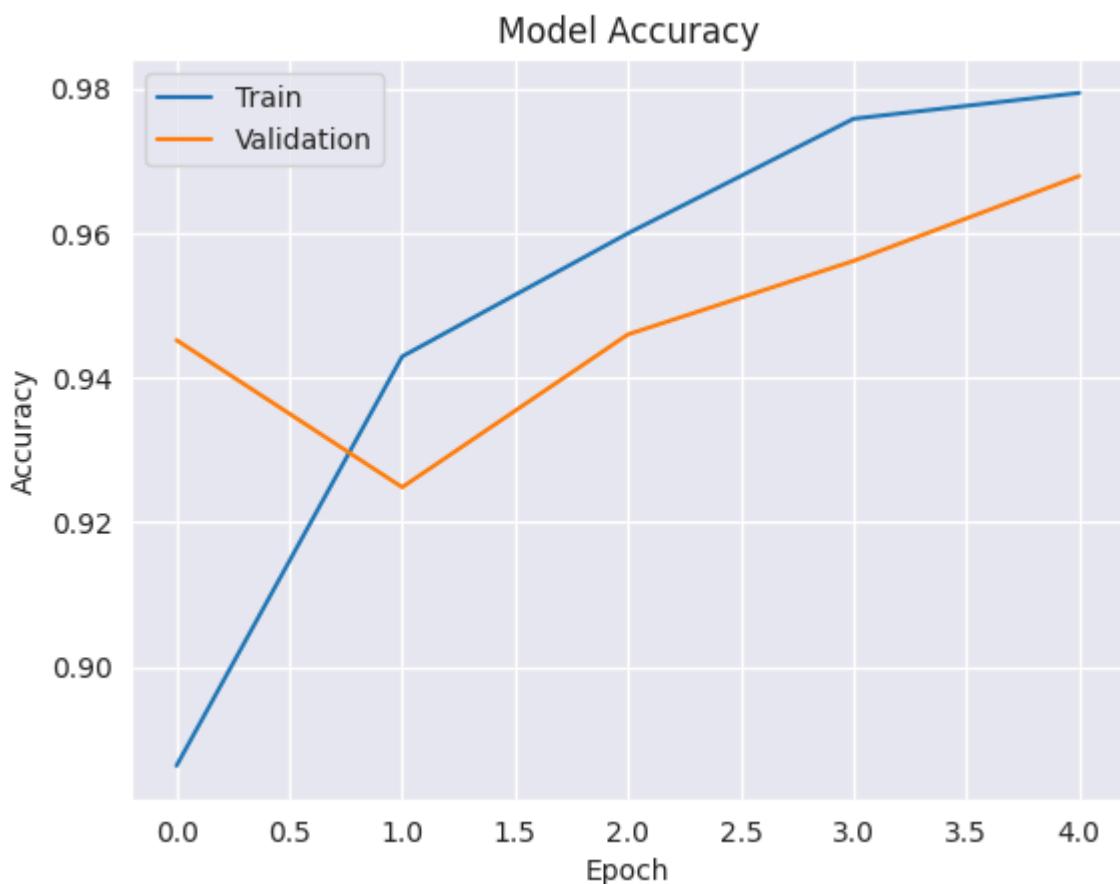
Total params: 37,337,796 (142.43 MB)
Trainable params: 34,107,908 (130.11 MB)
Non-trainable params: 3,229,888 (12.32 MB)

```
In [ ]: history = cnn_model.fit(
    train_gen_new,
    validation_data=valid_gen_new,
    epochs=5,
    callbacks=[early_stopping],
    verbose=1
)
```

```
Epoch 1/5
1278/1278 113s 79ms/step - accuracy: 0.8454 - loss: 0.4413 -
val_accuracy: 0.9452 - val_loss: 0.1433
Epoch 2/5
1278/1278 92s 72ms/step - accuracy: 0.9393 - loss: 0.1700 -
val_accuracy: 0.9249 - val_loss: 0.2051
Epoch 3/5
1278/1278 91s 71ms/step - accuracy: 0.9602 - loss: 0.1159 -
val_accuracy: 0.9460 - val_loss: 0.1740
Epoch 4/5
1278/1278 92s 71ms/step - accuracy: 0.9772 - loss: 0.0695 -
val_accuracy: 0.9562 - val_loss: 0.1707
Epoch 5/5
1278/1278 93s 72ms/step - accuracy: 0.9807 - loss: 0.0558 -
val_accuracy: 0.9679 - val_loss: 0.1093
```

```
In [ ]: plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()

plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model Loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()
```



```
In [ ]: test_labels = test_gen_new.classes
predictions = cnn_model.predict(test_gen_new)
predicted_classes = np.argmax(predictions, axis=1)
```

160/160 ━━━━━━━━ 13s 71ms/step

```
In [ ]: report = classification_report(test_labels,
                                         predicted_classes,
                                         target_names=list(test_gen_new.class_indices.keys()))
print("Report for MobileNET =>")
print(report)
```

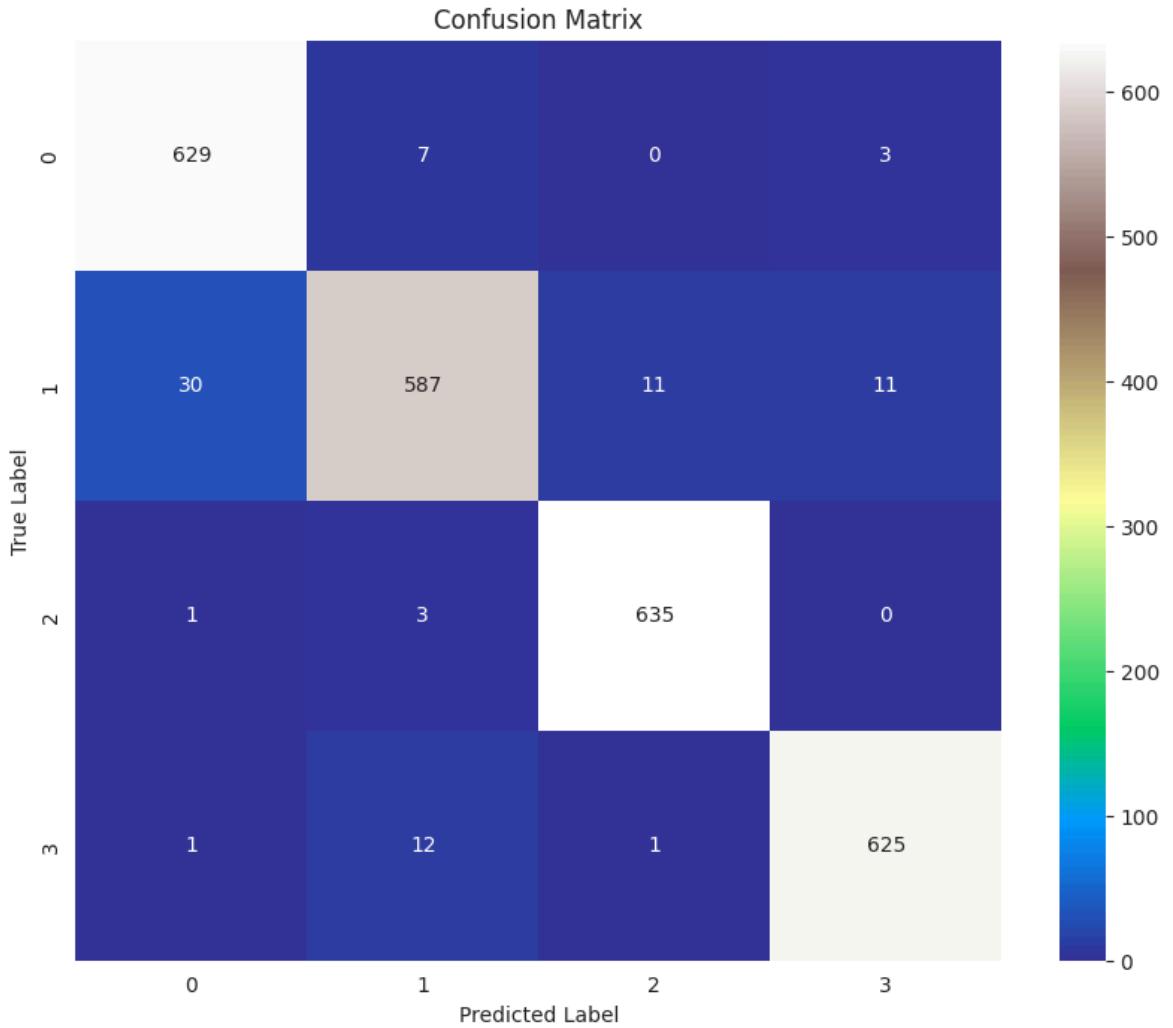
```
Report for MobileNET =>
      precision    recall  f1-score   support

          0       0.95     0.98     0.97     639
          1       0.96     0.92     0.94     639
          2       0.98     0.99     0.99     639
          3       0.98     0.98     0.98     639

   accuracy                           0.97      2556
macro avg       0.97     0.97     0.97      2556
weighted avg    0.97     0.97     0.97      2556
```

```
In [ ]: conf_matrix = confusion_matrix(test_labels, predicted_classes)
```

```
In [ ]: plt.figure(figsize=(10, 8))
sns.heatmap(conf_matrix, annot=True, fmt='d',
            cmap='terrain',
            xticklabels=list(test_gen_new.class_indices.keys()),
            yticklabels=list(test_gen_new.class_indices.keys()))
plt.title('Confusion Matrix')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```



```
In [ ]: def create_xception_model(input_shape):

    inputs = Input(shape=input_shape)

    base_model = Xception(weights='imagenet',
                           input_tensor=inputs,
                           include_top=False)

    for layer in base_model.layers:
        layer.trainable = False

    x = base_model.output

    height, width, channels = 7, 7, 2048
    x = Reshape((height * width, channels))(x)

    attention_output = MultiHeadAttention(num_heads=8, key_dim=channels)(x, x)

    attention_output = Reshape((height, width, channels))(attention_output)

    x = GaussianNoise(0.25)(attention_output)
    x = GlobalAveragePooling2D()(x)
    x = Dense(512, activation='relu')(x)
    x = BatchNormalization()(x)
    x = GaussianNoise(0.25)(x)
    x = Dropout(0.25)(x)
    outputs = Dense(4, activation='softmax')(x)
```

```
model = Model(inputs=inputs, outputs=outputs)

return model

input_shape = (224, 224, 3)
cnn_model = create_xception_model(input_shape)

cnn_model.compile(optimizer=Adam(learning_rate=0.0001),
                   loss='sparse_categorical_crossentropy',
                   metrics=['accuracy'])
```

Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/xception/xception_weights_tf_dim_ordering_tf_kernels_notop.h5
83683744/83683744 5s 0us/step

In []: `cnn_model.summary()`

Model: "functional_3"

Layer (type)	Output Shape	Param #	Co
input_layer_3 (InputLayer)	(None, 224, 224, 3)	0	-
block1_conv1 (Conv2D)	(None, 111, 111, 32)	864	in
block1_conv1_bn (BatchNormalization)	(None, 111, 111, 32)	128	bl
block1_conv1_act (Activation)	(None, 111, 111, 32)	0	bl
block1_conv2 (Conv2D)	(None, 109, 109, 64)	18,432	bl
block1_conv2_bn (BatchNormalization)	(None, 109, 109, 64)	256	bl
block1_conv2_act (Activation)	(None, 109, 109, 64)	0	bl
block2_sepconv1 (SeparableConv2D)	(None, 109, 109, 128)	8,768	bl
block2_sepconv1_bn (BatchNormalization)	(None, 109, 109, 128)	512	bl
block2_sepconv2_act (Activation)	(None, 109, 109, 128)	0	bl
block2_sepconv2 (SeparableConv2D)	(None, 109, 109, 128)	17,536	bl
block2_sepconv2_bn (BatchNormalization)	(None, 109, 109, 128)	512	bl
conv2d (Conv2D)	(None, 55, 55, 128)	8,192	bl
block2_pool (MaxPooling2D)	(None, 55, 55, 128)	0	bl
batch_normalization_3 (BatchNormalization)	(None, 55, 55, 128)	512	co
add (Add)	(None, 55, 55, 128)	0	bl ba
block3_sepconv1_act (Activation)	(None, 55, 55, 128)	0	ad
block3_sepconv1 (SeparableConv2D)	(None, 55, 55, 256)	33,920	bl
block3_sepconv1_bn (BatchNormalization)	(None, 55, 55, 256)	1,024	bl
block3_sepconv2_act (Activation)	(None, 55, 55, 256)	0	bl

block3_sepconv2 (SeparableConv2D)	(None, 55, 55, 256)	67,840	b1
block3_sepconv2_bn (BatchNormalization)	(None, 55, 55, 256)	1,024	b1
conv2d_1 (Conv2D)	(None, 28, 28, 256)	32,768	ad
block3_pool (MaxPooling2D)	(None, 28, 28, 256)	0	b1
batch_normalization_4 (BatchNormalization)	(None, 28, 28, 256)	1,024	co
add_1 (Add)	(None, 28, 28, 256)	0	b1 ba
block4_sepconv1_act (Activation)	(None, 28, 28, 256)	0	ad
block4_sepconv1 (SeparableConv2D)	(None, 28, 28, 728)	188,672	b1
block4_sepconv1_bn (BatchNormalization)	(None, 28, 28, 728)	2,912	b1
block4_sepconv2_act (Activation)	(None, 28, 28, 728)	0	b1
block4_sepconv2 (SeparableConv2D)	(None, 28, 28, 728)	536,536	b1
block4_sepconv2_bn (BatchNormalization)	(None, 28, 28, 728)	2,912	b1
conv2d_2 (Conv2D)	(None, 14, 14, 728)	186,368	ad
block4_pool (MaxPooling2D)	(None, 14, 14, 728)	0	b1
batch_normalization_5 (BatchNormalization)	(None, 14, 14, 728)	2,912	co
add_2 (Add)	(None, 14, 14, 728)	0	b1 ba
block5_sepconv1_act (Activation)	(None, 14, 14, 728)	0	ad
block5_sepconv1 (SeparableConv2D)	(None, 14, 14, 728)	536,536	b1
block5_sepconv1_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	b1
block5_sepconv2_act (Activation)	(None, 14, 14, 728)	0	b1
block5_sepconv2 (SeparableConv2D)	(None, 14, 14, 728)	536,536	b1

block5_sepconv2_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block5_sepconv3_act (Activation)	(None, 14, 14, 728)	0	bl
block5_sepconv3 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block5_sepconv3_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
add_3 (Add)	(None, 14, 14, 728)	0	bl ad
block6_sepconv1_act (Activation)	(None, 14, 14, 728)	0	ad
block6_sepconv1 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block6_sepconv1_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block6_sepconv2_act (Activation)	(None, 14, 14, 728)	0	bl
block6_sepconv2 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block6_sepconv2_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block6_sepconv3_act (Activation)	(None, 14, 14, 728)	0	bl
block6_sepconv3 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block6_sepconv3_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
add_4 (Add)	(None, 14, 14, 728)	0	bl ad
block7_sepconv1_act (Activation)	(None, 14, 14, 728)	0	ad
block7_sepconv1 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block7_sepconv1_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block7_sepconv2_act (Activation)	(None, 14, 14, 728)	0	bl
block7_sepconv2 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl

block7_sepconv2_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block7_sepconv3_act (Activation)	(None, 14, 14, 728)	0	bl
block7_sepconv3 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block7_sepconv3_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
add_5 (Add)	(None, 14, 14, 728)	0	bl ad
block8_sepconv1_act (Activation)	(None, 14, 14, 728)	0	ad
block8_sepconv1 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block8_sepconv1_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block8_sepconv2_act (Activation)	(None, 14, 14, 728)	0	bl
block8_sepconv2 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block8_sepconv2_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block8_sepconv3_act (Activation)	(None, 14, 14, 728)	0	bl
block8_sepconv3 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block8_sepconv3_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
add_6 (Add)	(None, 14, 14, 728)	0	bl ad
block9_sepconv1_act (Activation)	(None, 14, 14, 728)	0	ad
block9_sepconv1 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block9_sepconv1_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block9_sepconv2_act (Activation)	(None, 14, 14, 728)	0	bl
block9_sepconv2 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl

block9_sepconv2_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block9_sepconv3_act (Activation)	(None, 14, 14, 728)	0	bl
block9_sepconv3 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block9_sepconv3_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
add_7 (Add)	(None, 14, 14, 728)	0	bl ad
block10_sepconv1_act (Activation)	(None, 14, 14, 728)	0	ad
block10_sepconv1 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block10_sepconv1_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block10_sepconv2_act (Activation)	(None, 14, 14, 728)	0	bl
block10_sepconv2 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block10_sepconv2_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block10_sepconv3_act (Activation)	(None, 14, 14, 728)	0	bl
block10_sepconv3 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block10_sepconv3_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
add_8 (Add)	(None, 14, 14, 728)	0	bl ad
block11_sepconv1_act (Activation)	(None, 14, 14, 728)	0	ad
block11_sepconv1 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block11_sepconv1_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block11_sepconv2_act (Activation)	(None, 14, 14, 728)	0	bl
block11_sepconv2 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl

block11_sepconv2_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block11_sepconv3_act (Activation)	(None, 14, 14, 728)	0	bl
block11_sepconv3 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block11_sepconv3_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
add_9 (Add)	(None, 14, 14, 728)	0	bl ad
block12_sepconv1_act (Activation)	(None, 14, 14, 728)	0	ad
block12_sepconv1 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block12_sepconv1_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block12_sepconv2_act (Activation)	(None, 14, 14, 728)	0	bl
block12_sepconv2 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block12_sepconv2_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block12_sepconv3_act (Activation)	(None, 14, 14, 728)	0	bl
block12_sepconv3 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block12_sepconv3_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
add_10 (Add)	(None, 14, 14, 728)	0	bl ad
block13_sepconv1_act (Activation)	(None, 14, 14, 728)	0	ad
block13_sepconv1 (SeparableConv2D)	(None, 14, 14, 728)	536,536	bl
block13_sepconv1_bn (BatchNormalization)	(None, 14, 14, 728)	2,912	bl
block13_sepconv2_act (Activation)	(None, 14, 14, 728)	0	bl
block13_sepconv2 (SeparableConv2D)	(None, 14, 14, 1024)	752,024	bl

block13_sepconv2_bn (BatchNormalization)	(None, 14, 14, 1024)	4,096	bl
conv2d_3 (Conv2D)	(None, 7, 7, 1024)	745,472	ad
block13_pool (MaxPooling2D)	(None, 7, 7, 1024)	0	bl
batch_normalization_6 (BatchNormalization)	(None, 7, 7, 1024)	4,096	co
add_11 (Add)	(None, 7, 7, 1024)	0	bl ba
block14_sepconv1 (SeparableConv2D)	(None, 7, 7, 1536)	1,582,080	ad
block14_sepconv1_bn (BatchNormalization)	(None, 7, 7, 1536)	6,144	bl
block14_sepconv1_act (Activation)	(None, 7, 7, 1536)	0	bl
block14_sepconv2 (SeparableConv2D)	(None, 7, 7, 2048)	3,159,552	bl
block14_sepconv2_bn (BatchNormalization)	(None, 7, 7, 2048)	8,192	bl
block14_sepconv2_act (Activation)	(None, 7, 7, 2048)	0	bl
reshape_6 (Reshape)	(None, 49, 2048)	0	bl
multi_head_attention_3 (MultiHeadAttention)	(None, 49, 2048)	134,268,928	re re
reshape_7 (Reshape)	(None, 7, 7, 2048)	0	mu
gaussian_noise_6 (GaussianNoise)	(None, 7, 7, 2048)	0	re
global_average_pooling2d... (GlobalAveragePooling2D)	(None, 2048)	0	ga
dense_6 (Dense)	(None, 512)	1,049,088	gl
batch_normalization_7 (BatchNormalization)	(None, 512)	2,048	de
gaussian_noise_7 (GaussianNoise)	(None, 512)	0	ba
dropout_7 (Dropout)	(None, 512)	0	ga
dense_7 (Dense)	(None, 4)	2,052	dr

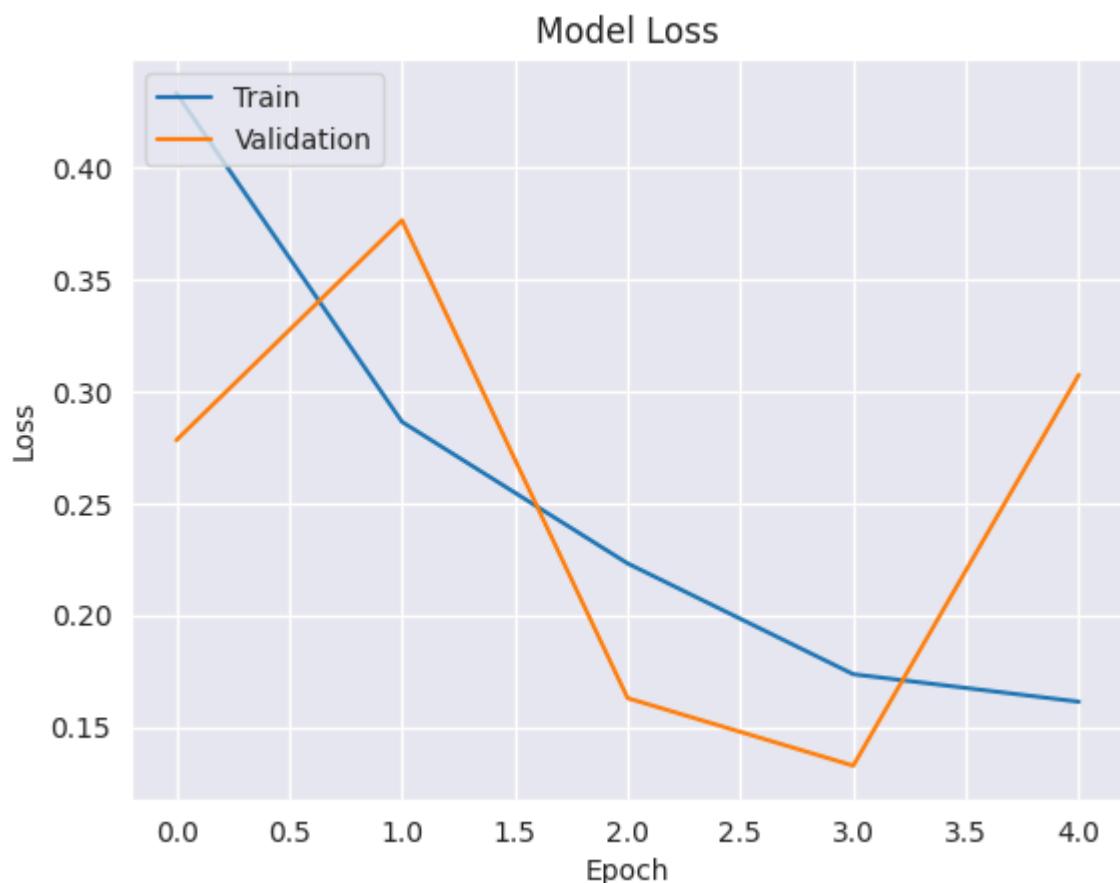
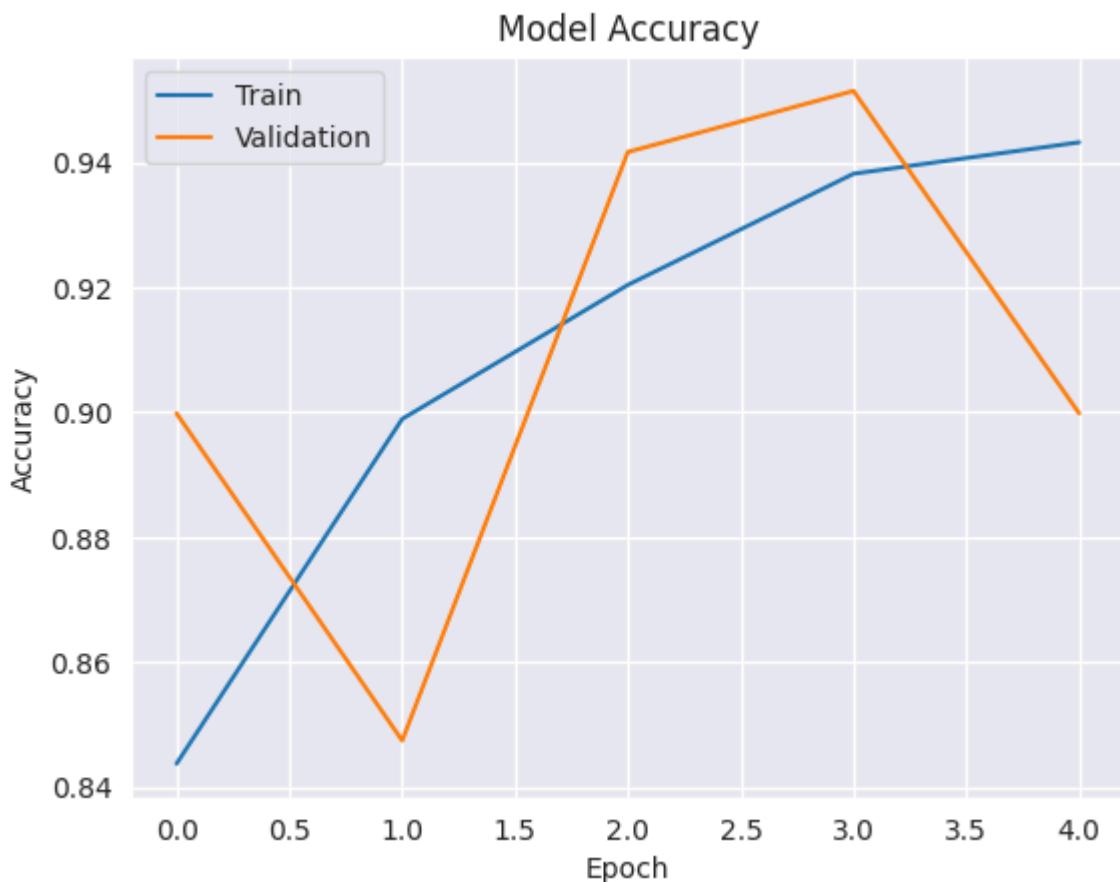
```
Total params: 156,183,596 (595.79 MB)
Trainable params: 135,321,092 (516.21 MB)
Non-trainable params: 20,862,504 (79.58 MB)
```

```
In [ ]: history = cnn_model.fit(
    train_gen_new,
    validation_data=valid_gen_new,
    epochs=5,
    callbacks=[early_stopping],
    verbose=1
)
```

```
Epoch 1/5
1278/1278 356s 262ms/step - accuracy: 0.7997 - loss: 0.5633
- val_accuracy: 0.8998 - val_loss: 0.2782
Epoch 2/5
1278/1278 317s 248ms/step - accuracy: 0.8969 - loss: 0.2920
- val_accuracy: 0.8474 - val_loss: 0.3767
Epoch 3/5
1278/1278 317s 248ms/step - accuracy: 0.9158 - loss: 0.2349
- val_accuracy: 0.9417 - val_loss: 0.1629
Epoch 4/5
1278/1278 317s 248ms/step - accuracy: 0.9397 - loss: 0.1656
- val_accuracy: 0.9515 - val_loss: 0.1327
Epoch 5/5
1278/1278 318s 248ms/step - accuracy: 0.9368 - loss: 0.1728
- val_accuracy: 0.8998 - val_loss: 0.3076
```

```
In [ ]: plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()

plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model Loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()
```



```
In [ ]: test_labels = test_gen_new.classes
predictions = cnn_model.predict(test_gen_new)
predicted_classes = np.argmax(predictions, axis=1)
```

160/160 ━━━━━━━━ 24s 138ms/step

```
In [ ]: report = classification_report(test_labels, predicted_classes, target_names=list
print("Report for Xeption =>")
print(report)
```

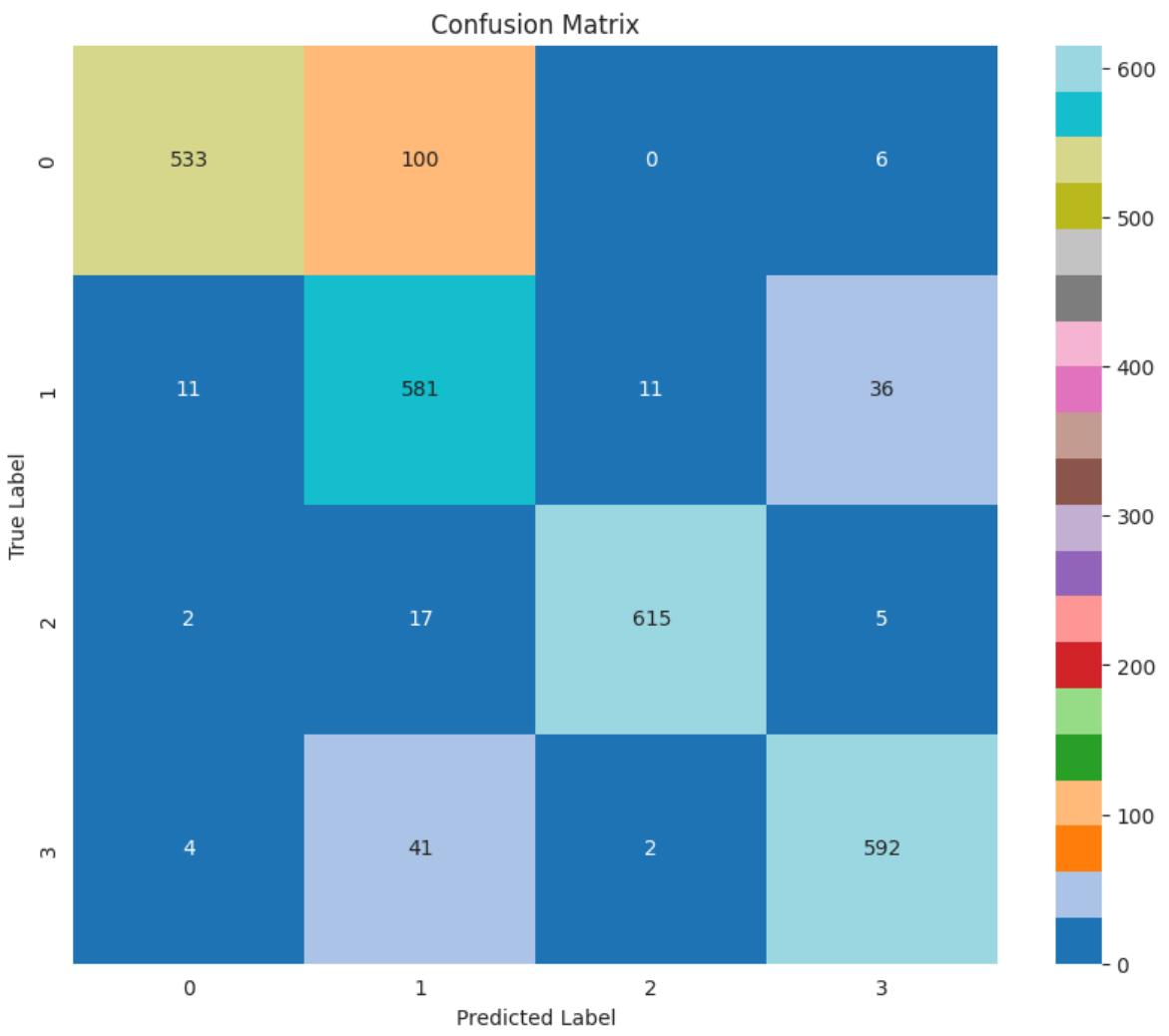
```
Report for Xeption =>
      precision    recall  f1-score   support

          0       0.97     0.83      0.90      639
          1       0.79     0.91      0.84      639
          2       0.98     0.96      0.97      639
          3       0.93     0.93      0.93      639

   accuracy                           0.91      2556
  macro avg       0.92     0.91      0.91      2556
weighted avg       0.92     0.91      0.91      2556
```

```
In [ ]: conf_matrix = confusion_matrix(test_labels, predicted_classes)
```

```
In [ ]: plt.figure(figsize=(10, 8))
sns.heatmap(conf_matrix, annot=True, fmt='d',
            cmap='tab20',
            xticklabels=list(test_gen_new.class_indices.keys()),
            yticklabels=list(test_gen_new.class_indices.keys()))
plt.title('Confusion Matrix')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```



```
In [ ]: def create_inception_model(input_shape):

    inputs = Input(shape=input_shape)

    base_model = InceptionV3(weights='imagenet',
                             input_tensor=inputs,
                             include_top=False)

    for layer in base_model.layers:
        layer.trainable = False

    x = base_model.output

    height, width, channels = 5, 5, 2048
    x = Reshape((height * width, channels))(x)

    attention_output = MultiHeadAttention(num_heads=8, key_dim=channels)(x, x)

    attention_output = Reshape((height, width, channels))(attention_output)

    x = GaussianNoise(0.25)(attention_output)
    x = GlobalAveragePooling2D()(x)
    x = Dense(512, activation='relu')(x)
    x = BatchNormalization()(x)
    x = GaussianNoise(0.25)(x)
    x = Dropout(0.25)(x)
    outputs = Dense(4, activation='softmax')(x)
```

```
model = Model(inputs=inputs, outputs=outputs)

return model

input_shape = (224, 224, 3)
cnn_model = create_inception_model(input_shape)

cnn_model.compile(optimizer=Adam(learning_rate=0.0001),
                   loss='sparse_categorical_crossentropy',
                   metrics=['accuracy'])
```

Downloading data from https://storage.googleapis.com/tensorflow/keras-application/s/inception_v3/inception_v3_weights_tf_dim_ordering_tf_kernels_notop.h5
87910968/87910968 5s 0us/step

In []: `cnn_model.summary()`

Model: "functional_4"

Layer (type)	Output Shape	Param #	Co
input_layer_4 (InputLayer)	(None, 224, 224, 3)	0	-
conv2d_4 (Conv2D)	(None, 111, 111, 32)	864	in
batch_normalization_8 (BatchNormalization)	(None, 111, 111, 32)	96	co
activation (Activation)	(None, 111, 111, 32)	0	ba
conv2d_5 (Conv2D)	(None, 109, 109, 32)	9,216	ac
batch_normalization_9 (BatchNormalization)	(None, 109, 109, 32)	96	co
activation_1 (Activation)	(None, 109, 109, 32)	0	ba
conv2d_6 (Conv2D)	(None, 109, 109, 64)	18,432	ac
batch_normalization_10 (BatchNormalization)	(None, 109, 109, 64)	192	co
activation_2 (Activation)	(None, 109, 109, 64)	0	ba
max_pooling2d (MaxPooling2D)	(None, 54, 54, 64)	0	ac
conv2d_7 (Conv2D)	(None, 54, 54, 80)	5,120	ma
batch_normalization_11 (BatchNormalization)	(None, 54, 54, 80)	240	co
activation_3 (Activation)	(None, 54, 54, 80)	0	ba
conv2d_8 (Conv2D)	(None, 52, 52, 192)	138,240	ac
batch_normalization_12 (BatchNormalization)	(None, 52, 52, 192)	576	co
activation_4 (Activation)	(None, 52, 52, 192)	0	ba
max_pooling2d_1 (MaxPooling2D)	(None, 25, 25, 192)	0	ac
conv2d_12 (Conv2D)	(None, 25, 25, 64)	12,288	ma
batch_normalization_16 (BatchNormalization)	(None, 25, 25, 64)	192	co
activation_8 (Activation)	(None, 25, 25, 64)	0	ba
conv2d_10 (Conv2D)	(None, 25, 25, 48)	9,216	ma
conv2d_13 (Conv2D)	(None, 25, 25, 96)	55,296	ac
batch_normalization_14 (BatchNormalization)	(None, 25, 25, 48)	144	co

batch_normalization_17 (BatchNormalization)	(None, 25, 25, 96)	288	co
activation_6 (Activation)	(None, 25, 25, 48)	0	ba
activation_9 (Activation)	(None, 25, 25, 96)	0	ba
average_pooling2d (AveragePooling2D)	(None, 25, 25, 192)	0	ma
conv2d_9 (Conv2D)	(None, 25, 25, 64)	12,288	ma
conv2d_11 (Conv2D)	(None, 25, 25, 64)	76,800	ac
conv2d_14 (Conv2D)	(None, 25, 25, 96)	82,944	ac
conv2d_15 (Conv2D)	(None, 25, 25, 32)	6,144	av
batch_normalization_13 (BatchNormalization)	(None, 25, 25, 64)	192	co
batch_normalization_15 (BatchNormalization)	(None, 25, 25, 64)	192	co
batch_normalization_18 (BatchNormalization)	(None, 25, 25, 96)	288	co
batch_normalization_19 (BatchNormalization)	(None, 25, 25, 32)	96	co
activation_5 (Activation)	(None, 25, 25, 64)	0	ba
activation_7 (Activation)	(None, 25, 25, 64)	0	ba
activation_10 (Activation)	(None, 25, 25, 96)	0	ba
activation_11 (Activation)	(None, 25, 25, 32)	0	ba
mixed0 (Concatenate)	(None, 25, 25, 256)	0	ac
		0	ac
		0	ac
		0	ac
conv2d_19 (Conv2D)	(None, 25, 25, 64)	16,384	mi
batch_normalization_23 (BatchNormalization)	(None, 25, 25, 64)	192	co
activation_15 (Activation)	(None, 25, 25, 64)	0	ba
conv2d_17 (Conv2D)	(None, 25, 25, 48)	12,288	mi
conv2d_20 (Conv2D)	(None, 25, 25, 96)	55,296	ac
batch_normalization_21 (BatchNormalization)	(None, 25, 25, 48)	144	co

batch_normalization_24 (BatchNormalization)	(None, 25, 25, 96)	288	co
activation_13 (Activation)	(None, 25, 25, 48)	0	ba
activation_16 (Activation)	(None, 25, 25, 96)	0	ba
average_pooling2d_1 (AveragePooling2D)	(None, 25, 25, 256)	0	mi
conv2d_16 (Conv2D)	(None, 25, 25, 64)	16,384	mi
conv2d_18 (Conv2D)	(None, 25, 25, 64)	76,800	ac
conv2d_21 (Conv2D)	(None, 25, 25, 96)	82,944	ac
conv2d_22 (Conv2D)	(None, 25, 25, 64)	16,384	av
batch_normalization_20 (BatchNormalization)	(None, 25, 25, 64)	192	co
batch_normalization_22 (BatchNormalization)	(None, 25, 25, 64)	192	co
batch_normalization_25 (BatchNormalization)	(None, 25, 25, 96)	288	co
batch_normalization_26 (BatchNormalization)	(None, 25, 25, 64)	192	co
activation_12 (Activation)	(None, 25, 25, 64)	0	ba
activation_14 (Activation)	(None, 25, 25, 64)	0	ba
activation_17 (Activation)	(None, 25, 25, 96)	0	ba
activation_18 (Activation)	(None, 25, 25, 64)	0	ba
mixed1 (Concatenate)	(None, 25, 25, 288)	0	ac
		0	ac
		0	ac
		0	ac
conv2d_26 (Conv2D)	(None, 25, 25, 64)	18,432	mi
batch_normalization_30 (BatchNormalization)	(None, 25, 25, 64)	192	co
activation_22 (Activation)	(None, 25, 25, 64)	0	ba
conv2d_24 (Conv2D)	(None, 25, 25, 48)	13,824	mi

conv2d_27 (Conv2D)	(None, 25, 25, 96)	55,296	ac
batch_normalization_28 (BatchNormalization)	(None, 25, 25, 48)	144	co
batch_normalization_31 (BatchNormalization)	(None, 25, 25, 96)	288	co
activation_20 (Activation)	(None, 25, 25, 48)	0	ba
activation_23 (Activation)	(None, 25, 25, 96)	0	ba
average_pooling2d_2 (AveragePooling2D)	(None, 25, 25, 288)	0	mi
conv2d_23 (Conv2D)	(None, 25, 25, 64)	18,432	mi
conv2d_25 (Conv2D)	(None, 25, 25, 64)	76,800	ac
conv2d_28 (Conv2D)	(None, 25, 25, 96)	82,944	ac
conv2d_29 (Conv2D)	(None, 25, 25, 64)	18,432	av
batch_normalization_27 (BatchNormalization)	(None, 25, 25, 64)	192	co
batch_normalization_29 (BatchNormalization)	(None, 25, 25, 64)	192	co
batch_normalization_32 (BatchNormalization)	(None, 25, 25, 96)	288	co
batch_normalization_33 (BatchNormalization)	(None, 25, 25, 64)	192	co
activation_19 (Activation)	(None, 25, 25, 64)	0	ba
activation_21 (Activation)	(None, 25, 25, 64)	0	ba
activation_24 (Activation)	(None, 25, 25, 96)	0	ba
activation_25 (Activation)	(None, 25, 25, 64)	0	ba
mixed2 (Concatenate)	(None, 25, 25, 288)	0	ac ac ac ac
conv2d_31 (Conv2D)	(None, 25, 25, 64)	18,432	mi
batch_normalization_35 (BatchNormalization)	(None, 25, 25, 64)	192	co
activation_27	(None, 25, 25, 64)	0	ba

(Activation)				
conv2d_32 (Conv2D)	(None, 25, 25, 96)	55,296		ac
batch_normalization_36 (BatchNormalization)	(None, 25, 25, 96)	288		co
activation_28 (Activation)	(None, 25, 25, 96)	0		ba
conv2d_30 (Conv2D)	(None, 12, 12, 384)	995,328		mi
conv2d_33 (Conv2D)	(None, 12, 12, 96)	82,944		ac
batch_normalization_34 (BatchNormalization)	(None, 12, 12, 384)	1,152		co
batch_normalization_37 (BatchNormalization)	(None, 12, 12, 96)	288		co
activation_26 (Activation)	(None, 12, 12, 384)	0		ba
activation_29 (Activation)	(None, 12, 12, 96)	0		ba
max_pooling2d_2 (MaxPooling2D)	(None, 12, 12, 288)	0		mi
mixed3 (Concatenate)	(None, 12, 12, 768)	0	ac ac ma	
conv2d_38 (Conv2D)	(None, 12, 12, 128)	98,304		mi
batch_normalization_42 (BatchNormalization)	(None, 12, 12, 128)	384		co
activation_34 (Activation)	(None, 12, 12, 128)	0		ba
conv2d_39 (Conv2D)	(None, 12, 12, 128)	114,688		ac
batch_normalization_43 (BatchNormalization)	(None, 12, 12, 128)	384		co
activation_35 (Activation)	(None, 12, 12, 128)	0		ba
conv2d_35 (Conv2D)	(None, 12, 12, 128)	98,304		mi
conv2d_40 (Conv2D)	(None, 12, 12, 128)	114,688		ac
batch_normalization_39 (BatchNormalization)	(None, 12, 12, 128)	384		co
batch_normalization_44 (BatchNormalization)	(None, 12, 12, 128)	384		co
activation_31	(None, 12, 12, 128)	0		ba

(Activation)				
activation_36 (Activation)	(None, 12, 12, 128)	0	ba	
conv2d_36 (Conv2D)	(None, 12, 12, 128)	114,688	ac	
conv2d_41 (Conv2D)	(None, 12, 12, 128)	114,688	ac	
batch_normalization_40 (BatchNormalization)	(None, 12, 12, 128)	384	co	
batch_normalization_45 (BatchNormalization)	(None, 12, 12, 128)	384	co	
activation_32 (Activation)	(None, 12, 12, 128)	0	ba	
activation_37 (Activation)	(None, 12, 12, 128)	0	ba	
average_pooling2d_3 (AveragePooling2D)	(None, 12, 12, 768)	0	mi	
conv2d_34 (Conv2D)	(None, 12, 12, 192)	147,456	mi	
conv2d_37 (Conv2D)	(None, 12, 12, 192)	172,032	ac	
conv2d_42 (Conv2D)	(None, 12, 12, 192)	172,032	ac	
conv2d_43 (Conv2D)	(None, 12, 12, 192)	147,456	av	
batch_normalization_38 (BatchNormalization)	(None, 12, 12, 192)	576	co	
batch_normalization_41 (BatchNormalization)	(None, 12, 12, 192)	576	co	
batch_normalization_46 (BatchNormalization)	(None, 12, 12, 192)	576	co	
batch_normalization_47 (BatchNormalization)	(None, 12, 12, 192)	576	co	
activation_30 (Activation)	(None, 12, 12, 192)	0	ba	
activation_33 (Activation)	(None, 12, 12, 192)	0	ba	
activation_38 (Activation)	(None, 12, 12, 192)	0	ba	
activation_39 (Activation)	(None, 12, 12, 192)	0	ba	
mixed4 (Concatenate)	(None, 12, 12, 768)	0	ac	
			ac	
			ac	
			ac	

conv2d_48 (Conv2D)	(None, 12, 12, 160)	122,880	mi
batch_normalization_52 (BatchNormalization)	(None, 12, 12, 160)	480	co
activation_44 (Activation)	(None, 12, 12, 160)	0	ba
conv2d_49 (Conv2D)	(None, 12, 12, 160)	179,200	ac
batch_normalization_53 (BatchNormalization)	(None, 12, 12, 160)	480	co
activation_45 (Activation)	(None, 12, 12, 160)	0	ba
conv2d_45 (Conv2D)	(None, 12, 12, 160)	122,880	mi
conv2d_50 (Conv2D)	(None, 12, 12, 160)	179,200	ac
batch_normalization_49 (BatchNormalization)	(None, 12, 12, 160)	480	co
batch_normalization_54 (BatchNormalization)	(None, 12, 12, 160)	480	co
activation_41 (Activation)	(None, 12, 12, 160)	0	ba
activation_46 (Activation)	(None, 12, 12, 160)	0	ba
conv2d_46 (Conv2D)	(None, 12, 12, 160)	179,200	ac
conv2d_51 (Conv2D)	(None, 12, 12, 160)	179,200	ac
batch_normalization_50 (BatchNormalization)	(None, 12, 12, 160)	480	co
batch_normalization_55 (BatchNormalization)	(None, 12, 12, 160)	480	co
activation_42 (Activation)	(None, 12, 12, 160)	0	ba
activation_47 (Activation)	(None, 12, 12, 160)	0	ba
average_pooling2d_4 (AveragePooling2D)	(None, 12, 12, 768)	0	mi
conv2d_44 (Conv2D)	(None, 12, 12, 192)	147,456	mi
conv2d_47 (Conv2D)	(None, 12, 12, 192)	215,040	ac
conv2d_52 (Conv2D)	(None, 12, 12, 192)	215,040	ac
conv2d_53 (Conv2D)	(None, 12, 12, 192)	147,456	av

batch_normalization_48 (BatchNormalization)	(None, 12, 12, 192)	576	co
batch_normalization_51 (BatchNormalization)	(None, 12, 12, 192)	576	co
batch_normalization_56 (BatchNormalization)	(None, 12, 12, 192)	576	co
batch_normalization_57 (BatchNormalization)	(None, 12, 12, 192)	576	co
activation_40 (Activation)	(None, 12, 12, 192)	0	ba
activation_43 (Activation)	(None, 12, 12, 192)	0	ba
activation_48 (Activation)	(None, 12, 12, 192)	0	ba
activation_49 (Activation)	(None, 12, 12, 192)	0	ba
mixed5 (Concatenate)	(None, 12, 12, 768)	0	ac ac ac ac
conv2d_58 (Conv2D)	(None, 12, 12, 160)	122,880	mi
batch_normalization_62 (BatchNormalization)	(None, 12, 12, 160)	480	co
activation_54 (Activation)	(None, 12, 12, 160)	0	ba
conv2d_59 (Conv2D)	(None, 12, 12, 160)	179,200	ac
batch_normalization_63 (BatchNormalization)	(None, 12, 12, 160)	480	co
activation_55 (Activation)	(None, 12, 12, 160)	0	ba
conv2d_55 (Conv2D)	(None, 12, 12, 160)	122,880	mi
conv2d_60 (Conv2D)	(None, 12, 12, 160)	179,200	ac
batch_normalization_59 (BatchNormalization)	(None, 12, 12, 160)	480	co
batch_normalization_64 (BatchNormalization)	(None, 12, 12, 160)	480	co
activation_51 (Activation)	(None, 12, 12, 160)	0	ba
activation_56 (Activation)	(None, 12, 12, 160)	0	ba

conv2d_56 (Conv2D)	(None, 12, 12, 160)	179,200	ac
conv2d_61 (Conv2D)	(None, 12, 12, 160)	179,200	ac
batch_normalization_60 (BatchNormalization)	(None, 12, 12, 160)	480	co
batch_normalization_65 (BatchNormalization)	(None, 12, 12, 160)	480	co
activation_52 (Activation)	(None, 12, 12, 160)	0	ba
activation_57 (Activation)	(None, 12, 12, 160)	0	ba
average_pooling2d_5 (AveragePooling2D)	(None, 12, 12, 768)	0	mi
conv2d_54 (Conv2D)	(None, 12, 12, 192)	147,456	mi
conv2d_57 (Conv2D)	(None, 12, 12, 192)	215,040	ac
conv2d_62 (Conv2D)	(None, 12, 12, 192)	215,040	ac
conv2d_63 (Conv2D)	(None, 12, 12, 192)	147,456	av
batch_normalization_58 (BatchNormalization)	(None, 12, 12, 192)	576	co
batch_normalization_61 (BatchNormalization)	(None, 12, 12, 192)	576	co
batch_normalization_66 (BatchNormalization)	(None, 12, 12, 192)	576	co
batch_normalization_67 (BatchNormalization)	(None, 12, 12, 192)	576	co
activation_50 (Activation)	(None, 12, 12, 192)	0	ba
activation_53 (Activation)	(None, 12, 12, 192)	0	ba
activation_58 (Activation)	(None, 12, 12, 192)	0	ba
activation_59 (Activation)	(None, 12, 12, 192)	0	ba
mixed6 (Concatenate)	(None, 12, 12, 768)	0	ac ac ac ac
conv2d_68 (Conv2D)	(None, 12, 12, 192)	147,456	mi
batch_normalization_72	(None, 12, 12, 192)	576	co

(BatchNormalization)				
activation_64 (Activation)	(None, 12, 12, 192)	0	ba	
conv2d_69 (Conv2D)	(None, 12, 12, 192)	258,048	ac	
batch_normalization_73 (BatchNormalization)	(None, 12, 12, 192)	576	co	
activation_65 (Activation)	(None, 12, 12, 192)	0	ba	
conv2d_65 (Conv2D)	(None, 12, 12, 192)	147,456	mi	
conv2d_70 (Conv2D)	(None, 12, 12, 192)	258,048	ac	
batch_normalization_69 (BatchNormalization)	(None, 12, 12, 192)	576	co	
batch_normalization_74 (BatchNormalization)	(None, 12, 12, 192)	576	co	
activation_61 (Activation)	(None, 12, 12, 192)	0	ba	
activation_66 (Activation)	(None, 12, 12, 192)	0	ba	
conv2d_66 (Conv2D)	(None, 12, 12, 192)	258,048	ac	
conv2d_71 (Conv2D)	(None, 12, 12, 192)	258,048	ac	
batch_normalization_70 (BatchNormalization)	(None, 12, 12, 192)	576	co	
batch_normalization_75 (BatchNormalization)	(None, 12, 12, 192)	576	co	
activation_62 (Activation)	(None, 12, 12, 192)	0	ba	
activation_67 (Activation)	(None, 12, 12, 192)	0	ba	
average_pooling2d_6 (AveragePooling2D)	(None, 12, 12, 768)	0	mi	
conv2d_64 (Conv2D)	(None, 12, 12, 192)	147,456	mi	
conv2d_67 (Conv2D)	(None, 12, 12, 192)	258,048	ac	
conv2d_72 (Conv2D)	(None, 12, 12, 192)	258,048	ac	
conv2d_73 (Conv2D)	(None, 12, 12, 192)	147,456	av	
batch_normalization_68 (BatchNormalization)	(None, 12, 12, 192)	576	co	
batch_normalization_71	(None, 12, 12, 192)	576	co	

(BatchNormalization)				
batch_normalization_76 (BatchNormalization)	(None, 12, 12, 192)	576	co	
batch_normalization_77 (BatchNormalization)	(None, 12, 12, 192)	576	co	
activation_60 (Activation)	(None, 12, 12, 192)	0	ba	
activation_63 (Activation)	(None, 12, 12, 192)	0	ba	
activation_68 (Activation)	(None, 12, 12, 192)	0	ba	
activation_69 (Activation)	(None, 12, 12, 192)	0	ba	
mixed7 (Concatenate)	(None, 12, 12, 768)	0	ac	
			ac	
			ac	
			ac	
conv2d_76 (Conv2D)	(None, 12, 12, 192)	147,456	mi	
batch_normalization_80 (BatchNormalization)	(None, 12, 12, 192)	576	co	
activation_72 (Activation)	(None, 12, 12, 192)	0	ba	
conv2d_77 (Conv2D)	(None, 12, 12, 192)	258,048	ac	
batch_normalization_81 (BatchNormalization)	(None, 12, 12, 192)	576	co	
activation_73 (Activation)	(None, 12, 12, 192)	0	ba	
conv2d_74 (Conv2D)	(None, 12, 12, 192)	147,456	mi	
conv2d_78 (Conv2D)	(None, 12, 12, 192)	258,048	ac	
batch_normalization_78 (BatchNormalization)	(None, 12, 12, 192)	576	co	
batch_normalization_82 (BatchNormalization)	(None, 12, 12, 192)	576	co	
activation_70 (Activation)	(None, 12, 12, 192)	0	ba	
activation_74 (Activation)	(None, 12, 12, 192)	0	ba	
conv2d_75 (Conv2D)	(None, 5, 5, 320)	552,960	ac	
conv2d_79 (Conv2D)	(None, 5, 5, 192)	331,776	ac	

batch_normalization_79 (BatchNormalization)	(None, 5, 5, 320)	960	co
batch_normalization_83 (BatchNormalization)	(None, 5, 5, 192)	576	co
activation_71 (Activation)	(None, 5, 5, 320)	0	ba
activation_75 (Activation)	(None, 5, 5, 192)	0	ba
max_pooling2d_3 (MaxPooling2D)	(None, 5, 5, 768)	0	mi
mixed8 (Concatenate)	(None, 5, 5, 1280)	0	ac ac ma
conv2d_84 (Conv2D)	(None, 5, 5, 448)	573,440	mi
batch_normalization_88 (BatchNormalization)	(None, 5, 5, 448)	1,344	co
activation_80 (Activation)	(None, 5, 5, 448)	0	ba
conv2d_81 (Conv2D)	(None, 5, 5, 384)	491,520	mi
conv2d_85 (Conv2D)	(None, 5, 5, 384)	1,548,288	ac
batch_normalization_85 (BatchNormalization)	(None, 5, 5, 384)	1,152	co
batch_normalization_89 (BatchNormalization)	(None, 5, 5, 384)	1,152	co
activation_77 (Activation)	(None, 5, 5, 384)	0	ba
activation_81 (Activation)	(None, 5, 5, 384)	0	ba
conv2d_82 (Conv2D)	(None, 5, 5, 384)	442,368	ac
conv2d_83 (Conv2D)	(None, 5, 5, 384)	442,368	ac
conv2d_86 (Conv2D)	(None, 5, 5, 384)	442,368	ac
conv2d_87 (Conv2D)	(None, 5, 5, 384)	442,368	ac
average_pooling2d_7 (AveragePooling2D)	(None, 5, 5, 1280)	0	mi
conv2d_80 (Conv2D)	(None, 5, 5, 320)	409,600	mi
batch_normalization_86 (BatchNormalization)	(None, 5, 5, 384)	1,152	co

batch_normalization_87 (BatchNormalization)	(None, 5, 5, 384)	1,152	co
batch_normalization_90 (BatchNormalization)	(None, 5, 5, 384)	1,152	co
batch_normalization_91 (BatchNormalization)	(None, 5, 5, 384)	1,152	co
conv2d_88 (Conv2D)	(None, 5, 5, 192)	245,760	av
batch_normalization_84 (BatchNormalization)	(None, 5, 5, 320)	960	co
activation_78 (Activation)	(None, 5, 5, 384)	0	ba
activation_79 (Activation)	(None, 5, 5, 384)	0	ba
activation_82 (Activation)	(None, 5, 5, 384)	0	ba
activation_83 (Activation)	(None, 5, 5, 384)	0	ba
batch_normalization_92 (BatchNormalization)	(None, 5, 5, 192)	576	co
activation_76 (Activation)	(None, 5, 5, 320)	0	ba
mixed9_0 (Concatenate)	(None, 5, 5, 768)	0	ac ac
concatenate (Concatenate)	(None, 5, 5, 768)	0	ac ac
activation_84 (Activation)	(None, 5, 5, 192)	0	ba
mixed9 (Concatenate)	(None, 5, 5, 2048)	0	ac mi co ac
conv2d_93 (Conv2D)	(None, 5, 5, 448)	917,504	mi
batch_normalization_97 (BatchNormalization)	(None, 5, 5, 448)	1,344	co
activation_89 (Activation)	(None, 5, 5, 448)	0	ba
conv2d_90 (Conv2D)	(None, 5, 5, 384)	786,432	mi
conv2d_94 (Conv2D)	(None, 5, 5, 384)	1,548,288	ac
batch_normalization_94 (BatchNormalization)	(None, 5, 5, 384)	1,152	co

batch_normalization_98 (BatchNormalization)	(None, 5, 5, 384)	1,152	co
activation_86 (Activation)	(None, 5, 5, 384)	0	ba
activation_90 (Activation)	(None, 5, 5, 384)	0	ba
conv2d_91 (Conv2D)	(None, 5, 5, 384)	442,368	ac
conv2d_92 (Conv2D)	(None, 5, 5, 384)	442,368	ac
conv2d_95 (Conv2D)	(None, 5, 5, 384)	442,368	ac
conv2d_96 (Conv2D)	(None, 5, 5, 384)	442,368	ac
average_pooling2d_8 (AveragePooling2D)	(None, 5, 5, 2048)	0	mi
conv2d_89 (Conv2D)	(None, 5, 5, 320)	655,360	mi
batch_normalization_95 (BatchNormalization)	(None, 5, 5, 384)	1,152	co
batch_normalization_96 (BatchNormalization)	(None, 5, 5, 384)	1,152	co
batch_normalization_99 (BatchNormalization)	(None, 5, 5, 384)	1,152	co
batch_normalization_100 (BatchNormalization)	(None, 5, 5, 384)	1,152	co
conv2d_97 (Conv2D)	(None, 5, 5, 192)	393,216	av
batch_normalization_93 (BatchNormalization)	(None, 5, 5, 320)	960	co
activation_87 (Activation)	(None, 5, 5, 384)	0	ba
activation_88 (Activation)	(None, 5, 5, 384)	0	ba
activation_91 (Activation)	(None, 5, 5, 384)	0	ba
activation_92 (Activation)	(None, 5, 5, 384)	0	ba
batch_normalization_101 (BatchNormalization)	(None, 5, 5, 192)	576	co
activation_85 (Activation)	(None, 5, 5, 320)	0	ba
mixed9_1 (Concatenate)	(None, 5, 5, 768)	0	ac ac

concatenate_1 (Concatenate)	(None, 5, 5, 768)	0	ac ac
activation_93 (Activation)	(None, 5, 5, 192)	0	ba
mixed10 (Concatenate)	(None, 5, 5, 2048)	0	ac mi co ac
reshape_8 (Reshape)	(None, 25, 2048)	0	mi
multi_head_attention_4 (MultiHeadAttention)	(None, 25, 2048)	134,268,928	re re
reshape_9 (Reshape)	(None, 5, 5, 2048)	0	mu
gaussian_noise_8 (GaussianNoise)	(None, 5, 5, 2048)	0	re
global_average_pooling2d... (GlobalAveragePooling2D)	(None, 2048)	0	ga
dense_8 (Dense)	(None, 512)	1,049,088	gl
batch_normalization_102 (BatchNormalization)	(None, 512)	2,048	de
gaussian_noise_9 (GaussianNoise)	(None, 512)	0	ba
dropout_9 (Dropout)	(None, 512)	0	ga
dense_9 (Dense)	(None, 4)	2,052	dr

Total params: 157,124,900 (599.38 MB)

Trainable params: 135,321,092 (516.21 MB)

Non-trainable params: 21,803,808 (83.17 MB)

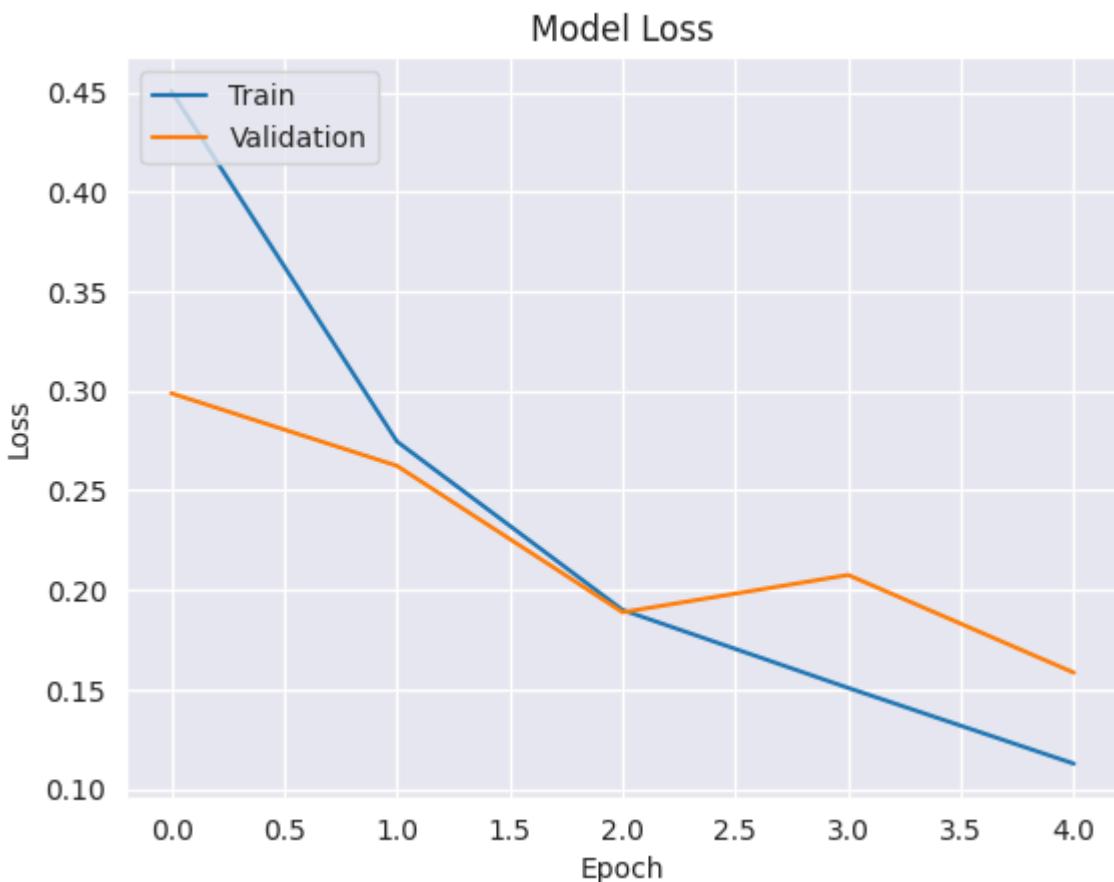
```
In [ ]: history = cnn_model.fit(
    train_gen_new,
    validation_data=valid_gen_new,
    epochs=5,
    callbacks=[early_stopping],
    verbose=1
)
```

```
Epoch 1/5
1278/1278 216s 154ms/step - accuracy: 0.7849 - loss: 0.6009
- val_accuracy: 0.8971 - val_loss: 0.2989
Epoch 2/5
1278/1278 176s 137ms/step - accuracy: 0.8976 - loss: 0.2835
- val_accuracy: 0.8987 - val_loss: 0.2624
Epoch 3/5
1278/1278 177s 138ms/step - accuracy: 0.9330 - loss: 0.1885
- val_accuracy: 0.9315 - val_loss: 0.1888
Epoch 4/5
1278/1278 176s 137ms/step - accuracy: 0.9483 - loss: 0.1444
- val_accuracy: 0.9257 - val_loss: 0.2076
Epoch 5/5
1278/1278 176s 137ms/step - accuracy: 0.9612 - loss: 0.1066
- val_accuracy: 0.9507 - val_loss: 0.1585
```

```
In [ ]: plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()

plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model Loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()
```





```
In [ ]: test_labels = test_gen_new.classes
         predictions = cnn_model.predict(test_gen_new)
         predicted_classes = np.argmax(predictions, axis=1)
```

160/160 ━━━━━━━━ 20s 93ms/step

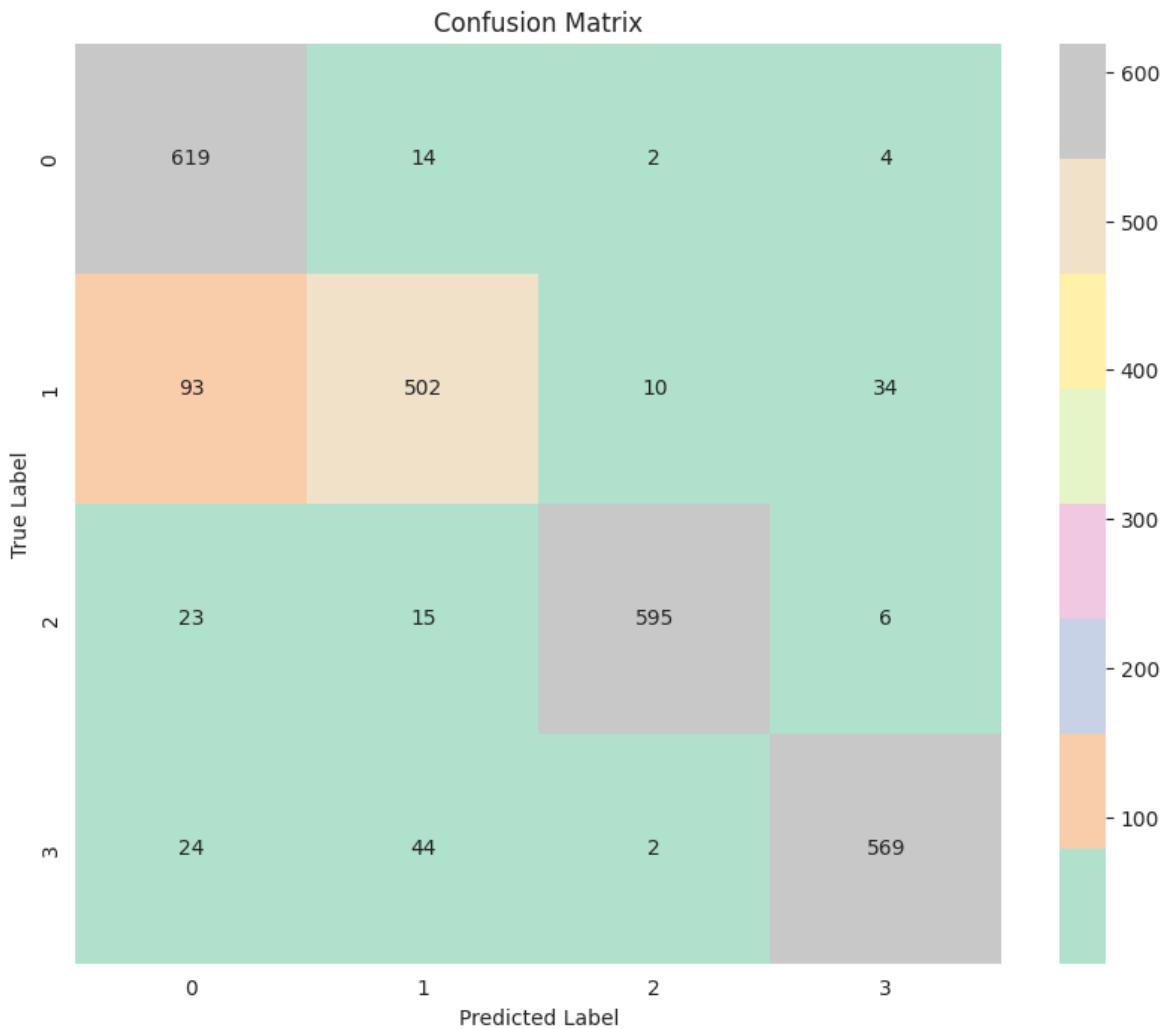
```
In [ ]: report = classification_report(test_labels, predicted_classes, target_names=list
                                         print("Report for Inception =>")
                                         print(report))
```

	precision	recall	f1-score	support
0	0.82	0.97	0.89	639
1	0.87	0.79	0.83	639
2	0.98	0.93	0.95	639
3	0.93	0.89	0.91	639
accuracy			0.89	2556
macro avg	0.90	0.89	0.89	2556
weighted avg	0.90	0.89	0.89	2556

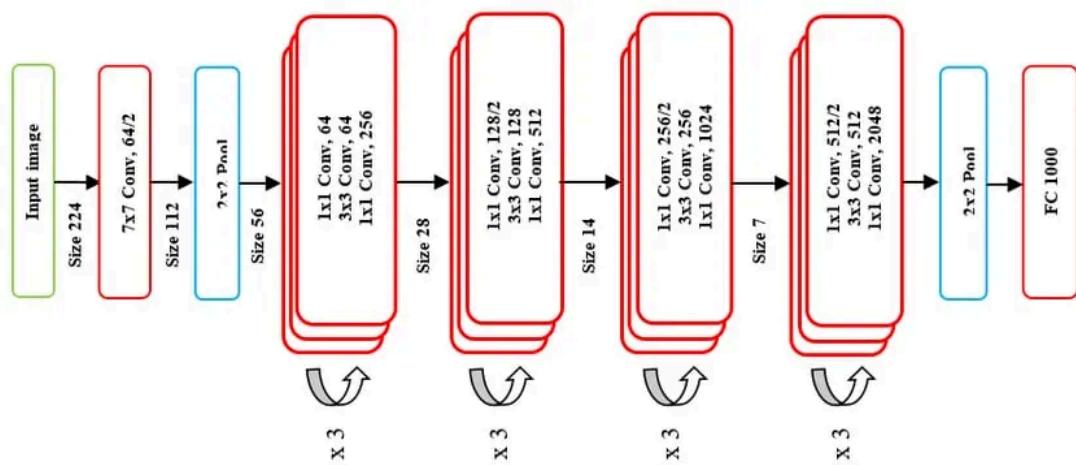
```
In [ ]: conf_matrix = confusion_matrix(test_labels, predicted_classes)
```

```
In [ ]: plt.figure(figsize=(10, 8))
         sns.heatmap(conf_matrix, annot=True, fmt='d',
                     cmap='Pastel2',
                     xticklabels=list(test_gen_new.class_indices.keys()),
                     yticklabels=list(test_gen_new.class_indices.keys()))
         plt.title('Confusion Matrix')
         plt.xlabel('Predicted Label')
```

```
plt.ylabel('True Label')
plt.show()
```



ResNet50



```
In [ ]: def resnet_model(input_shape):

    inputs = Input(shape=input_shape)

    base_model = ResNet50(weights='imagenet', input_tensor=inputs, include_top=False)

    for layer in base_model.layers:
        layer.trainable = False
```

```

x = base_model.output

height, width, channels = 7, 7, 2048
x = Reshape((height * width, channels))(x)

attention_output = MultiHeadAttention(num_heads=8, key_dim=channels)(x, x)

attention_output = Reshape((height, width, channels))(attention_output)

x = GaussianNoise(0.25)(attention_output)
x = GlobalAveragePooling2D()(x)
x = Dense(512, activation='relu')(x)
x = BatchNormalization()(x)
x = GaussianNoise(0.25)(x)
x = Dropout(0.25)(x)
outputs = Dense(4, activation='softmax')(x)

model = Model(inputs=inputs, outputs=outputs)

return model

input_shape = (224, 224, 3)
cnn_model = resnet_model(input_shape)

cnn_model.compile(optimizer=Adam(learning_rate=0.0001),
                   loss='sparse_categorical_crossentropy',
                   metrics=['accuracy'])

```

Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/resnet/resnet50_weights_tf_dim_ordering_tf_kernels_notop.h5
94765736/94765736 ————— 5s 0us/step

In []: `cnn_model.summary()`

Model: "functional_5"

Layer (type)	Output Shape	Param #	Co
input_layer_5 (InputLayer)	(None, 224, 224, 3)	0	-
conv1_pad (ZeroPadding2D)	(None, 230, 230, 3)	0	in
conv1_conv (Conv2D)	(None, 112, 112, 64)	9,472	co
conv1_bn (BatchNormalization)	(None, 112, 112, 64)	256	co
conv1_relu (Activation)	(None, 112, 112, 64)	0	co
pool1_pad (ZeroPadding2D)	(None, 114, 114, 64)	0	co
pool1_pool (MaxPooling2D)	(None, 56, 56, 64)	0	po
conv2_block1_1_conv (Conv2D)	(None, 56, 56, 64)	4,160	po
conv2_block1_1_bn (BatchNormalization)	(None, 56, 56, 64)	256	co
conv2_block1_1_relu (Activation)	(None, 56, 56, 64)	0	co
conv2_block1_2_conv (Conv2D)	(None, 56, 56, 64)	36,928	co
conv2_block1_2_bn (BatchNormalization)	(None, 56, 56, 64)	256	co
conv2_block1_2_relu (Activation)	(None, 56, 56, 64)	0	co
conv2_block1_0_conv (Conv2D)	(None, 56, 56, 256)	16,640	po
conv2_block1_3_conv (Conv2D)	(None, 56, 56, 256)	16,640	co
conv2_block1_0_bn (BatchNormalization)	(None, 56, 56, 256)	1,024	co
conv2_block1_3_bn (BatchNormalization)	(None, 56, 56, 256)	1,024	co
conv2_block1_add (Add)	(None, 56, 56, 256)	0	co co
conv2_block1_out (Activation)	(None, 56, 56, 256)	0	co
conv2_block2_1_conv (Conv2D)	(None, 56, 56, 64)	16,448	co
conv2_block2_1_bn (BatchNormalization)	(None, 56, 56, 64)	256	co

conv2_block2_1_relu (Activation)	(None, 56, 56, 64)	0	co
conv2_block2_2_conv (Conv2D)	(None, 56, 56, 64)	36,928	co
conv2_block2_2_bn (BatchNormalization)	(None, 56, 56, 64)	256	co
conv2_block2_2_relu (Activation)	(None, 56, 56, 64)	0	co
conv2_block2_3_conv (Conv2D)	(None, 56, 56, 256)	16,640	co
conv2_block2_3_bn (BatchNormalization)	(None, 56, 56, 256)	1,024	co
conv2_block2_add (Add)	(None, 56, 56, 256)	0	co co
conv2_block2_out (Activation)	(None, 56, 56, 256)	0	co
conv2_block3_1_conv (Conv2D)	(None, 56, 56, 64)	16,448	co
conv2_block3_1_bn (BatchNormalization)	(None, 56, 56, 64)	256	co
conv2_block3_1_relu (Activation)	(None, 56, 56, 64)	0	co
conv2_block3_2_conv (Conv2D)	(None, 56, 56, 64)	36,928	co
conv2_block3_2_bn (BatchNormalization)	(None, 56, 56, 64)	256	co
conv2_block3_2_relu (Activation)	(None, 56, 56, 64)	0	co
conv2_block3_3_conv (Conv2D)	(None, 56, 56, 256)	16,640	co
conv2_block3_3_bn (BatchNormalization)	(None, 56, 56, 256)	1,024	co
conv2_block3_add (Add)	(None, 56, 56, 256)	0	co co
conv2_block3_out (Activation)	(None, 56, 56, 256)	0	co
conv3_block1_1_conv (Conv2D)	(None, 28, 28, 128)	32,896	co
conv3_block1_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co

conv3_block1_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block1_2_conv (Conv2D)	(None, 28, 28, 128)	147,584	co
conv3_block1_2_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block1_2_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block1_0_conv (Conv2D)	(None, 28, 28, 512)	131,584	co
conv3_block1_3_conv (Conv2D)	(None, 28, 28, 512)	66,048	co
conv3_block1_0_bn (BatchNormalization)	(None, 28, 28, 512)	2,048	co
conv3_block1_3_bn (BatchNormalization)	(None, 28, 28, 512)	2,048	co
conv3_block1_add (Add)	(None, 28, 28, 512)	0	co co
conv3_block1_out (Activation)	(None, 28, 28, 512)	0	co
conv3_block2_1_conv (Conv2D)	(None, 28, 28, 128)	65,664	co
conv3_block2_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block2_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block2_2_conv (Conv2D)	(None, 28, 28, 128)	147,584	co
conv3_block2_2_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block2_2_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block2_3_conv (Conv2D)	(None, 28, 28, 512)	66,048	co
conv3_block2_3_bn (BatchNormalization)	(None, 28, 28, 512)	2,048	co
conv3_block2_add (Add)	(None, 28, 28, 512)	0	co co
conv3_block2_out (Activation)	(None, 28, 28, 512)	0	co

conv3_block3_1_conv (Conv2D)	(None, 28, 28, 128)	65,664	co
conv3_block3_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block3_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block3_2_conv (Conv2D)	(None, 28, 28, 128)	147,584	co
conv3_block3_2_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block3_2_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block3_3_conv (Conv2D)	(None, 28, 28, 512)	66,048	co
conv3_block3_3_bn (BatchNormalization)	(None, 28, 28, 512)	2,048	co
conv3_block3_add (Add)	(None, 28, 28, 512)	0	co co
conv3_block3_out (Activation)	(None, 28, 28, 512)	0	co
conv3_block4_1_conv (Conv2D)	(None, 28, 28, 128)	65,664	co
conv3_block4_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block4_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block4_2_conv (Conv2D)	(None, 28, 28, 128)	147,584	co
conv3_block4_2_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block4_2_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block4_3_conv (Conv2D)	(None, 28, 28, 512)	66,048	co
conv3_block4_3_bn (BatchNormalization)	(None, 28, 28, 512)	2,048	co
conv3_block4_add (Add)	(None, 28, 28, 512)	0	co co
conv3_block4_out (Activation)	(None, 28, 28, 512)	0	co

conv4_block1_1_conv (Conv2D)	(None, 14, 14, 256)	131,328	co
conv4_block1_1_bn (BatchNormalization)	(None, 14, 14, 256)	1,024	co
conv4_block1_1_relu (Activation)	(None, 14, 14, 256)	0	co
conv4_block1_2_conv (Conv2D)	(None, 14, 14, 256)	590,080	co
conv4_block1_2_bn (BatchNormalization)	(None, 14, 14, 256)	1,024	co
conv4_block1_2_relu (Activation)	(None, 14, 14, 256)	0	co
conv4_block1_0_conv (Conv2D)	(None, 14, 14, 1024)	525,312	co
conv4_block1_3_conv (Conv2D)	(None, 14, 14, 1024)	263,168	co
conv4_block1_0_bn (BatchNormalization)	(None, 14, 14, 1024)	4,096	co
conv4_block1_3_bn (BatchNormalization)	(None, 14, 14, 1024)	4,096	co
conv4_block1_add (Add)	(None, 14, 14, 1024)	0	co co
conv4_block1_out (Activation)	(None, 14, 14, 1024)	0	co
conv4_block2_1_conv (Conv2D)	(None, 14, 14, 256)	262,400	co
conv4_block2_1_bn (BatchNormalization)	(None, 14, 14, 256)	1,024	co
conv4_block2_1_relu (Activation)	(None, 14, 14, 256)	0	co
conv4_block2_2_conv (Conv2D)	(None, 14, 14, 256)	590,080	co
conv4_block2_2_bn (BatchNormalization)	(None, 14, 14, 256)	1,024	co
conv4_block2_2_relu (Activation)	(None, 14, 14, 256)	0	co
conv4_block2_3_conv (Conv2D)	(None, 14, 14, 1024)	263,168	co
conv4_block2_3_bn (BatchNormalization)	(None, 14, 14, 1024)	4,096	co

conv4_block2_add (Add)	(None, 14, 14, 1024)	0	co co
conv4_block2_out (Activation)	(None, 14, 14, 1024)	0	co
conv4_block3_1_conv (Conv2D)	(None, 14, 14, 256)	262,400	co
conv4_block3_1_bn (BatchNormalization)	(None, 14, 14, 256)	1,024	co
conv4_block3_1_relu (Activation)	(None, 14, 14, 256)	0	co
conv4_block3_2_conv (Conv2D)	(None, 14, 14, 256)	590,080	co
conv4_block3_2_bn (BatchNormalization)	(None, 14, 14, 256)	1,024	co
conv4_block3_2_relu (Activation)	(None, 14, 14, 256)	0	co
conv4_block3_3_conv (Conv2D)	(None, 14, 14, 1024)	263,168	co
conv4_block3_3_bn (BatchNormalization)	(None, 14, 14, 1024)	4,096	co
conv4_block3_add (Add)	(None, 14, 14, 1024)	0	co co
conv4_block3_out (Activation)	(None, 14, 14, 1024)	0	co
conv4_block4_1_conv (Conv2D)	(None, 14, 14, 256)	262,400	co
conv4_block4_1_bn (BatchNormalization)	(None, 14, 14, 256)	1,024	co
conv4_block4_1_relu (Activation)	(None, 14, 14, 256)	0	co
conv4_block4_2_conv (Conv2D)	(None, 14, 14, 256)	590,080	co
conv4_block4_2_bn (BatchNormalization)	(None, 14, 14, 256)	1,024	co
conv4_block4_2_relu (Activation)	(None, 14, 14, 256)	0	co
conv4_block4_3_conv (Conv2D)	(None, 14, 14, 1024)	263,168	co
conv4_block4_3_bn (BatchNormalization)	(None, 14, 14, 1024)	4,096	co

conv4_block4_add (Add)	(None, 14, 14, 1024)	0	co co
conv4_block4_out (Activation)	(None, 14, 14, 1024)	0	co
conv4_block5_1_conv (Conv2D)	(None, 14, 14, 256)	262,400	co
conv4_block5_1_bn (BatchNormalization)	(None, 14, 14, 256)	1,024	co
conv4_block5_1_relu (Activation)	(None, 14, 14, 256)	0	co
conv4_block5_2_conv (Conv2D)	(None, 14, 14, 256)	590,080	co
conv4_block5_2_bn (BatchNormalization)	(None, 14, 14, 256)	1,024	co
conv4_block5_2_relu (Activation)	(None, 14, 14, 256)	0	co
conv4_block5_3_conv (Conv2D)	(None, 14, 14, 1024)	263,168	co
conv4_block5_3_bn (BatchNormalization)	(None, 14, 14, 1024)	4,096	co
conv4_block5_add (Add)	(None, 14, 14, 1024)	0	co co
conv4_block5_out (Activation)	(None, 14, 14, 1024)	0	co
conv4_block6_1_conv (Conv2D)	(None, 14, 14, 256)	262,400	co
conv4_block6_1_bn (BatchNormalization)	(None, 14, 14, 256)	1,024	co
conv4_block6_1_relu (Activation)	(None, 14, 14, 256)	0	co
conv4_block6_2_conv (Conv2D)	(None, 14, 14, 256)	590,080	co
conv4_block6_2_bn (BatchNormalization)	(None, 14, 14, 256)	1,024	co
conv4_block6_2_relu (Activation)	(None, 14, 14, 256)	0	co
conv4_block6_3_conv (Conv2D)	(None, 14, 14, 1024)	263,168	co
conv4_block6_3_bn (BatchNormalization)	(None, 14, 14, 1024)	4,096	co

conv4_block6_add (Add)	(None, 14, 14, 1024)	0	co co
conv4_block6_out (Activation)	(None, 14, 14, 1024)	0	co
conv5_block1_1_conv (Conv2D)	(None, 7, 7, 512)	524,800	co
conv5_block1_1_bn (BatchNormalization)	(None, 7, 7, 512)	2,048	co
conv5_block1_1_relu (Activation)	(None, 7, 7, 512)	0	co
conv5_block1_2_conv (Conv2D)	(None, 7, 7, 512)	2,359,808	co
conv5_block1_2_bn (BatchNormalization)	(None, 7, 7, 512)	2,048	co
conv5_block1_2_relu (Activation)	(None, 7, 7, 512)	0	co
conv5_block1_0_conv (Conv2D)	(None, 7, 7, 2048)	2,099,200	co
conv5_block1_3_conv (Conv2D)	(None, 7, 7, 2048)	1,050,624	co
conv5_block1_0_bn (BatchNormalization)	(None, 7, 7, 2048)	8,192	co
conv5_block1_3_bn (BatchNormalization)	(None, 7, 7, 2048)	8,192	co
conv5_block1_add (Add)	(None, 7, 7, 2048)	0	co co
conv5_block1_out (Activation)	(None, 7, 7, 2048)	0	co
conv5_block2_1_conv (Conv2D)	(None, 7, 7, 512)	1,049,088	co
conv5_block2_1_bn (BatchNormalization)	(None, 7, 7, 512)	2,048	co
conv5_block2_1_relu (Activation)	(None, 7, 7, 512)	0	co
conv5_block2_2_conv (Conv2D)	(None, 7, 7, 512)	2,359,808	co
conv5_block2_2_bn (BatchNormalization)	(None, 7, 7, 512)	2,048	co
conv5_block2_2_relu (Activation)	(None, 7, 7, 512)	0	co

conv5_block2_3_conv (Conv2D)	(None, 7, 7, 2048)	1,050,624	co
conv5_block2_3_bn (BatchNormalization)	(None, 7, 7, 2048)	8,192	co
conv5_block2_add (Add)	(None, 7, 7, 2048)	0	co co
conv5_block2_out (Activation)	(None, 7, 7, 2048)	0	co
conv5_block3_1_conv (Conv2D)	(None, 7, 7, 512)	1,049,088	co
conv5_block3_1_bn (BatchNormalization)	(None, 7, 7, 512)	2,048	co
conv5_block3_1_relu (Activation)	(None, 7, 7, 512)	0	co
conv5_block3_2_conv (Conv2D)	(None, 7, 7, 512)	2,359,808	co
conv5_block3_2_bn (BatchNormalization)	(None, 7, 7, 512)	2,048	co
conv5_block3_2_relu (Activation)	(None, 7, 7, 512)	0	co
conv5_block3_3_conv (Conv2D)	(None, 7, 7, 2048)	1,050,624	co
conv5_block3_3_bn (BatchNormalization)	(None, 7, 7, 2048)	8,192	co
conv5_block3_add (Add)	(None, 7, 7, 2048)	0	co co
conv5_block3_out (Activation)	(None, 7, 7, 2048)	0	co
reshape_10 (Reshape)	(None, 49, 2048)	0	co
multi_head_attention_5 (MultiHeadAttention)	(None, 49, 2048)	134,268,928	re re
reshape_11 (Reshape)	(None, 7, 7, 2048)	0	mu
gaussian_noise_10 (GaussianNoise)	(None, 7, 7, 2048)	0	re
global_average_pooling2d... (GlobalAveragePooling2D)	(None, 2048)	0	ga
dense_10 (Dense)	(None, 512)	1,049,088	gl
batch_normalization_103 (BatchNormalization)	(None, 512)	2,048	de

gaussian_noise_11 (GaussianNoise)	(None, 512)	0	ba
dropout_11 (Dropout)	(None, 512)	0	ga
dense_11 (Dense)	(None, 4)	2,052	dr

Total params: 158,909,828 (606.19 MB)

Trainable params: 135,321,092 (516.21 MB)

Non-trainable params: 23,588,736 (89.98 MB)

```
In [ ]: history = cnn_model.fit(
    train_gen_new,
    validation_data=valid_gen_new,
    epochs=5,
    callbacks=[early_stopping],
    verbose=1
)
```

```
Epoch 1/5
1278/1278 306s 228ms/step - accuracy: 0.6023 - loss: 0.9860
- val_accuracy: 0.5391 - val_loss: 2.8409
Epoch 2/5
1278/1278 280s 219ms/step - accuracy: 0.7328 - loss: 0.6688
- val_accuracy: 0.2500 - val_loss: 47.2115
Epoch 3/5
1278/1278 280s 219ms/step - accuracy: 0.7722 - loss: 0.5779
- val_accuracy: 0.2500 - val_loss: 13.0876
Epoch 4/5
1278/1278 280s 218ms/step - accuracy: 0.7942 - loss: 0.5343
- val_accuracy: 0.7058 - val_loss: 0.7504
Epoch 5/5
1278/1278 280s 219ms/step - accuracy: 0.8064 - loss: 0.4949
- val_accuracy: 0.2520 - val_loss: 11.7010
```

```
In [ ]: plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()

plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model Loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()
```



```
In [ ]: test_labels = test_gen_new.classes  
predictions = cnn_model.predict(test_gen_new)  
predicted_classes = np.argmax(predictions, axis=1)
```

160/160 ━━━━━━━━ 22s 120ms/step

```
In [ ]: report = classification_report(test_labels,
                                         predicted_classes,
                                         target_names=list(test_gen_new.class_indices.keys()))
print("Report for ResNet50 =>")
print(report)
```

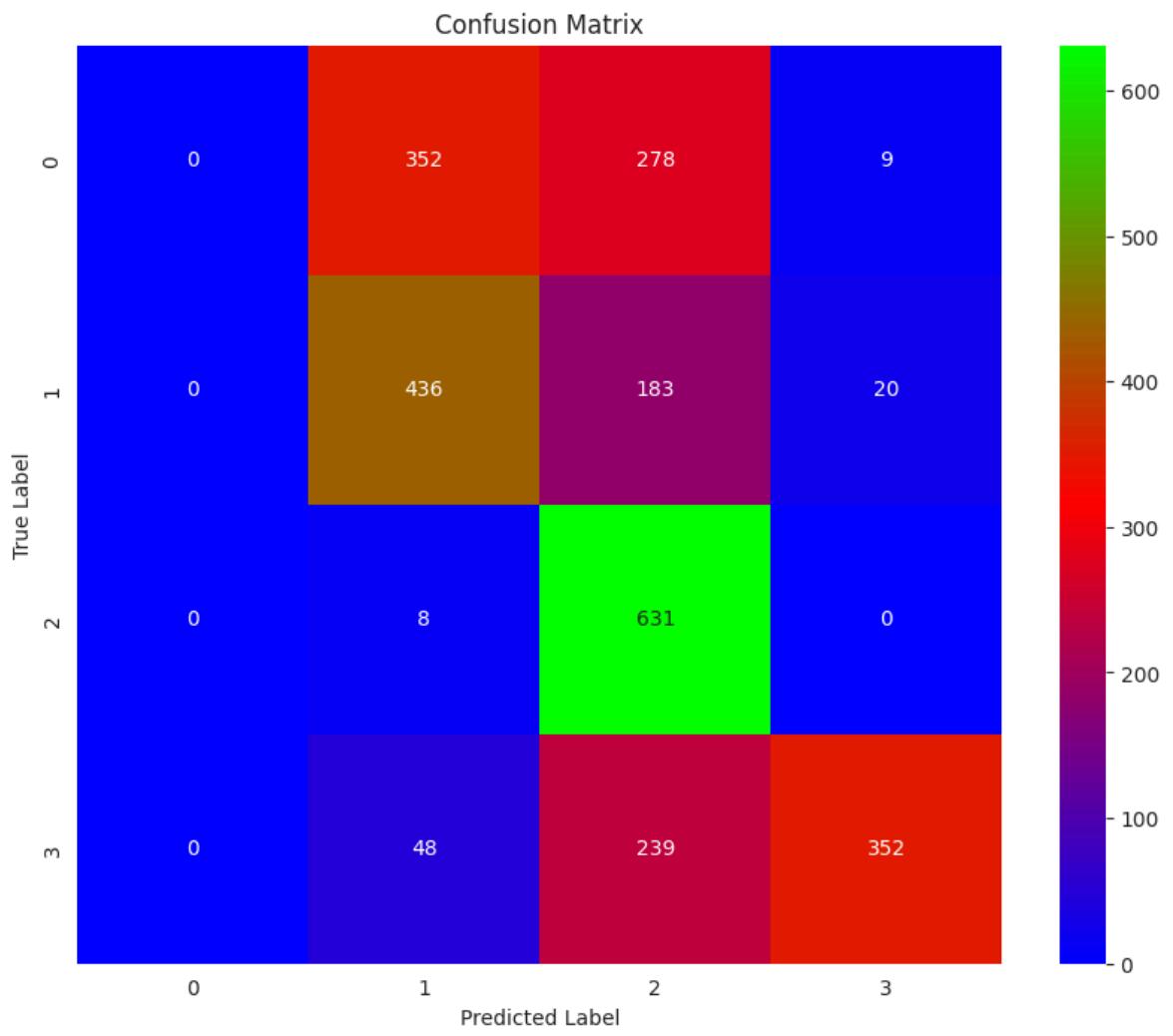
```
Report for ResNet50 =>
      precision    recall  f1-score   support

          0       0.00     0.00     0.00      639
          1       0.52     0.68     0.59      639
          2       0.47     0.99     0.64      639
          3       0.92     0.55     0.69      639

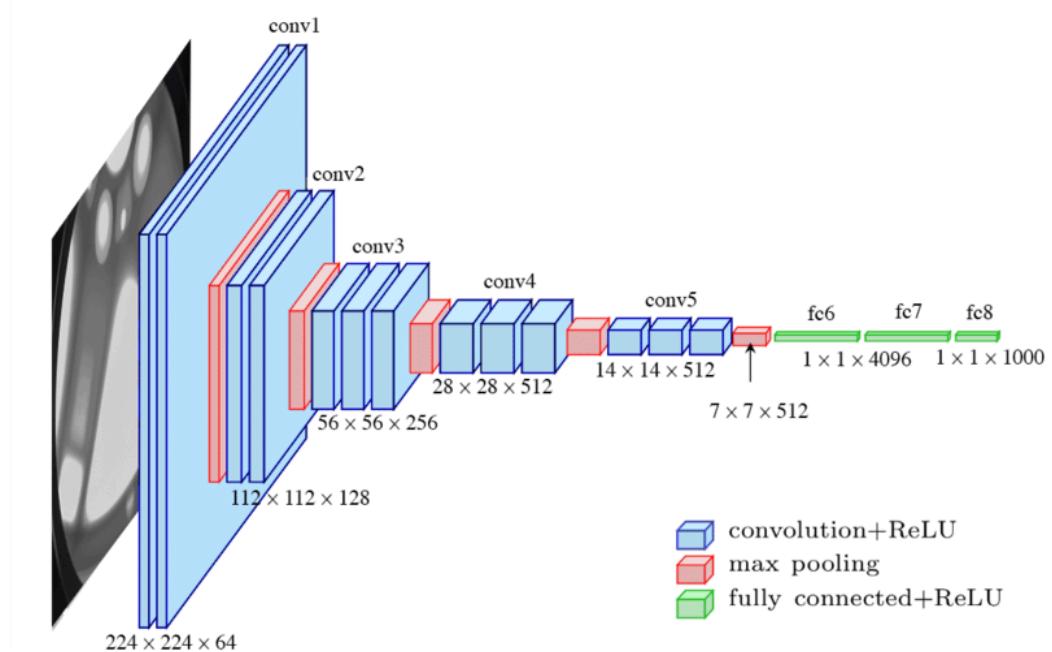
   accuracy                           0.56      2556
  macro avg       0.48     0.56     0.48      2556
weighted avg       0.48     0.56     0.48      2556
```

```
In [ ]: conf_matrix = confusion_matrix(test_labels, predicted_classes)
```

```
In [ ]: plt.figure(figsize=(10, 8))
sns.heatmap(conf_matrix, annot=True, fmt='d',
            cmap='brg',
            xticklabels=list(test_gen_new.class_indices.keys()),
            yticklabels=list(test_gen_new.class_indices.keys()))
plt.title('Confusion Matrix')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```



DenseNet



```
In [ ]: def densenet_model(input_shape):
```

```
    inputs = Input(shape=input_shape)
```

```

base_model = DenseNet121(weights='imagenet',
                         input_tensor=inputs,
                         include_top=False)

for layer in base_model.layers:
    layer.trainable = False

x = base_model.output

height, width, channels = 7, 7, 1024
x = Reshape((height * width, channels))(x)

attention_output = MultiHeadAttention(num_heads=8, key_dim=channels)(x, x)

attention_output = Reshape((height, width, channels))(attention_output)

x = GaussianNoise(0.25)(attention_output)
x = GlobalAveragePooling2D()(x)
x = Dense(512, activation='relu')(x)
x = BatchNormalization()(x)
x = GaussianNoise(0.25)(x)
x = Dropout(0.25)(x)
outputs = Dense(4, activation='softmax')(x)

model = Model(inputs=inputs, outputs=outputs)

return model

```

input_shape = (224, 224, 3)
cnn_model = densenet_model(input_shape)

cnn_model.compile(optimizer=Adam(learning_rate=0.0001),
loss='sparse_categorical_crossentropy',
metrics=['accuracy'])

Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/densenet/densenet121_weights_tf_dim_ordering_tf_kernels_notop.h5
29084464/29084464 2s 0us/step

In []: `cnn_model.summary()`

Model: "functional_6"

Layer (type)	Output Shape	Param #	Co
input_layer_6 (InputLayer)	(None, 224, 224, 3)	0	-
zero_padding2d (ZeroPadding2D)	(None, 230, 230, 3)	0	in
conv1_conv (Conv2D)	(None, 112, 112, 64)	9,408	ze
conv1_bn (BatchNormalization)	(None, 112, 112, 64)	256	co
conv1_relu (Activation)	(None, 112, 112, 64)	0	co
zero_padding2d_1 (ZeroPadding2D)	(None, 114, 114, 64)	0	co
pool1 (MaxPooling2D)	(None, 56, 56, 64)	0	ze
conv2_block1_0_bn (BatchNormalization)	(None, 56, 56, 64)	256	po
conv2_block1_0_relu (Activation)	(None, 56, 56, 64)	0	co
conv2_block1_1_conv (Conv2D)	(None, 56, 56, 128)	8,192	co
conv2_block1_1_bn (BatchNormalization)	(None, 56, 56, 128)	512	co
conv2_block1_1_relu (Activation)	(None, 56, 56, 128)	0	co
conv2_block1_2_conv (Conv2D)	(None, 56, 56, 32)	36,864	co
conv2_block1_concat (Concatenate)	(None, 56, 56, 96)	0	po co
conv2_block2_0_bn (BatchNormalization)	(None, 56, 56, 96)	384	co
conv2_block2_0_relu (Activation)	(None, 56, 56, 96)	0	co
conv2_block2_1_conv (Conv2D)	(None, 56, 56, 128)	12,288	co
conv2_block2_1_bn (BatchNormalization)	(None, 56, 56, 128)	512	co
conv2_block2_1_relu (Activation)	(None, 56, 56, 128)	0	co
conv2_block2_2_conv (Conv2D)	(None, 56, 56, 32)	36,864	co

conv2_block2_concat (Concatenate)	(None, 56, 56, 128)	0	co co
conv2_block3_0_bn (BatchNormalization)	(None, 56, 56, 128)	512	co
conv2_block3_0_relu (Activation)	(None, 56, 56, 128)	0	co
conv2_block3_1_conv (Conv2D)	(None, 56, 56, 128)	16,384	co
conv2_block3_1_bn (BatchNormalization)	(None, 56, 56, 128)	512	co
conv2_block3_1_relu (Activation)	(None, 56, 56, 128)	0	co
conv2_block3_2_conv (Conv2D)	(None, 56, 56, 32)	36,864	co
conv2_block3_concat (Concatenate)	(None, 56, 56, 160)	0	co co
conv2_block4_0_bn (BatchNormalization)	(None, 56, 56, 160)	640	co
conv2_block4_0_relu (Activation)	(None, 56, 56, 160)	0	co
conv2_block4_1_conv (Conv2D)	(None, 56, 56, 128)	20,480	co
conv2_block4_1_bn (BatchNormalization)	(None, 56, 56, 128)	512	co
conv2_block4_1_relu (Activation)	(None, 56, 56, 128)	0	co
conv2_block4_2_conv (Conv2D)	(None, 56, 56, 32)	36,864	co
conv2_block4_concat (Concatenate)	(None, 56, 56, 192)	0	co co
conv2_block5_0_bn (BatchNormalization)	(None, 56, 56, 192)	768	co
conv2_block5_0_relu (Activation)	(None, 56, 56, 192)	0	co
conv2_block5_1_conv (Conv2D)	(None, 56, 56, 128)	24,576	co
conv2_block5_1_bn (BatchNormalization)	(None, 56, 56, 128)	512	co
conv2_block5_1_relu (Activation)	(None, 56, 56, 128)	0	co

conv2_block5_2_conv (Conv2D)	(None, 56, 56, 32)	36,864	co
conv2_block5_concat (Concatenate)	(None, 56, 56, 224)	0	co co
conv2_block6_0_bn (BatchNormalization)	(None, 56, 56, 224)	896	co
conv2_block6_0_relu (Activation)	(None, 56, 56, 224)	0	co
conv2_block6_1_conv (Conv2D)	(None, 56, 56, 128)	28,672	co
conv2_block6_1_bn (BatchNormalization)	(None, 56, 56, 128)	512	co
conv2_block6_1_relu (Activation)	(None, 56, 56, 128)	0	co
conv2_block6_2_conv (Conv2D)	(None, 56, 56, 32)	36,864	co
conv2_block6_concat (Concatenate)	(None, 56, 56, 256)	0	co co
pool2_bn (BatchNormalization)	(None, 56, 56, 256)	1,024	co
pool2_relu (Activation)	(None, 56, 56, 256)	0	po
pool2_conv (Conv2D)	(None, 56, 56, 128)	32,768	po
pool2_pool (AveragePooling2D)	(None, 28, 28, 128)	0	po
conv3_block1_0_bn (BatchNormalization)	(None, 28, 28, 128)	512	po
conv3_block1_0_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block1_1_conv (Conv2D)	(None, 28, 28, 128)	16,384	co
conv3_block1_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block1_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block1_2_conv (Conv2D)	(None, 28, 28, 32)	36,864	co
conv3_block1_concat (Concatenate)	(None, 28, 28, 160)	0	po co
conv3_block2_0_bn (BatchNormalization)	(None, 28, 28, 160)	640	co

conv3_block2_0_relu (Activation)	(None, 28, 28, 160)	0	co
conv3_block2_1_conv (Conv2D)	(None, 28, 28, 128)	20,480	co
conv3_block2_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block2_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block2_2_conv (Conv2D)	(None, 28, 28, 32)	36,864	co
conv3_block2_concat (Concatenate)	(None, 28, 28, 192)	0	co co
conv3_block3_0_bn (BatchNormalization)	(None, 28, 28, 192)	768	co
conv3_block3_0_relu (Activation)	(None, 28, 28, 192)	0	co
conv3_block3_1_conv (Conv2D)	(None, 28, 28, 128)	24,576	co
conv3_block3_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block3_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block3_2_conv (Conv2D)	(None, 28, 28, 32)	36,864	co
conv3_block3_concat (Concatenate)	(None, 28, 28, 224)	0	co co
conv3_block4_0_bn (BatchNormalization)	(None, 28, 28, 224)	896	co
conv3_block4_0_relu (Activation)	(None, 28, 28, 224)	0	co
conv3_block4_1_conv (Conv2D)	(None, 28, 28, 128)	28,672	co
conv3_block4_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block4_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block4_2_conv (Conv2D)	(None, 28, 28, 32)	36,864	co
conv3_block4_concat (Concatenate)	(None, 28, 28, 256)	0	co co

conv3_block5_0_bn (BatchNormalization)	(None, 28, 28, 256)	1,024	co
conv3_block5_0_relu (Activation)	(None, 28, 28, 256)	0	co
conv3_block5_1_conv (Conv2D)	(None, 28, 28, 128)	32,768	co
conv3_block5_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block5_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block5_2_conv (Conv2D)	(None, 28, 28, 32)	36,864	co
conv3_block5_concat (Concatenate)	(None, 28, 28, 288)	0	co co
conv3_block6_0_bn (BatchNormalization)	(None, 28, 28, 288)	1,152	co
conv3_block6_0_relu (Activation)	(None, 28, 28, 288)	0	co
conv3_block6_1_conv (Conv2D)	(None, 28, 28, 128)	36,864	co
conv3_block6_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block6_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block6_2_conv (Conv2D)	(None, 28, 28, 32)	36,864	co
conv3_block6_concat (Concatenate)	(None, 28, 28, 320)	0	co co
conv3_block7_0_bn (BatchNormalization)	(None, 28, 28, 320)	1,280	co
conv3_block7_0_relu (Activation)	(None, 28, 28, 320)	0	co
conv3_block7_1_conv (Conv2D)	(None, 28, 28, 128)	40,960	co
conv3_block7_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block7_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block7_2_conv (Conv2D)	(None, 28, 28, 32)	36,864	co

conv3_block7_concat (Concatenate)	(None, 28, 28, 352)	0	co co
conv3_block8_0_bn (BatchNormalization)	(None, 28, 28, 352)	1,408	co
conv3_block8_0_relu (Activation)	(None, 28, 28, 352)	0	co
conv3_block8_1_conv (Conv2D)	(None, 28, 28, 128)	45,056	co
conv3_block8_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block8_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block8_2_conv (Conv2D)	(None, 28, 28, 32)	36,864	co
conv3_block8_concat (Concatenate)	(None, 28, 28, 384)	0	co co
conv3_block9_0_bn (BatchNormalization)	(None, 28, 28, 384)	1,536	co
conv3_block9_0_relu (Activation)	(None, 28, 28, 384)	0	co
conv3_block9_1_conv (Conv2D)	(None, 28, 28, 128)	49,152	co
conv3_block9_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block9_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block9_2_conv (Conv2D)	(None, 28, 28, 32)	36,864	co
conv3_block9_concat (Concatenate)	(None, 28, 28, 416)	0	co co
conv3_block10_0_bn (BatchNormalization)	(None, 28, 28, 416)	1,664	co
conv3_block10_0_relu (Activation)	(None, 28, 28, 416)	0	co
conv3_block10_1_conv (Conv2D)	(None, 28, 28, 128)	53,248	co
conv3_block10_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block10_1_relu (Activation)	(None, 28, 28, 128)	0	co

conv3_block10_2_conv (Conv2D)	(None, 28, 28, 32)	36,864	co
conv3_block10_concat (Concatenate)	(None, 28, 28, 448)	0	co co
conv3_block11_0_bn (BatchNormalization)	(None, 28, 28, 448)	1,792	co
conv3_block11_0_relu (Activation)	(None, 28, 28, 448)	0	co
conv3_block11_1_conv (Conv2D)	(None, 28, 28, 128)	57,344	co
conv3_block11_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block11_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block11_2_conv (Conv2D)	(None, 28, 28, 32)	36,864	co
conv3_block11_concat (Concatenate)	(None, 28, 28, 480)	0	co co
conv3_block12_0_bn (BatchNormalization)	(None, 28, 28, 480)	1,920	co
conv3_block12_0_relu (Activation)	(None, 28, 28, 480)	0	co
conv3_block12_1_conv (Conv2D)	(None, 28, 28, 128)	61,440	co
conv3_block12_1_bn (BatchNormalization)	(None, 28, 28, 128)	512	co
conv3_block12_1_relu (Activation)	(None, 28, 28, 128)	0	co
conv3_block12_2_conv (Conv2D)	(None, 28, 28, 32)	36,864	co
conv3_block12_concat (Concatenate)	(None, 28, 28, 512)	0	co co
pool3_bn (BatchNormalization)	(None, 28, 28, 512)	2,048	co
pool3_relu (Activation)	(None, 28, 28, 512)	0	po
pool3_conv (Conv2D)	(None, 28, 28, 256)	131,072	po
pool3_pool (AveragePooling2D)	(None, 14, 14, 256)	0	po
conv4_block1_0_bn	(None, 14, 14, 256)	1,024	po

(BatchNormalization)				
conv4_block1_0_relu (Activation)	(None, 14, 14, 256)	0	co	
conv4_block1_1_conv (Conv2D)	(None, 14, 14, 128)	32,768	co	
conv4_block1_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co	
conv4_block1_1_relu (Activation)	(None, 14, 14, 128)	0	co	
conv4_block1_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co	
conv4_block1_concat (Concatenate)	(None, 14, 14, 288)	0	po co	
conv4_block2_0_bn (BatchNormalization)	(None, 14, 14, 288)	1,152	co	
conv4_block2_0_relu (Activation)	(None, 14, 14, 288)	0	co	
conv4_block2_1_conv (Conv2D)	(None, 14, 14, 128)	36,864	co	
conv4_block2_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co	
conv4_block2_1_relu (Activation)	(None, 14, 14, 128)	0	co	
conv4_block2_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co	
conv4_block2_concat (Concatenate)	(None, 14, 14, 320)	0	co co	
conv4_block3_0_bn (BatchNormalization)	(None, 14, 14, 320)	1,280	co	
conv4_block3_0_relu (Activation)	(None, 14, 14, 320)	0	co	
conv4_block3_1_conv (Conv2D)	(None, 14, 14, 128)	40,960	co	
conv4_block3_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co	
conv4_block3_1_relu (Activation)	(None, 14, 14, 128)	0	co	
conv4_block3_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co	
conv4_block3_concat	(None, 14, 14, 352)	0	co	

(Concatenate)			co
conv4_block4_0_bn (BatchNormalization)	(None, 14, 14, 352)	1,408	co
conv4_block4_0_relu (Activation)	(None, 14, 14, 352)	0	co
conv4_block4_1_conv (Conv2D)	(None, 14, 14, 128)	45,056	co
conv4_block4_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co
conv4_block4_1_relu (Activation)	(None, 14, 14, 128)	0	co
conv4_block4_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co
conv4_block4_concat (Concatenate)	(None, 14, 14, 384)	0	co
conv4_block4_concat (Concatenate)		co	co
conv4_block5_0_bn (BatchNormalization)	(None, 14, 14, 384)	1,536	co
conv4_block5_0_relu (Activation)	(None, 14, 14, 384)	0	co
conv4_block5_1_conv (Conv2D)	(None, 14, 14, 128)	49,152	co
conv4_block5_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co
conv4_block5_1_relu (Activation)	(None, 14, 14, 128)	0	co
conv4_block5_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co
conv4_block5_concat (Concatenate)	(None, 14, 14, 416)	0	co
conv4_block5_concat (Concatenate)		co	co
conv4_block6_0_bn (BatchNormalization)	(None, 14, 14, 416)	1,664	co
conv4_block6_0_relu (Activation)	(None, 14, 14, 416)	0	co
conv4_block6_1_conv (Conv2D)	(None, 14, 14, 128)	53,248	co
conv4_block6_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co
conv4_block6_1_relu (Activation)	(None, 14, 14, 128)	0	co
conv4_block6_2_conv	(None, 14, 14, 32)	36,864	co

(Conv2D)				
conv4_block6_concat (Concatenate)	(None, 14, 14, 448)	0	co	co
conv4_block7_0_bn (BatchNormalization)	(None, 14, 14, 448)	1,792	co	
conv4_block7_0_relu (Activation)	(None, 14, 14, 448)	0	co	
conv4_block7_1_conv (Conv2D)	(None, 14, 14, 128)	57,344	co	
conv4_block7_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co	
conv4_block7_1_relu (Activation)	(None, 14, 14, 128)	0	co	
conv4_block7_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co	
conv4_block7_concat (Concatenate)	(None, 14, 14, 480)	0	co	co
conv4_block8_0_bn (BatchNormalization)	(None, 14, 14, 480)	1,920	co	
conv4_block8_0_relu (Activation)	(None, 14, 14, 480)	0	co	
conv4_block8_1_conv (Conv2D)	(None, 14, 14, 128)	61,440	co	
conv4_block8_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co	
conv4_block8_1_relu (Activation)	(None, 14, 14, 128)	0	co	
conv4_block8_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co	
conv4_block8_concat (Concatenate)	(None, 14, 14, 512)	0	co	co
conv4_block9_0_bn (BatchNormalization)	(None, 14, 14, 512)	2,048	co	
conv4_block9_0_relu (Activation)	(None, 14, 14, 512)	0	co	
conv4_block9_1_conv (Conv2D)	(None, 14, 14, 128)	65,536	co	
conv4_block9_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co	
conv4_block9_1_relu	(None, 14, 14, 128)	0	co	

(Activation)			
conv4_block9_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co
conv4_block9_concat (Concatenate)	(None, 14, 14, 544)	0	co co
conv4_block10_0_bn (BatchNormalization)	(None, 14, 14, 544)	2,176	co
conv4_block10_0_relu (Activation)	(None, 14, 14, 544)	0	co
conv4_block10_1_conv (Conv2D)	(None, 14, 14, 128)	69,632	co
conv4_block10_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co
conv4_block10_1_relu (Activation)	(None, 14, 14, 128)	0	co
conv4_block10_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co
conv4_block10_concat (Concatenate)	(None, 14, 14, 576)	0	co co
conv4_block11_0_bn (BatchNormalization)	(None, 14, 14, 576)	2,304	co
conv4_block11_0_relu (Activation)	(None, 14, 14, 576)	0	co
conv4_block11_1_conv (Conv2D)	(None, 14, 14, 128)	73,728	co
conv4_block11_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co
conv4_block11_1_relu (Activation)	(None, 14, 14, 128)	0	co
conv4_block11_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co
conv4_block11_concat (Concatenate)	(None, 14, 14, 608)	0	co co
conv4_block12_0_bn (BatchNormalization)	(None, 14, 14, 608)	2,432	co
conv4_block12_0_relu (Activation)	(None, 14, 14, 608)	0	co
conv4_block12_1_conv (Conv2D)	(None, 14, 14, 128)	77,824	co
conv4_block12_1_bn	(None, 14, 14, 128)	512	co

(BatchNormalization)				
conv4_block12_1_relu (Activation)	(None, 14, 14, 128)	0	co	
conv4_block12_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co	
conv4_block12_concat (Concatenate)	(None, 14, 14, 640)	0	co	co
conv4_block13_0_bn (BatchNormalization)	(None, 14, 14, 640)	2,560	co	
conv4_block13_0_relu (Activation)	(None, 14, 14, 640)	0	co	
conv4_block13_1_conv (Conv2D)	(None, 14, 14, 128)	81,920	co	
conv4_block13_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co	
conv4_block13_1_relu (Activation)	(None, 14, 14, 128)	0	co	
conv4_block13_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co	
conv4_block13_concat (Concatenate)	(None, 14, 14, 672)	0	co	co
conv4_block14_0_bn (BatchNormalization)	(None, 14, 14, 672)	2,688	co	
conv4_block14_0_relu (Activation)	(None, 14, 14, 672)	0	co	
conv4_block14_1_conv (Conv2D)	(None, 14, 14, 128)	86,016	co	
conv4_block14_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co	
conv4_block14_1_relu (Activation)	(None, 14, 14, 128)	0	co	
conv4_block14_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co	
conv4_block14_concat (Concatenate)	(None, 14, 14, 704)	0	co	co
conv4_block15_0_bn (BatchNormalization)	(None, 14, 14, 704)	2,816	co	
conv4_block15_0_relu (Activation)	(None, 14, 14, 704)	0	co	
conv4_block15_1_conv	(None, 14, 14, 128)	90,112	co	

(Conv2D)				
conv4_block15_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co	
conv4_block15_1_relu (Activation)	(None, 14, 14, 128)	0	co	
conv4_block15_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co	
conv4_block15_concat (Concatenate)	(None, 14, 14, 736)	0	co	co
conv4_block16_0_bn (BatchNormalization)	(None, 14, 14, 736)	2,944	co	
conv4_block16_0_relu (Activation)	(None, 14, 14, 736)	0	co	
conv4_block16_1_conv (Conv2D)	(None, 14, 14, 128)	94,208	co	
conv4_block16_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co	
conv4_block16_1_relu (Activation)	(None, 14, 14, 128)	0	co	
conv4_block16_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co	
conv4_block16_concat (Concatenate)	(None, 14, 14, 768)	0	co	co
conv4_block17_0_bn (BatchNormalization)	(None, 14, 14, 768)	3,072	co	
conv4_block17_0_relu (Activation)	(None, 14, 14, 768)	0	co	
conv4_block17_1_conv (Conv2D)	(None, 14, 14, 128)	98,304	co	
conv4_block17_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co	
conv4_block17_1_relu (Activation)	(None, 14, 14, 128)	0	co	
conv4_block17_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co	
conv4_block17_concat (Concatenate)	(None, 14, 14, 800)	0	co	co
conv4_block18_0_bn (BatchNormalization)	(None, 14, 14, 800)	3,200	co	
conv4_block18_0_relu	(None, 14, 14, 800)	0	co	

(Activation)			
conv4_block18_1_conv (Conv2D)	(None, 14, 14, 128)	102,400	co
conv4_block18_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co
conv4_block18_1_relu (Activation)	(None, 14, 14, 128)	0	co
conv4_block18_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co
conv4_block18_concat (Concatenate)	(None, 14, 14, 832)	0	co
conv4_block19_0_bn (BatchNormalization)	(None, 14, 14, 832)	3,328	co
conv4_block19_0_relu (Activation)	(None, 14, 14, 832)	0	co
conv4_block19_1_conv (Conv2D)	(None, 14, 14, 128)	106,496	co
conv4_block19_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co
conv4_block19_1_relu (Activation)	(None, 14, 14, 128)	0	co
conv4_block19_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co
conv4_block19_concat (Concatenate)	(None, 14, 14, 864)	0	co
conv4_block20_0_bn (BatchNormalization)	(None, 14, 14, 864)	3,456	co
conv4_block20_0_relu (Activation)	(None, 14, 14, 864)	0	co
conv4_block20_1_conv (Conv2D)	(None, 14, 14, 128)	110,592	co
conv4_block20_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co
conv4_block20_1_relu (Activation)	(None, 14, 14, 128)	0	co
conv4_block20_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co
conv4_block20_concat (Concatenate)	(None, 14, 14, 896)	0	co
conv4_block21_0_bn	(None, 14, 14, 896)	3,584	co

(BatchNormalization)				
conv4_block21_0_relu (Activation)	(None, 14, 14, 896)	0	co	
conv4_block21_1_conv (Conv2D)	(None, 14, 14, 128)	114,688	co	
conv4_block21_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co	
conv4_block21_1_relu (Activation)	(None, 14, 14, 128)	0	co	
conv4_block21_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co	
conv4_block21_concat (Concatenate)	(None, 14, 14, 928)	0	co	co
conv4_block22_0_bn (BatchNormalization)	(None, 14, 14, 928)	3,712	co	
conv4_block22_0_relu (Activation)	(None, 14, 14, 928)	0	co	
conv4_block22_1_conv (Conv2D)	(None, 14, 14, 128)	118,784	co	
conv4_block22_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co	
conv4_block22_1_relu (Activation)	(None, 14, 14, 128)	0	co	
conv4_block22_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co	
conv4_block22_concat (Concatenate)	(None, 14, 14, 960)	0	co	co
conv4_block23_0_bn (BatchNormalization)	(None, 14, 14, 960)	3,840	co	
conv4_block23_0_relu (Activation)	(None, 14, 14, 960)	0	co	
conv4_block23_1_conv (Conv2D)	(None, 14, 14, 128)	122,880	co	
conv4_block23_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co	
conv4_block23_1_relu (Activation)	(None, 14, 14, 128)	0	co	
conv4_block23_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co	
conv4_block23_concat	(None, 14, 14, 992)	0	co	

(Concatenate)			co
conv4_block24_0_bn (BatchNormalization)	(None, 14, 14, 992)	3,968	co
conv4_block24_0_relu (Activation)	(None, 14, 14, 992)	0	co
conv4_block24_1_conv (Conv2D)	(None, 14, 14, 128)	126,976	co
conv4_block24_1_bn (BatchNormalization)	(None, 14, 14, 128)	512	co
conv4_block24_1_relu (Activation)	(None, 14, 14, 128)	0	co
conv4_block24_2_conv (Conv2D)	(None, 14, 14, 32)	36,864	co
conv4_block24_concat (Concatenate)	(None, 14, 14, 1024)	0	co
pool4_bn (BatchNormalization)	(None, 14, 14, 1024)	4,096	co
pool4_relu (Activation)	(None, 14, 14, 1024)	0	po
pool4_conv (Conv2D)	(None, 14, 14, 512)	524,288	po
pool4_pool (AveragePooling2D)	(None, 7, 7, 512)	0	po
conv5_block1_0_bn (BatchNormalization)	(None, 7, 7, 512)	2,048	po
conv5_block1_0_relu (Activation)	(None, 7, 7, 512)	0	co
conv5_block1_1_conv (Conv2D)	(None, 7, 7, 128)	65,536	co
conv5_block1_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block1_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block1_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block1_concat (Concatenate)	(None, 7, 7, 544)	0	po
conv5_block1_concat (Concatenate)	(None, 7, 7, 544)	0	co
conv5_block2_0_bn (BatchNormalization)	(None, 7, 7, 544)	2,176	co
conv5_block2_0_relu (Activation)	(None, 7, 7, 544)	0	co

conv5_block2_1_conv (Conv2D)	(None, 7, 7, 128)	69,632	co
conv5_block2_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block2_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block2_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block2_concat (Concatenate)	(None, 7, 7, 576)	0	co co
conv5_block3_0_bn (BatchNormalization)	(None, 7, 7, 576)	2,304	co
conv5_block3_0_relu (Activation)	(None, 7, 7, 576)	0	co
conv5_block3_1_conv (Conv2D)	(None, 7, 7, 128)	73,728	co
conv5_block3_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block3_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block3_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block3_concat (Concatenate)	(None, 7, 7, 608)	0	co co
conv5_block4_0_bn (BatchNormalization)	(None, 7, 7, 608)	2,432	co
conv5_block4_0_relu (Activation)	(None, 7, 7, 608)	0	co
conv5_block4_1_conv (Conv2D)	(None, 7, 7, 128)	77,824	co
conv5_block4_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block4_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block4_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block4_concat (Concatenate)	(None, 7, 7, 640)	0	co co
conv5_block5_0_bn (BatchNormalization)	(None, 7, 7, 640)	2,560	co

conv5_block5_0_relu (Activation)	(None, 7, 7, 640)	0	co
conv5_block5_1_conv (Conv2D)	(None, 7, 7, 128)	81,920	co
conv5_block5_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block5_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block5_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block5_concat (Concatenate)	(None, 7, 7, 672)	0	co co
conv5_block6_0_bn (BatchNormalization)	(None, 7, 7, 672)	2,688	co
conv5_block6_0_relu (Activation)	(None, 7, 7, 672)	0	co
conv5_block6_1_conv (Conv2D)	(None, 7, 7, 128)	86,016	co
conv5_block6_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block6_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block6_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block6_concat (Concatenate)	(None, 7, 7, 704)	0	co co
conv5_block7_0_bn (BatchNormalization)	(None, 7, 7, 704)	2,816	co
conv5_block7_0_relu (Activation)	(None, 7, 7, 704)	0	co
conv5_block7_1_conv (Conv2D)	(None, 7, 7, 128)	90,112	co
conv5_block7_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block7_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block7_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block7_concat (Concatenate)	(None, 7, 7, 736)	0	co co

conv5_block8_0_bn (BatchNormalization)	(None, 7, 7, 736)	2,944	co
conv5_block8_0_relu (Activation)	(None, 7, 7, 736)	0	co
conv5_block8_1_conv (Conv2D)	(None, 7, 7, 128)	94,208	co
conv5_block8_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block8_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block8_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block8_concat (Concatenate)	(None, 7, 7, 768)	0	co co
conv5_block9_0_bn (BatchNormalization)	(None, 7, 7, 768)	3,072	co
conv5_block9_0_relu (Activation)	(None, 7, 7, 768)	0	co
conv5_block9_1_conv (Conv2D)	(None, 7, 7, 128)	98,304	co
conv5_block9_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block9_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block9_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block9_concat (Concatenate)	(None, 7, 7, 800)	0	co co
conv5_block10_0_bn (BatchNormalization)	(None, 7, 7, 800)	3,200	co
conv5_block10_0_relu (Activation)	(None, 7, 7, 800)	0	co
conv5_block10_1_conv (Conv2D)	(None, 7, 7, 128)	102,400	co
conv5_block10_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block10_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block10_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co

conv5_block10_concat (Concatenate)	(None, 7, 7, 832)	0	co co
conv5_block11_0_bn (BatchNormalization)	(None, 7, 7, 832)	3,328	co
conv5_block11_0_relu (Activation)	(None, 7, 7, 832)	0	co
conv5_block11_1_conv (Conv2D)	(None, 7, 7, 128)	106,496	co
conv5_block11_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block11_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block11_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block11_concat (Concatenate)	(None, 7, 7, 864)	0	co co
conv5_block12_0_bn (BatchNormalization)	(None, 7, 7, 864)	3,456	co
conv5_block12_0_relu (Activation)	(None, 7, 7, 864)	0	co
conv5_block12_1_conv (Conv2D)	(None, 7, 7, 128)	110,592	co
conv5_block12_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block12_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block12_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block12_concat (Concatenate)	(None, 7, 7, 896)	0	co co
conv5_block13_0_bn (BatchNormalization)	(None, 7, 7, 896)	3,584	co
conv5_block13_0_relu (Activation)	(None, 7, 7, 896)	0	co
conv5_block13_1_conv (Conv2D)	(None, 7, 7, 128)	114,688	co
conv5_block13_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block13_1_relu (Activation)	(None, 7, 7, 128)	0	co

conv5_block13_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block13_concat (Concatenate)	(None, 7, 7, 928)	0	co co
conv5_block14_0_bn (BatchNormalization)	(None, 7, 7, 928)	3,712	co
conv5_block14_0_relu (Activation)	(None, 7, 7, 928)	0	co
conv5_block14_1_conv (Conv2D)	(None, 7, 7, 128)	118,784	co
conv5_block14_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block14_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block14_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block14_concat (Concatenate)	(None, 7, 7, 960)	0	co co
conv5_block15_0_bn (BatchNormalization)	(None, 7, 7, 960)	3,840	co
conv5_block15_0_relu (Activation)	(None, 7, 7, 960)	0	co
conv5_block15_1_conv (Conv2D)	(None, 7, 7, 128)	122,880	co
conv5_block15_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co
conv5_block15_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block15_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block15_concat (Concatenate)	(None, 7, 7, 992)	0	co co
conv5_block16_0_bn (BatchNormalization)	(None, 7, 7, 992)	3,968	co
conv5_block16_0_relu (Activation)	(None, 7, 7, 992)	0	co
conv5_block16_1_conv (Conv2D)	(None, 7, 7, 128)	126,976	co
conv5_block16_1_bn (BatchNormalization)	(None, 7, 7, 128)	512	co

conv5_block16_1_relu (Activation)	(None, 7, 7, 128)	0	co
conv5_block16_2_conv (Conv2D)	(None, 7, 7, 32)	36,864	co
conv5_block16_concat (Concatenate)	(None, 7, 7, 1024)	0	co co
bn (BatchNormalization)	(None, 7, 7, 1024)	4,096	co
relu (Activation)	(None, 7, 7, 1024)	0	bn
reshape_12 (Reshape)	(None, 49, 1024)	0	re
multi_head_attention_6 (MultiHeadAttention)	(None, 49, 1024)	33,580,032	re re
reshape_13 (Reshape)	(None, 7, 7, 1024)	0	mu
gaussian_noise_12 (GaussianNoise)	(None, 7, 7, 1024)	0	re
global_average_pooling2d... (GlobalAveragePooling2D)	(None, 1024)	0	ga
dense_12 (Dense)	(None, 512)	524,800	gl
batch_normalization_104 (BatchNormalization)	(None, 512)	2,048	de
gaussian_noise_13 (GaussianNoise)	(None, 512)	0	ba
dropout_13 (Dropout)	(None, 512)	0	ga
dense_13 (Dense)	(None, 4)	2,052	dr

Total params: 41,146,436 (156.96 MB)

Trainable params: 34,107,908 (130.11 MB)

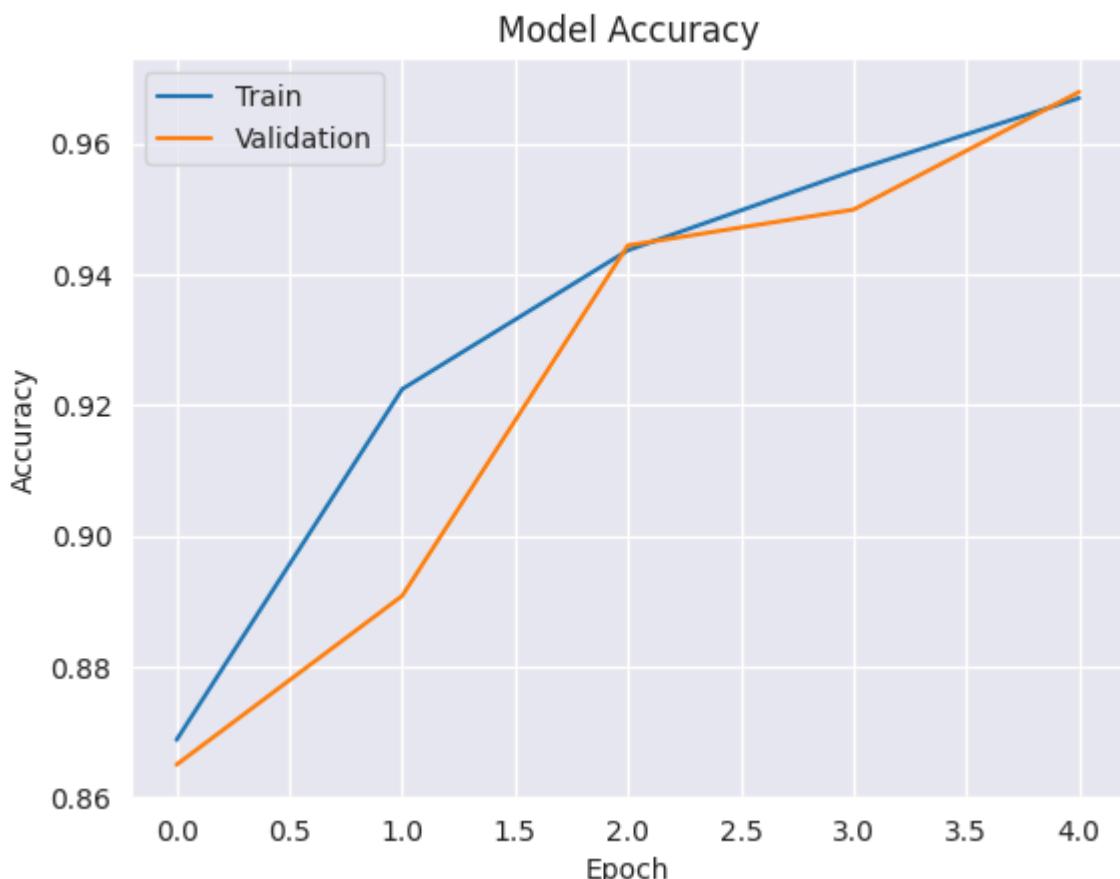
Non-trainable params: 7,038,528 (26.85 MB)

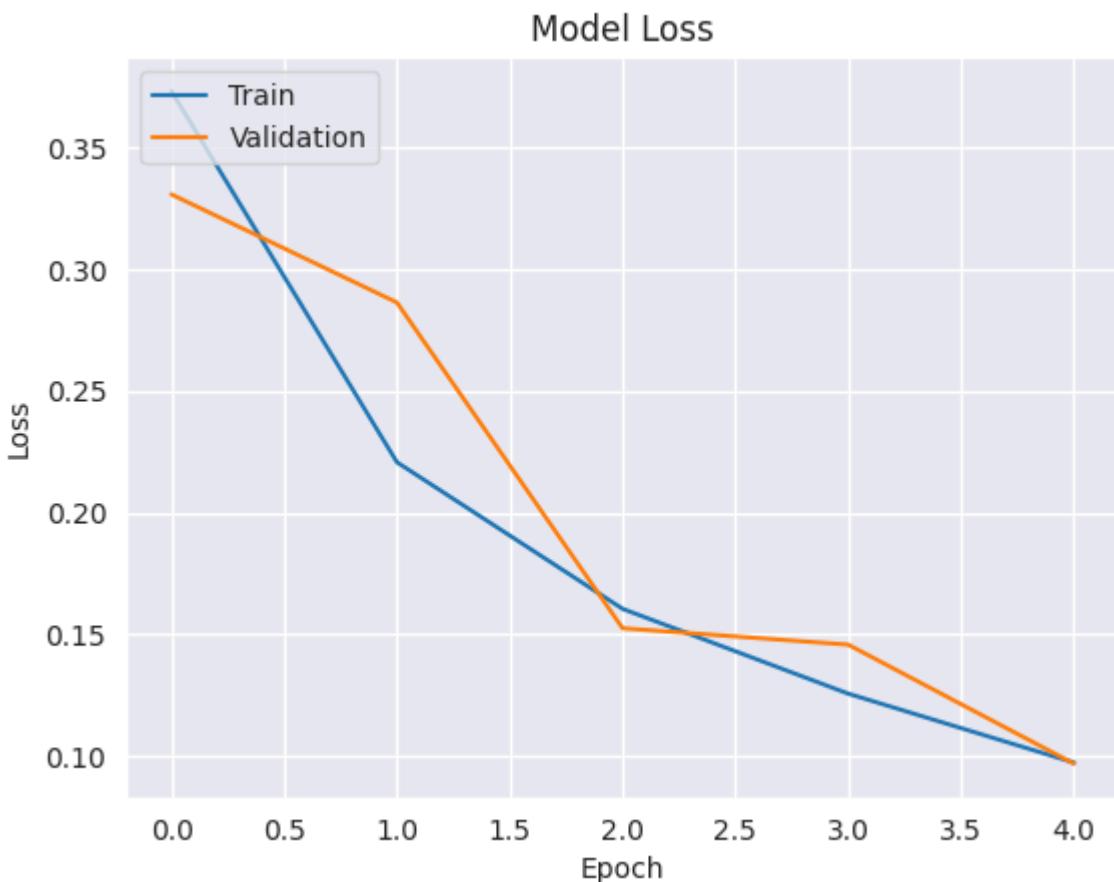
```
In [ ]: history = cnn_model.fit(
    train_gen_new,
    validation_data=valid_gen_new,
    epochs=5,
    callbacks=[early_stopping],
    verbose=1
)
```

```
Epoch 1/5
1278/1278 167s 111ms/step - accuracy: 0.8364 - loss: 0.4720
- val_accuracy: 0.8650 - val_loss: 0.3308
Epoch 2/5
1278/1278 118s 92ms/step - accuracy: 0.9156 - loss: 0.2381 -
val_accuracy: 0.8908 - val_loss: 0.2863
Epoch 3/5
1278/1278 117s 91ms/step - accuracy: 0.9460 - loss: 0.1551 -
val_accuracy: 0.9444 - val_loss: 0.1526
Epoch 4/5
1278/1278 117s 91ms/step - accuracy: 0.9566 - loss: 0.1250 -
val_accuracy: 0.9499 - val_loss: 0.1459
Epoch 5/5
1278/1278 118s 92ms/step - accuracy: 0.9674 - loss: 0.0952 -
val_accuracy: 0.9679 - val_loss: 0.0970
```

```
In [ ]: plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()

plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model Loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()
```





```
In [ ]: test_labels = test_gen_new.classes
         predictions = cnn_model.predict(test_gen_new)
         predicted_classes = np.argmax(predictions, axis=1)
```

160/160 ━━━━━━━━ 25s 109ms/step

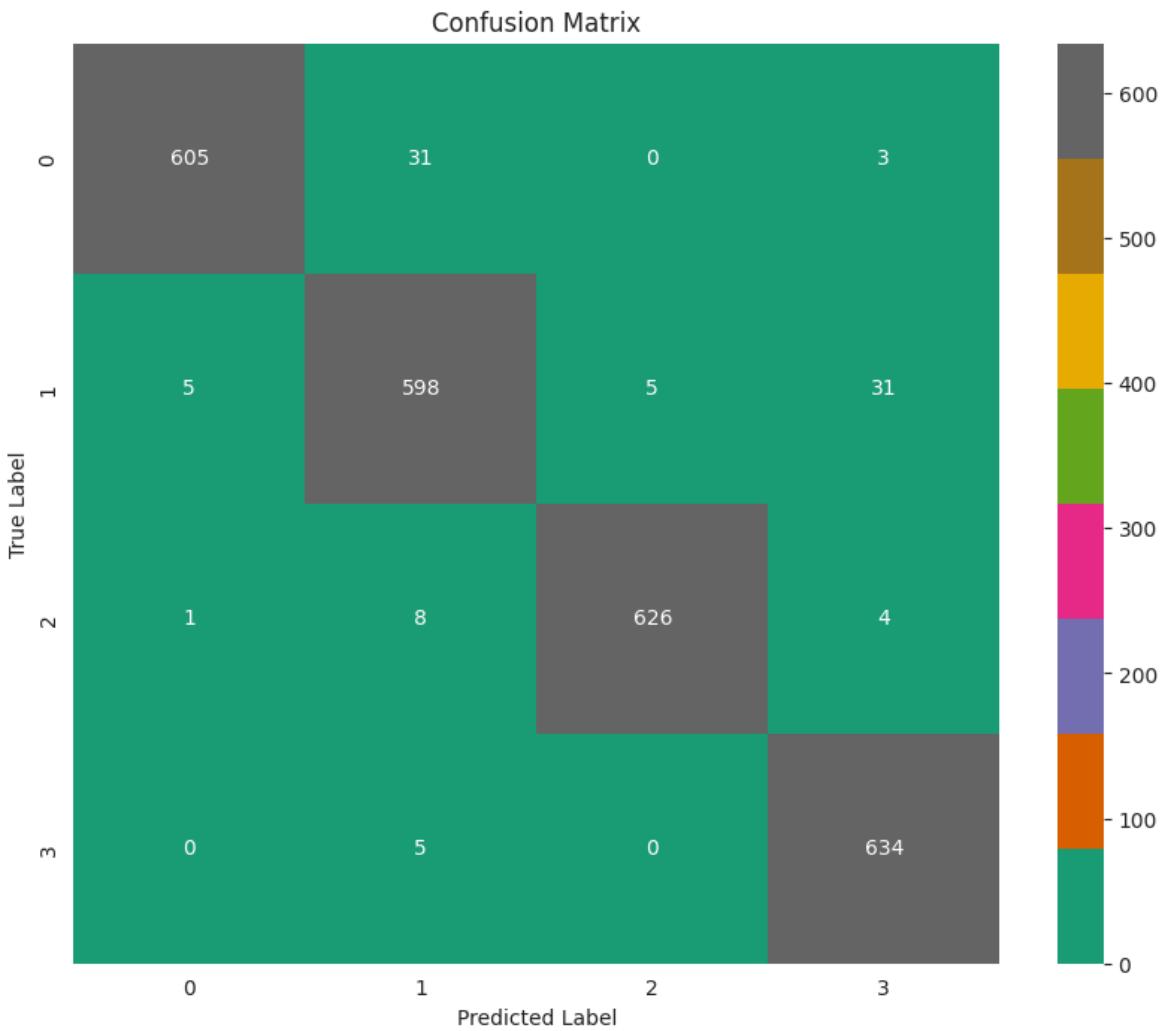
```
In [ ]: report = classification_report(test_labels, predicted_classes,
                                         target_names=list(test_gen_new.class_indices.keys()))
print("Report for DenseNet =>")
print(report)
```

Report for DenseNet =>				
	precision	recall	f1-score	support
0	0.99	0.95	0.97	639
1	0.93	0.94	0.93	639
2	0.99	0.98	0.99	639
3	0.94	0.99	0.97	639
accuracy			0.96	2556
macro avg	0.96	0.96	0.96	2556
weighted avg	0.96	0.96	0.96	2556

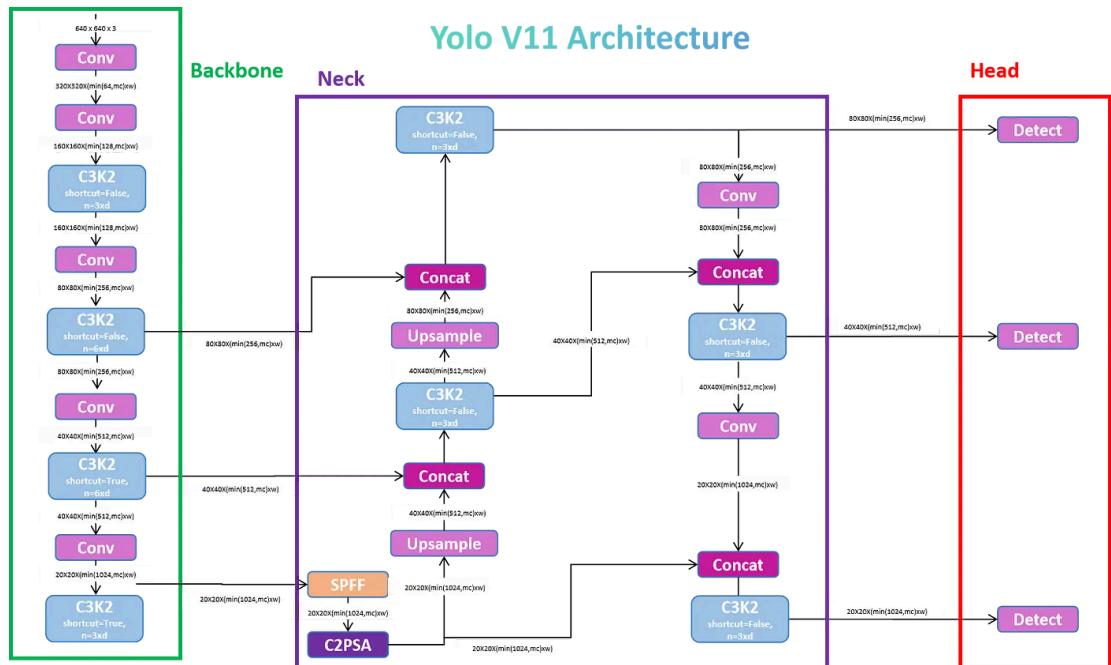
```
In [ ]: conf_matrix = confusion_matrix(test_labels, predicted_classes)
```

```
In [ ]: plt.figure(figsize=(10, 8))
sns.heatmap(conf_matrix, annot=True, fmt='d',
            cmap='Dark2',
            xticklabels=list(test_gen_new.class_indices.keys()),
            yticklabels=list(test_gen_new.class_indices.keys()))
plt.title('Confusion Matrix')
plt.xlabel('Predicted Label')
```

```
plt.ylabel('True Label')
plt.show()
```



Object Detection Using YOLO11



```
In [1]: from google.colab import drive
drive.mount('/content/gdrive/')
```

```
Mounted at /content/gdrive/
```

```
In [2]: %cd /content/gdrive/MyDrive
```

```
/content/gdrive/MyDrive
```

```
In [3]: import os  
if not os.path.isdir("yolov11"):  
    os.makedirs("yolov11")
```

```
In [4]: %cd yolov11
```

```
/content/gdrive/MyDrive/yolov11
```

```
In [5]: !git clone https://github.com/ultralytics/ultralytics.git
```

```
fatal: destination path 'ultralytics' already exists and is not an empty directory.
```

```
In [6]: %cd ultralytics
```

```
/content/gdrive/MyDrive/yolov11/ultralytics
```

```
In [8]: !pip install ultralytics
```

Collecting ultralytics

```
  Downloading ultralytics-8.3.39-py3-none-any.whl.metadata (35 kB)
Requirement already satisfied: numpy>=1.23.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (1.26.4)
Requirement already satisfied: matplotlib>=3.3.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (3.8.0)
Requirement already satisfied: opencv-python>=4.6.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (4.10.0.84)
Requirement already satisfied: pillow>=7.1.2 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (11.0.0)
Requirement already satisfied: pyyaml>=5.3.1 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (6.0.2)
Requirement already satisfied: requests>=2.23.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (2.32.3)
Requirement already satisfied: scipy>=1.4.1 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (1.13.1)
Requirement already satisfied: torch>=1.8.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (2.5.1+cu121)
Requirement already satisfied: torchvision>=0.9.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (0.20.1+cu121)
Requirement already satisfied: tqdm>=4.64.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (4.66.6)
Requirement already satisfied: psutil in /usr/local/lib/python3.10/dist-packages (from ultralytics) (5.9.5)
Requirement already satisfied: py-cpuinfo in /usr/local/lib/python3.10/dist-packages (from ultralytics) (9.0.0)
Requirement already satisfied: pandas>=1.1.4 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (2.2.2)
Requirement already satisfied: seaborn>=0.11.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (0.13.2)
Collecting ultralytics-thop>=2.0.0 (from ultralytics)
  Downloading ultralytics_thop-2.0.12-py3-none-any.whl.metadata (9.4 kB)
Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.3.0->ultralytics) (1.3.1)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.3.0->ultralytics) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.3.0->ultralytics) (4.55.0)
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.3.0->ultralytics) (1.4.7)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.3.0->ultralytics) (24.2)
Requirement already satisfied: pyparsing>=2.3.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.3.0->ultralytics) (3.2.0)
Requirement already satisfied: python-dateutil>=2.7 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.3.0->ultralytics) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-packages (from pandas>=1.1.4->ultralytics) (2024.2)
Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.10/dist-packages (from pandas>=1.1.4->ultralytics) (2024.2)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.10/dist-packages (from requests>=2.23.0->ultralytics) (3.4.0)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests>=2.23.0->ultralytics) (3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests>=2.23.0->ultralytics) (2.2.3)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests>=2.23.0->ultralytics) (2024.8.30)
Requirement already satisfied: filelock in /usr/local/lib/python3.10/dist-packages (from torch>=1.8.0->ultralytics) (3.16.1)
```

```
Requirement already satisfied: typing-extensions>=4.8.0 in /usr/local/lib/python3.10/dist-packages (from torch>=1.8.0->ultralytics) (4.12.2)
Requirement already satisfied: networkx in /usr/local/lib/python3.10/dist-packages (from torch>=1.8.0->ultralytics) (3.4.2)
Requirement already satisfied: jinja2 in /usr/local/lib/python3.10/dist-packages (from torch>=1.8.0->ultralytics) (3.1.4)
Requirement already satisfied: fsspec in /usr/local/lib/python3.10/dist-packages (from torch>=1.8.0->ultralytics) (2024.10.0)
Requirement already satisfied: sympy==1.13.1 in /usr/local/lib/python3.10/dist-packages (from torch>=1.8.0->ultralytics) (1.13.1)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in /usr/local/lib/python3.10/dist-packages (from sympy==1.13.1->torch>=1.8.0->ultralytics) (1.3.0)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.7->matplotlib>=3.3.0->ultralytics) (1.16.0)
Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.10/dist-packages (from jinja2->torch>=1.8.0->ultralytics) (3.0.2)
Downloading ultralytics-8.3.39-py3-none-any.whl (896 kB)
----- 896.9/896.9 kB 55.7 MB/s eta 0:00:00
Downloading ultralytics_thop-2.0.12-py3-none-any.whl (26 kB)
Installing collected packages: ultralytics-thop, ultralytics
Successfully installed ultralytics-8.3.39 ultralytics-thop-2.0.12
```

```
In [9]: !yolo task=detect mode=train model=yolo11n.pt data=/content/gdrive/MyDrive/yolov
```

```

Creating new Ultralytics Settings v0.0.6 file ✅
View Ultralytics Settings with 'yolo settings' or at '/root/.config/Ultralytics/settings.json'
Update Settings with 'yolo settings key=value', i.e. 'yolo settings runs_dir=path/to/dir'. For help see https://docs.ultralytics.com/quickstart/#ultralytics-settings.
Ultralytics 8.3.39 🚀 Python-3.10.12 torch-2.5.1+cu121 CUDA:0 (NVIDIA L4, 22700M iB)
engine/trainer: task=detect, mode=train, model=yolo11n.pt, data=/content/gdrive/M
yDrive/yolov11/ultralytics/Brain_dataset.yaml, epochs=10, time=None, patience=10
0, batch=16, imgsz=640, save=True, save_period=-1, cache=False, device=None, work
ers=8, project=None, name=train9, exist_ok=False, pretrained=True, optimizer=aut
o, verbose=True, seed=0, deterministic=True, single_cls=False, rect=False, cos_lr
=False, close_mosaic=10, resume=False, amp=True, fraction=1.0, profile=False, fre
eze=None, multi_scale=False, overlap_mask=True, mask_ratio=4, dropout=0.0, val=Tr
ue, split=val, save_json=False, save_hybrid=False, conf=None, iou=0.7, max_det=30
0, half=False, dnn=False, plots=True, source=None, vid_stride=1, stream_buffer=Fa
lse, visualize=False, augment=False, agnostic_nms=False, classes=None, retina_mas
ks=False, embed=None, show=False, save_frames=False, save_txt=False, save_conf=Fa
lse, save_crop=False, show_labels=True, show_conf=True, show_boxes=True, line_wid
th=None, format=torchscript, keras=False, optimize=False, int8=False, dynamic=Fa
lse, simplify=True, opset=None, workspace=None, nms=False, lr0=0.01, lrf=0.01, mom
entum=0.937, weight_decay=0.0005, warmup_epochs=3.0, warmup_momentum=0.8, warmup_
bias_lr=0.1, box=7.5, cls=0.5, df1=1.5, pose=12.0, kobj=1.0, nbs=64, hsv_h=0.015,
hsv_s=0.7, hsv_v=0.4, degrees=0.0, translate=0.1, scale=0.5, shear=0.0, perspecti
ve=0.0, flipud=0.0, fliplr=0.5, bgr=0.0, mosaic=1.0, mixup=0.0, copy_paste=0.0, c
opy_paste_mode=flip, auto_augment=randaugment, erasing=0.4, crop_fraction=1.0, cf
g=None, tracker=botsort.yaml, save_dir=runs/detect/train9
Downloading https://ultralytics.com/assets/Arial.ttf to '/root/.config/Ultralytic
s/Arial.ttf'...
100% 755k/755k [00:00<00:00, 107MB/s]
Overriding model.yaml nc=80 with nc=1

```

	from	n	params	module
arguments				
0		-1	1	464 ultralytics.nn.modules.conv.Conv
[3, 16, 3, 2]				
1		-1	1	4672 ultralytics.nn.modules.conv.Conv
[16, 32, 3, 2]				
2		-1	1	6640 ultralytics.nn.modules.block.C3k2
[32, 64, 1, False, 0.25]				
3		-1	1	36992 ultralytics.nn.modules.conv.Conv
[64, 64, 3, 2]				
4		-1	1	26080 ultralytics.nn.modules.block.C3k2
[64, 128, 1, False, 0.25]				
5		-1	1	147712 ultralytics.nn.modules.conv.Conv
[128, 128, 3, 2]				
6		-1	1	87040 ultralytics.nn.modules.block.C3k2
[128, 128, 1, True]				
7		-1	1	295424 ultralytics.nn.modules.conv.Conv
[128, 256, 3, 2]				
8		-1	1	346112 ultralytics.nn.modules.block.C3k2
[256, 256, 1, True]				
9		-1	1	164608 ultralytics.nn.modules.block.SPPF
[256, 256, 5]				
10		-1	1	249728 ultralytics.nn.modules.block.C2PSA
[256, 256, 1]				
11		-1	1	0 torch.nn.modules.upsampling.Upsample
[None, 2, 'nearest']				
12		[-1, 6]	1	0 ultralytics.nn.modules.conv.Concat

```

[1]
13           -1  1    111296 ultralytics.nn.modules.block.C3k2
[384, 128, 1, False]
14           -1  1        0 torch.nn.modules.upsampling.Upsample
[None, 2, 'nearest']
15           [-1, 4] 1        0 ultralytics.nn.modules.conv.Concat
[1]
16           -1  1    32096 ultralytics.nn.modules.block.C3k2
[256, 64, 1, False]
17           -1  1    36992 ultralytics.nn.modules.conv.Conv
[64, 64, 3, 2]
18           [-1, 13] 1        0 ultralytics.nn.modules.conv.Concat
[1]
19           -1  1    86720 ultralytics.nn.modules.block.C3k2
[192, 128, 1, False]
20           -1  1   147712 ultralytics.nn.modules.conv.Conv
[128, 128, 3, 2]
21           [-1, 10] 1        0 ultralytics.nn.modules.conv.Concat
[1]
22           -1  1   378880 ultralytics.nn.modules.block.C3k2
[384, 256, 1, True]
23           [16, 19, 22] 1   430867 ultralytics.nn.modules.head.Detect
[1, [64, 128, 256]]
YOLOv1n summary: 319 layers, 2,590,035 parameters, 2,590,019 gradients, 6.4 GFLOPs

```

Transferred 448/499 items from pretrained weights

TensorBoard: Start with 'tensorboard --logdir runs/detect/train9', view at http://localhost:6006/

Freezing layer 'model.23.dfl.conv.weight'

AMP: running Automatic Mixed Precision (AMP) checks...

AMP: checks passed ✓

train: Scanning /content/gdrive/MyDrive/yolov11/ultralytics/brain_tumor_dataset_new_yolo/train/labels.cache... 210 images, 0 backgrounds, 0 corrupt: 100% 210/210 [00:00<?, ?it/s]

/usr/local/lib/python3.10/dist-packages/albumenations/__init__.py:24: UserWarning: A new version of Albumenations is available: 1.4.21 (you have 1.4.20). Upgrade using: pip install -U albumenations. To disable automatic update checks, set the environment variable NO_ALBUMENATIONS_UPDATE to 1.

check_for_updates()

albumenations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01, blur_limit=(3, 7)), ToGray(p=0.01, num_output_channels=3, method='weighted_average'), CLAHE(p=0.01, clip_limit=(1.0, 4.0), tile_grid_size=(8, 8))

val: Scanning /content/gdrive/MyDrive/yolov11/ultralytics/brain_tumor_dataset_new_yolo/valid/labels.cache... 60 images, 1 backgrounds, 0 corrupt: 100% 60/60 [00:00<?, ?it/s]

Plotting labels to runs/detect/train9/labels.jpg...

optimizer: 'optimizer=auto' found, ignoring 'lr0=0.01' and 'momentum=0.937' and determining best 'optimizer', 'lr0' and 'momentum' automatically...

optimizer: AdamW(lr=0.002, momentum=0.9) with parameter groups 81 weight(decay=0.0), 88 weight(decay=0.0005), 87 bias(decay=0.0)

TensorBoard: model graph visualization added ✓

Image sizes 640 train, 640 val

Using 8 dataloader workers

Logging results to runs/detect/train9

Starting training for 10 epochs...

Closing dataloader mosaic

albumenations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01, blur_limit=(3, 7)), ToGray(p=0.01, num_output_channels=3, method='weighted_average'), CLAHE(p=0.01, clip_limit=(1.0, 4.0), tile_grid_size=(8, 8))

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
1/10	2.51G	1.885	4.33	2.027	2	640: 10
0% 14/14 [00:04<00:00, 3.15it/s]						
Class	Images	Instances		Box(P)	R	mAP50 mA
P50-95): 100%	2/2 [00:10<00:00, 5.02s/it]					
all	60	59	0.00311	0.949	0.207	
0.0754						
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
2/10	2.49G	2.003	3.548	1.681	2	640: 10
0% 14/14 [00:01<00:00, 7.81it/s]						
Class	Images	Instances		Box(P)	R	mAP50 mA
P50-95): 100%	2/2 [00:00<00:00, 6.31it/s]					
all	60	59	1	0.182	0.567	
0.213						
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
3/10	2.49G	1.931	3.093	1.606	2	640: 10
0% 14/14 [00:01<00:00, 8.12it/s]						
Class	Images	Instances		Box(P)	R	mAP50 mA
P50-95): 100%	2/2 [00:00<00:00, 6.89it/s]					
all	60	59	0.898	0.203	0.473	
0.175						
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
4/10	2.5G	1.935	2.954	1.62	2	640: 10
0% 14/14 [00:01<00:00, 8.45it/s]						
Class	Images	Instances		Box(P)	R	mAP50 mA
P50-95): 100%	2/2 [00:00<00:00, 6.00it/s]					
all	60	59	0.907	0.373	0.559	
0.242						
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
5/10	2.49G	1.968	2.81	1.703	2	640: 10
0% 14/14 [00:01<00:00, 8.32it/s]						
Class	Images	Instances		Box(P)	R	mAP50 mA
P50-95): 100%	2/2 [00:00<00:00, 6.94it/s]					
all	60	59	0.89	0.412	0.616	
0.28						
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
6/10	2.5G	1.836	2.564	1.563	2	640: 10
0% 14/14 [00:01<00:00, 8.91it/s]						
Class	Images	Instances		Box(P)	R	mAP50 mA
P50-95): 100%	2/2 [00:00<00:00, 6.74it/s]					
all	60	59	0.837	0.576	0.675	
0.298						
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
7/10	2.5G	1.755	2.402	1.562	2	640: 10
0% 14/14 [00:01<00:00, 8.68it/s]						
Class	Images	Instances		Box(P)	R	mAP50 mA
P50-95): 100%	2/2 [00:00<00:00, 5.84it/s]					
all	60	59	0.861	0.678	0.732	
0.31						
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
8/10	2.5G	1.702	2.323	1.495	2	640: 10
0% 14/14 [00:01<00:00, 8.24it/s]						

	Class	Images	Instances	Box(P)	R	mAP50	mA
P50-95): 100% 2/2 [00:00<00:00, 6.25it/s]	all	60	59	0.887	0.662	0.77	
0.325							
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size	
9/10	2.5G	1.763	2.271	1.552	2	640:	10
0% 14/14 [00:01<00:00, 8.87it/s]	Class	Images	Instances	Box(P)	R	mAP50	mA
P50-95): 100% 2/2 [00:00<00:00, 6.81it/s]	all	60	59	0.898	0.746	0.817	
0.324							
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size	
10/10	2.5G	1.685	2.148	1.479	2	640:	10
0% 14/14 [00:01<00:00, 8.72it/s]	Class	Images	Instances	Box(P)	R	mAP50	mA
P50-95): 100% 2/2 [00:00<00:00, 6.82it/s]	all	60	59	0.877	0.814	0.876	
0.376							

10 epochs completed in 0.013 hours.

Optimizer stripped from runs/detect/train9/weights/last.pt, 5.5MB

Optimizer stripped from runs/detect/train9/weights/best.pt, 5.5MB

Validating runs/detect/train9/weights/best.pt...

Ultralytics 8.3.39 🚀 Python-3.10.12 torch-2.5.1+cu121 CUDA:0 (NVIDIA L4, 22700M iB)

YOLOv11n summary (fused): 238 layers, 2,582,347 parameters, 0 gradients, 6.3 GFLOPs

	Class	Images	Instances	Box(P)	R	mAP50	mA
P50-95): 100% 2/2 [00:00<00:00, 5.55it/s]	all	60	59	0.88	0.814	0.876	

0.377

Speed: 0.2ms preprocess, 1.0ms inference, 0.0ms loss, 1.8ms postprocess per image

Results saved to `runs/detect/train9`

💡 Learn more at <https://docs.ultralytics.com/modes/train>

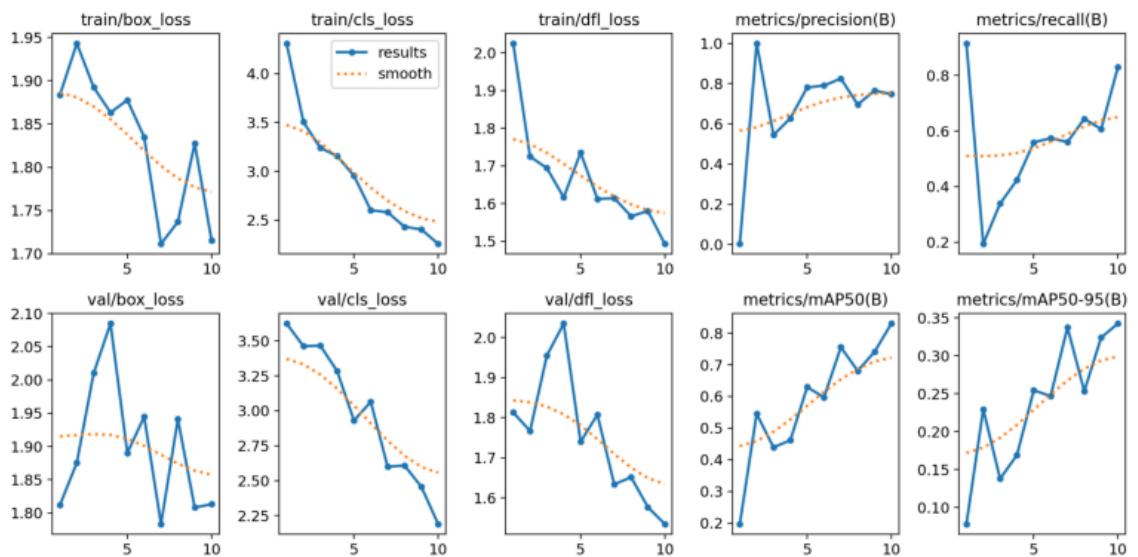
```
In [ ]: from PIL import Image
import matplotlib.pyplot as plt

# Define the path to the results image
img_path = "/content/gdrive/MyDrive/yolov11/ultralytics/runs/detect/train8/resul

# Load and display the image
img = Image.open(img_path)

plt.figure(figsize=(10, 10))
plt.imshow(img)
plt.axis("off")
plt.title("Training Results Overview")
plt.show()
```

Training Results Overview



```
In [ ]: import pandas as pd

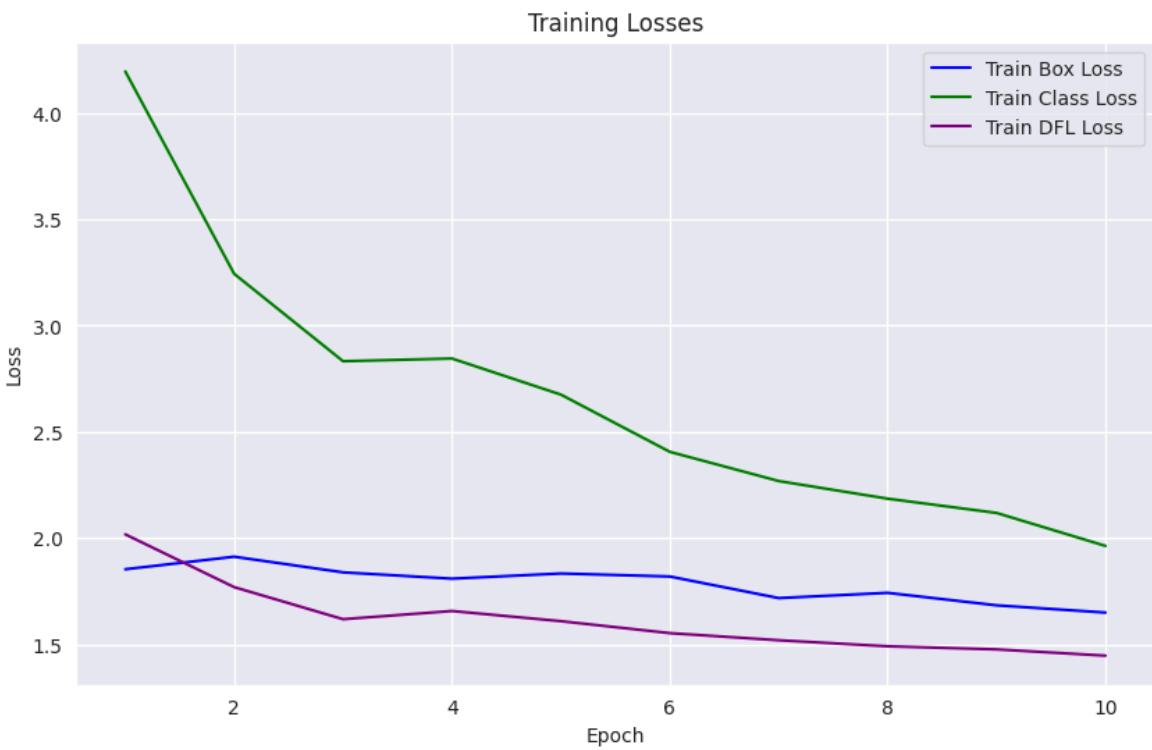
# Path to the results.csv file
csv_path = "/content/gdrive/MyDrive/yolov11/ultralytics/runs/detect/train8/resul

# Load the CSV
df = pd.read_csv(csv_path)

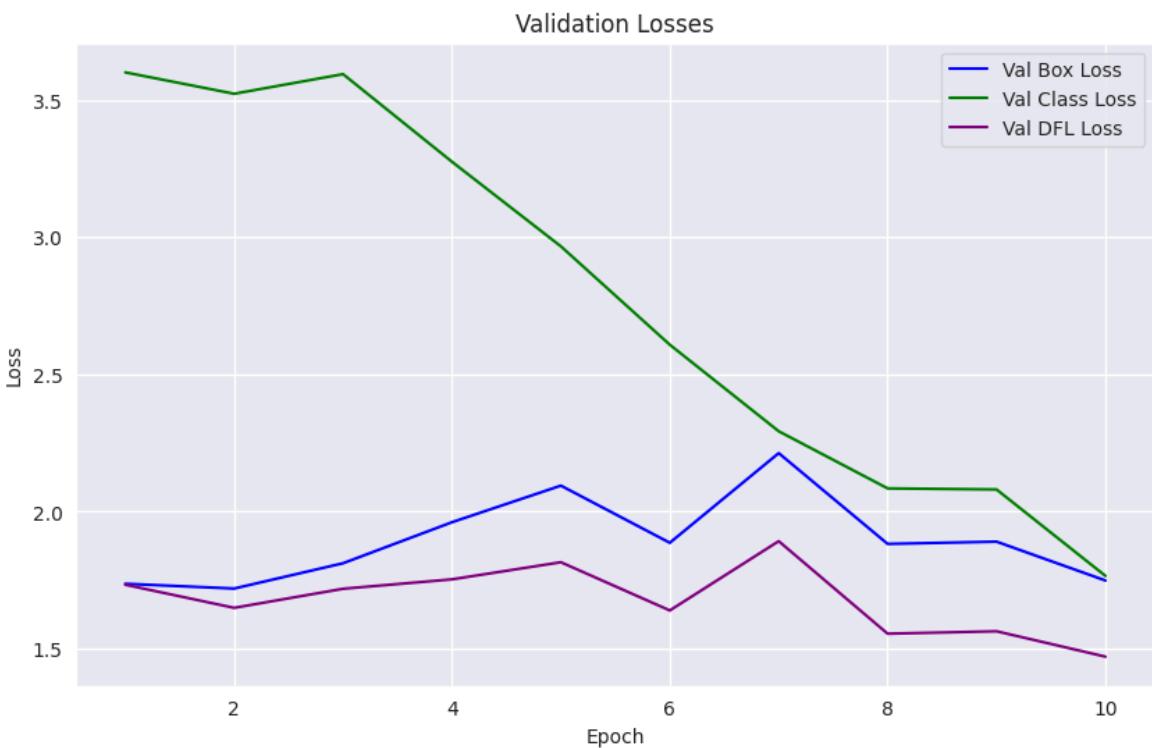
# Display the columns
print("Available columns in results.csv:")
print(df.columns)
```

```
Available columns in results.csv:
Index(['epoch', 'time', 'train/box_loss', 'train/cls_loss', 'train/dfl_loss',
       'metrics/precision(B)', 'metrics/recall(B)', 'metrics/mAP50(B)',
       'metrics/mAP50-95(B)', 'val/box_loss', 'val/cls_loss', 'val/dfl_loss',
       'lr/pg0', 'lr/pg1', 'lr/pg2'],
      dtype='object')
```

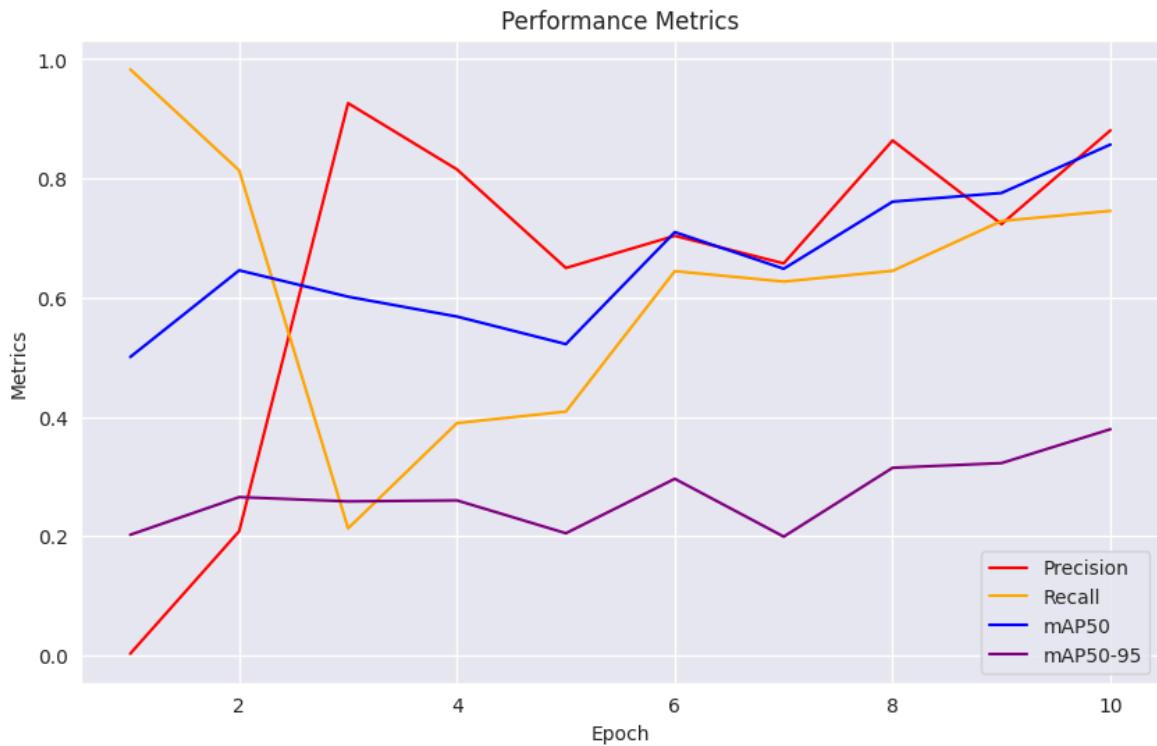
```
In [ ]: # Plot training losses
plt.figure(figsize=(10, 6))
plt.plot(df['epoch'], df['train/box_loss'], label='Train Box Loss', color='blue')
plt.plot(df['epoch'], df['train/cls_loss'], label='Train Class Loss', color='green')
plt.plot(df['epoch'], df['train/dfl_loss'], label='Train DFL Loss', color='purple')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Training Losses')
plt.legend()
plt.grid(True)
plt.show()
```



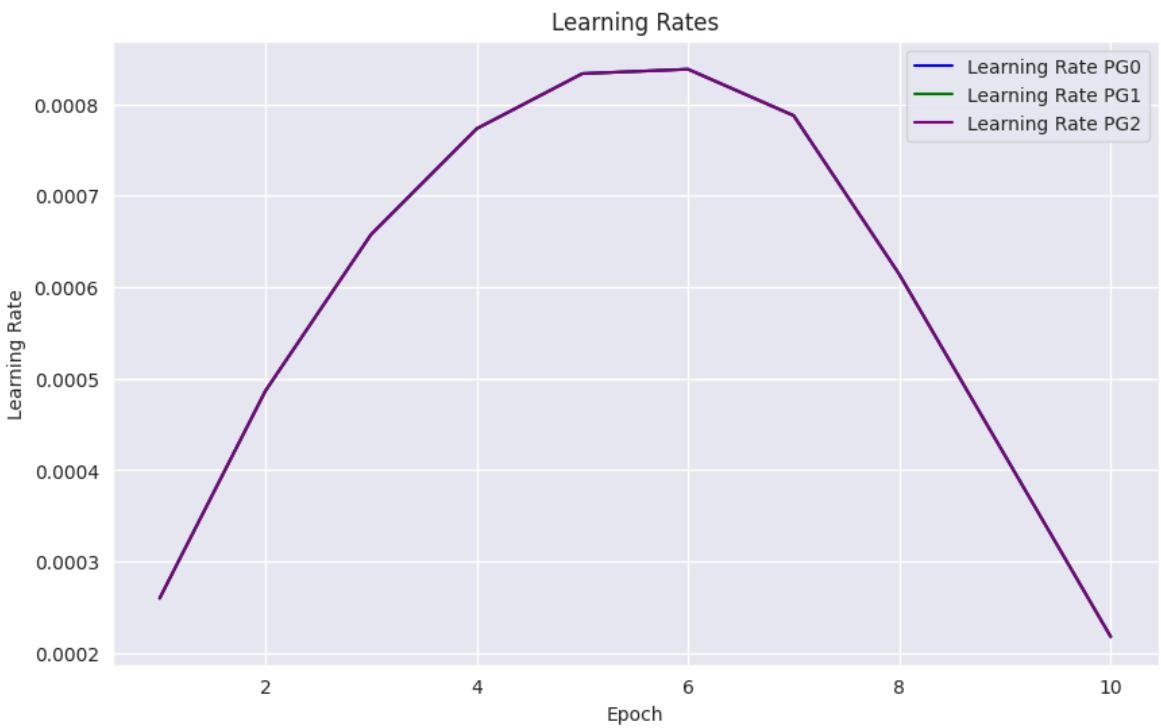
```
In [ ]: # Plot validation losses
plt.figure(figsize=(10, 6))
plt.plot(df['epoch'], df['val/box_loss'], label='Val Box Loss', color='blue')
plt.plot(df['epoch'], df['val/cls_loss'], label='Val Class Loss', color='green')
plt.plot(df['epoch'], df['val/dfl_loss'], label='Val DFL Loss', color='purple')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Validation Losses')
plt.legend()
plt.grid(True)
plt.show()
```



```
In [ ]: # Plot precision, recall, and mAP metrics
plt.figure(figsize=(10, 6))
plt.plot(df['epoch'], df['metrics/precision(B)'], label='Precision', color='red')
plt.plot(df['epoch'], df['metrics/recall(B)'], label='Recall', color='orange')
plt.plot(df['epoch'], df['metrics/mAP50(B)'], label='mAP50', color='blue')
plt.plot(df['epoch'], df['metrics/mAP50-95(B)'], label='mAP50-95', color='purple')
plt.xlabel('Epoch')
plt.ylabel('Metrics')
plt.title('Performance Metrics')
plt.legend()
plt.grid(True)
plt.show()
```



```
In [ ]: # Plot learning rates
plt.figure(figsize=(10, 6))
plt.plot(df['epoch'], df['lr/pg0'], label='Learning Rate PG0', color='blue')
plt.plot(df['epoch'], df['lr/pg1'], label='Learning Rate PG1', color='green')
plt.plot(df['epoch'], df['lr/pg2'], label='Learning Rate PG2', color='purple')
plt.xlabel('Epoch')
plt.ylabel('Learning Rate')
plt.title('Learning Rates')
plt.legend()
plt.grid(True)
plt.show()
```

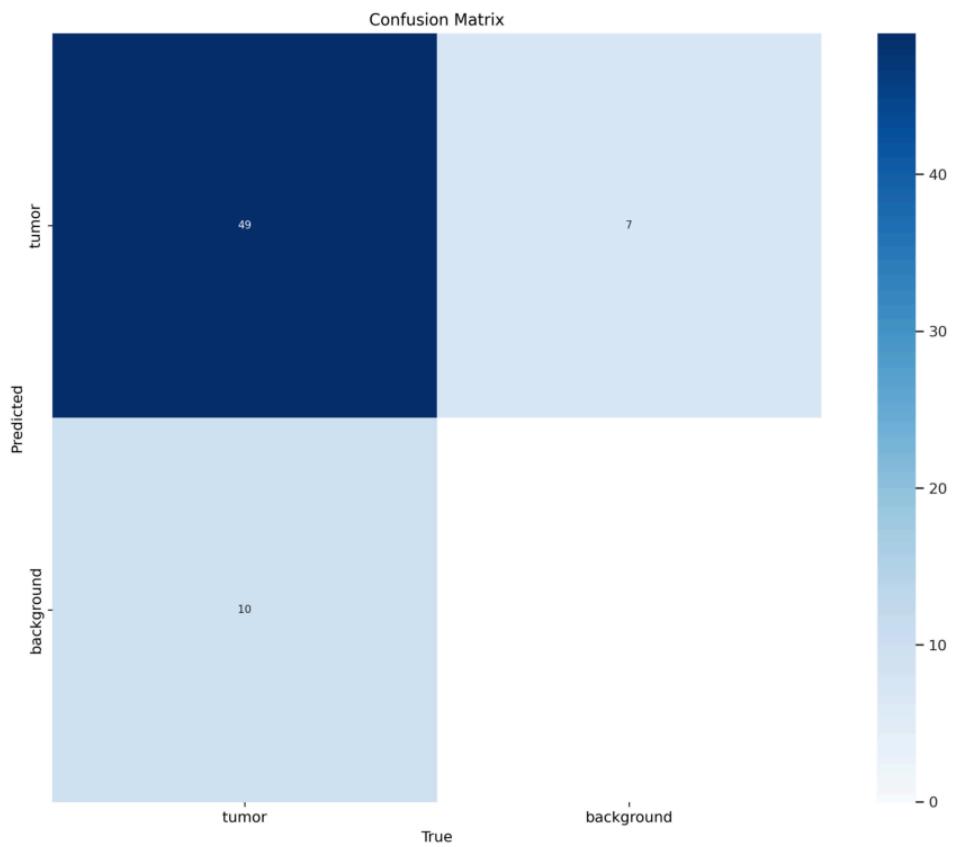


```
In [ ]: def imshow(path):
    import cv2
    import matplotlib.pyplot as plt
    %matplotlib inline

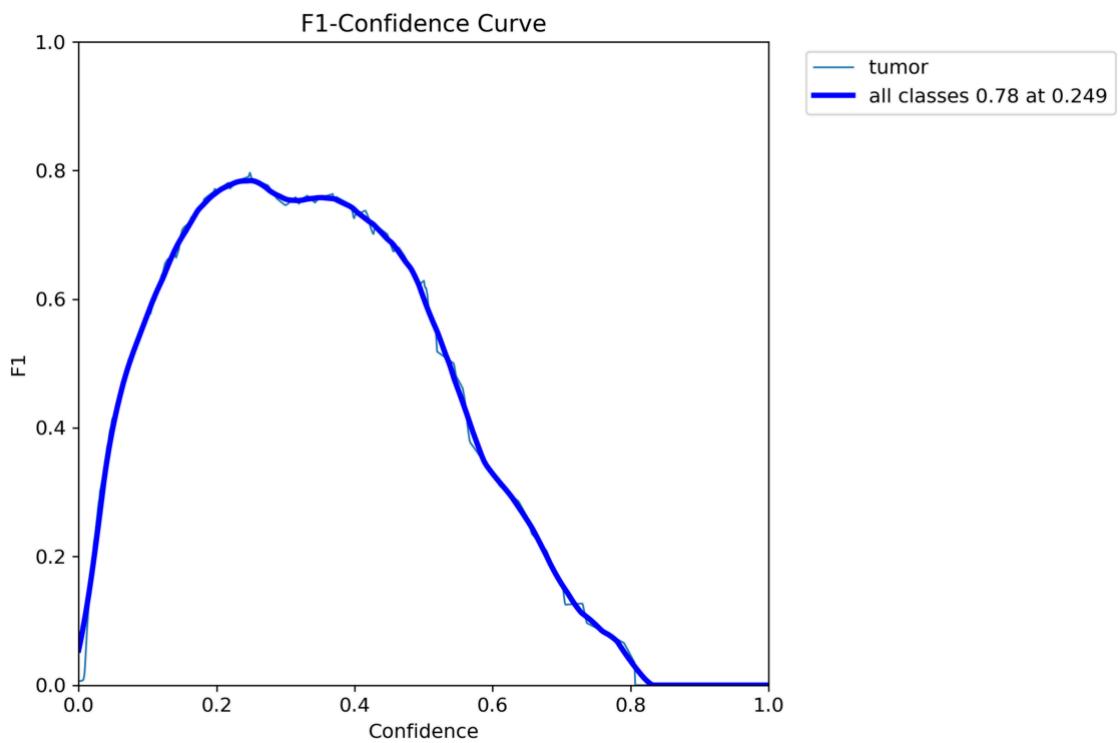
    image = cv2.imread(path)
    height, width = image.shape[:2]
    resized_image = cv2.resize(image,(3*width, 3*height),
                               interpolation = cv2.INTER_CUBIC)

    fig = plt.gcf()
    fig.set_size_inches(18, 10)
    plt.axis("off")
    plt.imshow(cv2.cvtColor(resized_image, cv2.COLOR_BGR2RGB))
    plt.show()
```

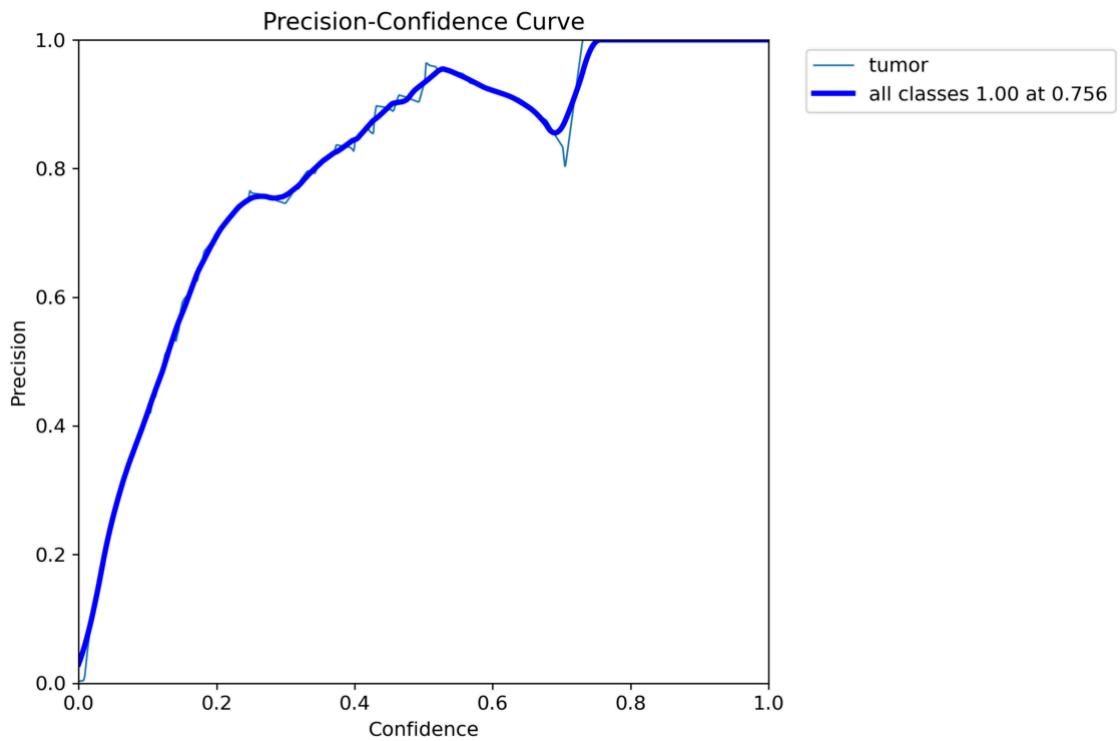
```
In [ ]: imshow("runs/detect/train8/confusion_matrix.png")
```



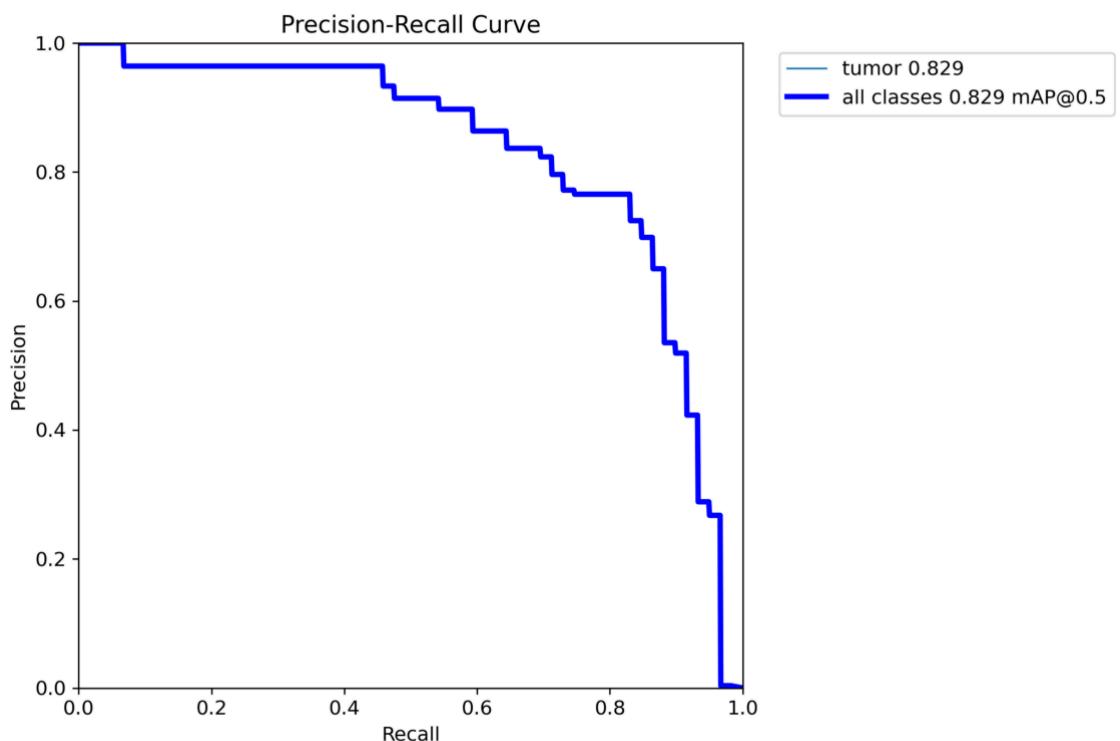
```
In [ ]: imshow("runs/detect/train8/F1_curve.png")
```



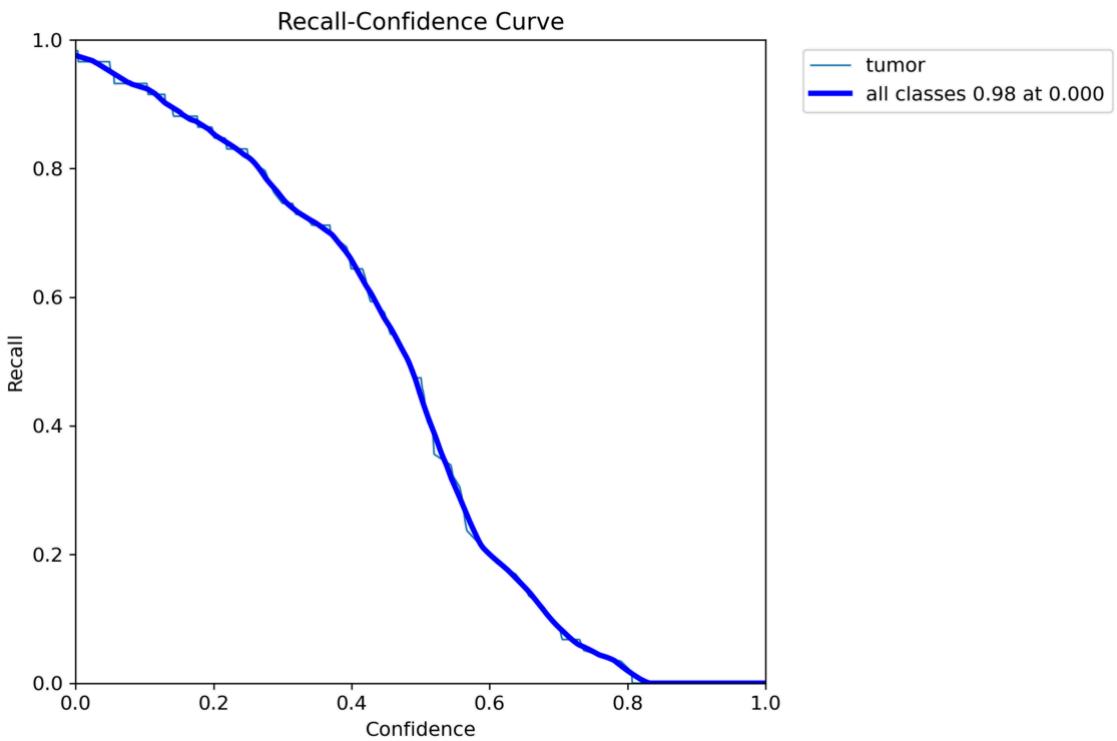
```
In [ ]: imshow("runs/detect/train8/P_curve.png")
```



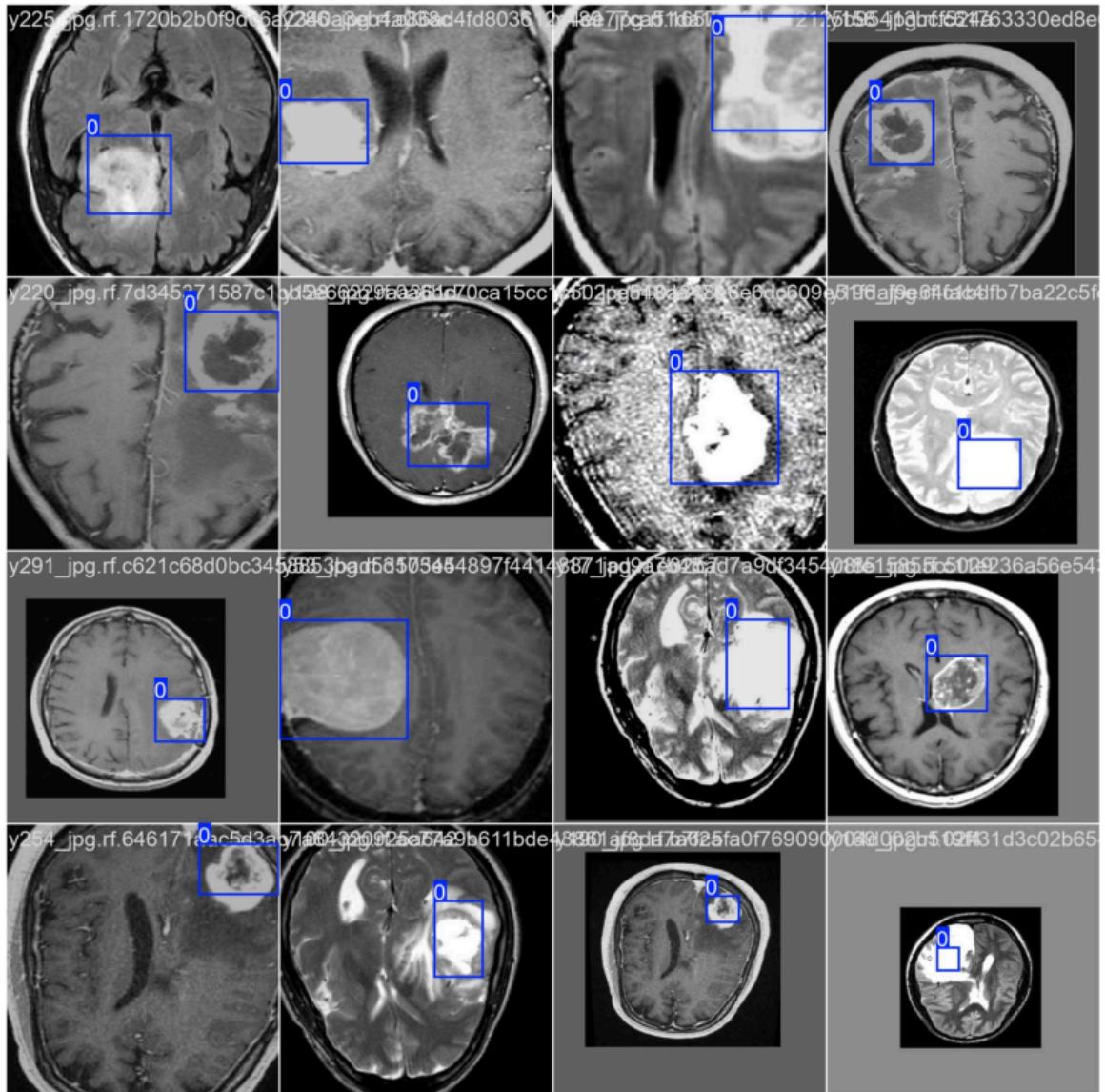
```
In [ ]: imshow("runs/detect/train8/PR_curve.png")
```



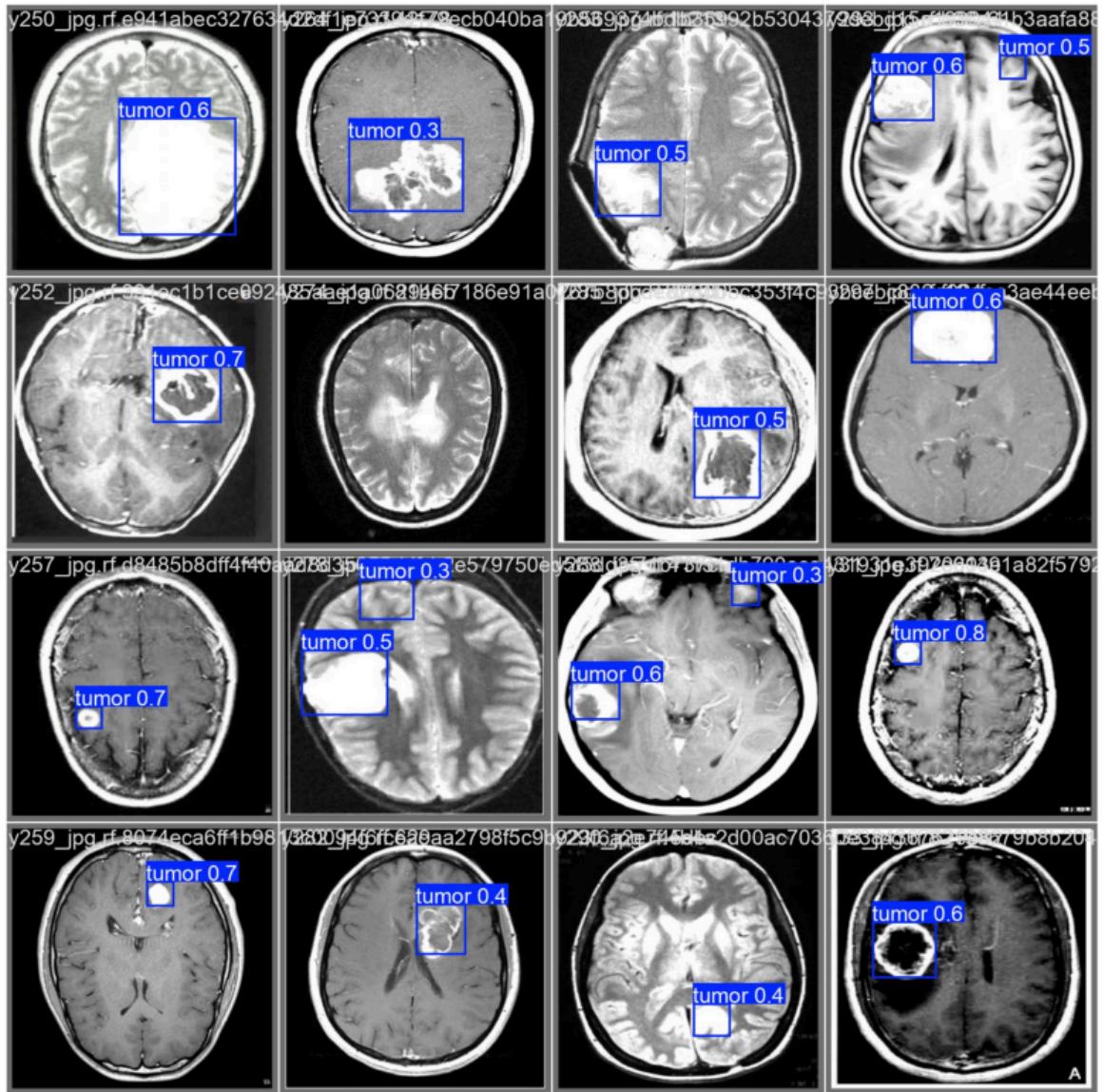
```
In [ ]: imshow("runs/detect/train8/R_curve.png")
```



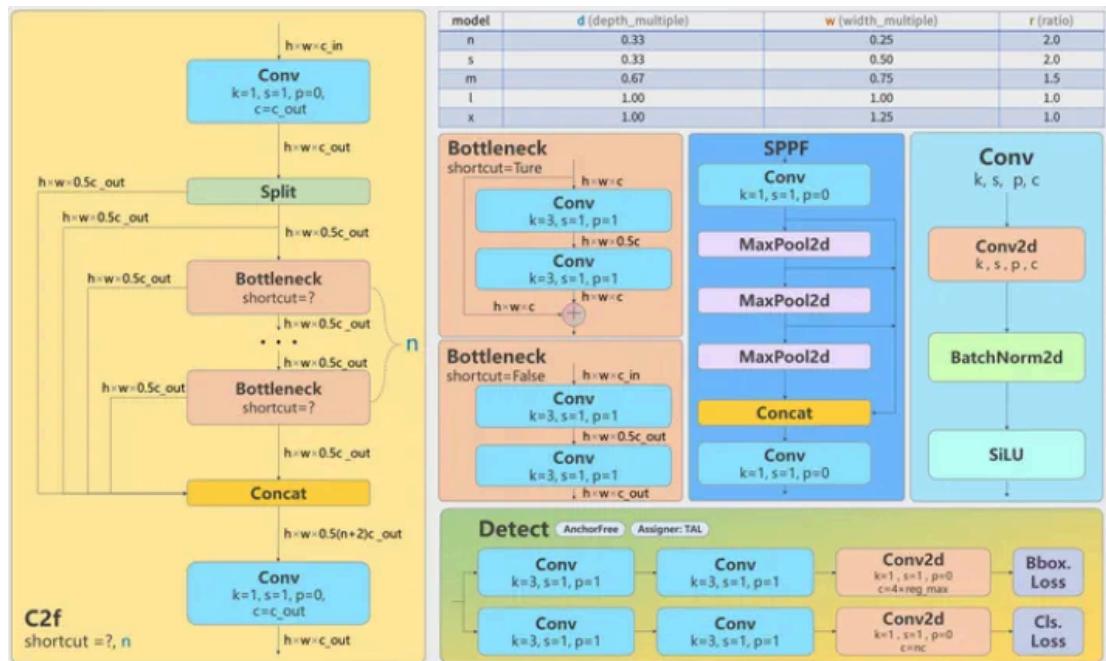
```
In [ ]: imshow("runs/detect/train8/train_batch2.jpg")
```



```
In [ ]: imshow("runs/detect/train8/val_batch1_pred.jpg")
```



Object Detection using YOLO8*



```
In [ ]: from google.colab import drive  
drive.mount('/content/gdrive/')

Drive already mounted at /content/gdrive/; to attempt to forcibly remount, call d
rive.mount("/content/gdrive/", force_remount=True).

In [10]: %cd /content/gdrive/MyDrive  
  
/content/gdrive/MyDrive

In [11]: import os  
if not os.path.isdir("yolov8"):  
    os.makedirs("yolov8")

In [12]: %cd yolov8  
  
/content/gdrive/MyDrive/yolov8

In [ ]: !git clone https://github.com/ultralytics/ultralytics.git  
  
fatal: destination path 'ultralytics' already exists and is not an empty director
y.

In [13]: %cd ultralytics  
  
/content/gdrive/MyDrive/yolov8/ultralytics

In [ ]: !pip install ultralytics
```

```
Requirement already satisfied: ultralytics in /usr/local/lib/python3.10/dist-packages (8.3.39)
Requirement already satisfied: numpy>=1.23.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (1.26.4)
Requirement already satisfied: matplotlib>=3.3.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (3.8.0)
Requirement already satisfied: opencv-python>=4.6.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (4.10.0.84)
Requirement already satisfied: pillow>=7.1.2 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (11.0.0)
Requirement already satisfied: pyyaml>=5.3.1 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (6.0.2)
Requirement already satisfied: requests>=2.23.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (2.32.3)
Requirement already satisfied: scipy>=1.4.1 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (1.13.1)
Requirement already satisfied: torch>=1.8.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (2.5.1+cu121)
Requirement already satisfied: torchvision>=0.9.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (0.20.1+cu121)
Requirement already satisfied: tqdm>=4.64.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (4.66.6)
Requirement already satisfied: psutil in /usr/local/lib/python3.10/dist-packages (from ultralytics) (5.9.5)
Requirement already satisfied: py-cpuinfo in /usr/local/lib/python3.10/dist-packages (from ultralytics) (9.0.0)
Requirement already satisfied: pandas>=1.1.4 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (2.2.2)
Requirement already satisfied: seaborn>=0.11.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (0.13.2)
Requirement already satisfied: ultralytics-thop>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from ultralytics) (2.0.12)
Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.3.0->ultralytics) (1.3.1)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.3.0->ultralytics) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.3.0->ultralytics) (4.55.0)
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.3.0->ultralytics) (1.4.7)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.3.0->ultralytics) (24.2)
Requirement already satisfied: pyparsing>=2.3.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.3.0->ultralytics) (3.2.0)
Requirement already satisfied: python-dateutil>=2.7 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.3.0->ultralytics) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-packages (from pandas>=1.1.4->ultralytics) (2024.2)
Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.10/dist-packages (from pandas>=1.1.4->ultralytics) (2024.2)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.10/dist-packages (from requests>=2.23.0->ultralytics) (3.4.0)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests>=2.23.0->ultralytics) (3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests>=2.23.0->ultralytics) (2.2.3)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests>=2.23.0->ultralytics) (2024.8.30)
Requirement already satisfied: filelock in /usr/local/lib/python3.10/dist-packages (from torch>=1.8.0->ultralytics) (3.16.1)
```

```
Requirement already satisfied: typing-extensions>=4.8.0 in /usr/local/lib/python3.10/dist-packages (from torch>=1.8.0->ultralytics) (4.12.2)
Requirement already satisfied: networkx in /usr/local/lib/python3.10/dist-packages (from torch>=1.8.0->ultralytics) (3.4.2)
Requirement already satisfied: jinja2 in /usr/local/lib/python3.10/dist-packages (from torch>=1.8.0->ultralytics) (3.1.4)
Requirement already satisfied: fsspec in /usr/local/lib/python3.10/dist-packages (from torch>=1.8.0->ultralytics) (2024.10.0)
Requirement already satisfied: sympy==1.13.1 in /usr/local/lib/python3.10/dist-packages (from torch>=1.8.0->ultralytics) (1.13.1)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in /usr/local/lib/python3.10/dist-packages (from sympy==1.13.1->torch>=1.8.0->ultralytics) (1.3.0)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.7->matplotlib>=3.3.0->ultralytics) (1.16.0)
Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.10/dist-packages (from jinja2->torch>=1.8.0->ultralytics) (3.0.2)
```

```
In [14]: !wget -O yolov8n.pt https://github.com/ultralytics/assets/releases/download/v0.0
--2024-11-29 16:51:29--  https://github.com/ultralytics/assets/releases/download/v0.0/yolov8n.pt
Resolving github.com (github.com)... 20.205.243.166
Connecting to github.com (github.com)|20.205.243.166|:443... connected.
HTTP request sent, awaiting response... 302 Found
Location: https://objects.githubusercontent.com/github-production-release-asset-2e65be/521807533/732c503e-9fcf-4a82-be7f-106baafbd15?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=releaseassetproduction%2F20241129%2Fs-east-1%2Fs3%2Faws4_request&X-Amz-Date=20241129T165129Z&X-Amz-Expires=300&X-Amz-Signature=77ec12c033fd0beed16b822bc4c29ecd1467109ae33a15f68c65b9e228da3a37&X-Amz-SignedHeaders=host&response-content-disposition=attachment%3B%20filename%3Dyolov8n.pt&response-content-type=application%2Foctet-stream [following]
--2024-11-29 16:51:29--  https://objects.githubusercontent.com/github-production-release-asset-2e65be/521807533/732c503e-9fcf-4a82-be7f-106baafbd15?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=releaseassetproduction%2F20241129%2Fs-east-1%2Fs3%2Faws4_request&X-Amz-Date=20241129T165129Z&X-Amz-Expires=300&X-Amz-Signature=77ec12c033fd0beed16b822bc4c29ecd1467109ae33a15f68c65b9e228da3a37&X-Amz-SignedHeaders=host&response-content-disposition=attachment%3B%20filename%3Dyolov8n.pt&response-content-type=application%2Foctet-stream
Resolving objects.githubusercontent.com (objects.githubusercontent.com)... 185.199.108.133, 185.199.109.133, 185.199.110.133, ...
Connecting to objects.githubusercontent.com (objects.githubusercontent.com)|185.199.108.133|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 6534387 (6.2M) [application/octet-stream]
Saving to: 'yolov8n.pt'

yolov8n.pt      100%[=====] 6.23M  --.-KB/s   in 0.06s

2024-11-29 16:51:30 (111 MB/s) - 'yolov8n.pt' saved [6534387/6534387]
```

```
In [15]: !yolo detect train data=brain_data.yaml model=yolov8n.pt epochs=10 imgsze=640
```

Ultralytics 8.3.39 🎨 Python-3.10.12 torch-2.5.1+cu121 CUDA:0 (NVIDIA L4, 22700M iB)

engine/trainer: task=detect, mode=train, model=yolov8n.pt, data=brain_data.yaml, epochs=10, time=None, patience=100, batch=16, imgsz=640, save=True, save_period=-1, cache=False, device=None, workers=8, project=None, name=train5, exist_ok=False, pretrained=True, optimizer=auto, verbose=True, seed=0, deterministic=True, single_cls=False, rect=False, cos_lr=False, close_mosaic=10, resume=False, amp=True, fraction=1.0, profile=False, freeze=None, multi_scale=False, overlap_mask=True, mask_ratio=4, dropout=0.0, val=True, split=val, save_json=False, save_hybrid=False, conf=None, iou=0.7, max_det=300, half=False, dnn=False, plots=True, source=None, vid_stride=1, stream_buffer=False, visualize=False, augment=False, agnostic_nms=False, classes=None, retina_masks=False, embed=None, show=False, save_frames=False, save_txt=False, save_conf=False, save_crop=False, show_labels=True, show_conf=True, show_boxes=True, line_width=None, format=torchscript, keras=False, optimize=False, int8=False, dynamic=False, simplify=True, opset=None, workspace=None, nms=False, lr0=0.01, lrf=0.01, momentum=0.937, weight_decay=0.0005, warmup_epochs=3.0, warmup_momentum=0.8, warmup_bias_lr=0.1, box=7.5, cls=0.5, df1=1.5, pose=12.0, kobj=1.0, nbs=64, hsv_h=0.015, hsv_s=0.7, hsv_v=0.4, degrees=0.0, translate=0.1, scale=0.5, shear=0.0, perspective=0.0, flipud=0.0, fliplr=0.5, bgr=0.0, mosaic=1.0, mixup=0.0, copy_paste=0.0, copy_paste_mode=flip, auto_augment=randaugment, erasing=0.4, crop_fraction=1.0, cfg=None, tracker=botsort.yaml, save_dir=runs/detect/train5

Overriding model.yaml nc=80 with nc=1

	from	n	params	module
arguments				
0		-1	1	464 ultralytics.nn.modules.conv.Conv
[3, 16, 3, 2]				
1		-1	1	4672 ultralytics.nn.modules.conv.Conv
[16, 32, 3, 2]				
2		-1	1	7360 ultralytics.nn.modules.block.C2f
[32, 32, 1, True]				
3		-1	1	18560 ultralytics.nn.modules.conv.Conv
[32, 64, 3, 2]				
4		-1	2	49664 ultralytics.nn.modules.block.C2f
[64, 64, 2, True]				
5		-1	1	73984 ultralytics.nn.modules.conv.Conv
[64, 128, 3, 2]				
6		-1	2	197632 ultralytics.nn.modules.block.C2f
[128, 128, 2, True]				
7		-1	1	295424 ultralytics.nn.modules.conv.Conv
[128, 256, 3, 2]				
8		-1	1	460288 ultralytics.nn.modules.block.C2f
[256, 256, 1, True]				
9		-1	1	164608 ultralytics.nn.modules.block.SPPF
[256, 256, 5]				
10		-1	1	0 torch.nn.modules.upsampling.Upsample
[None, 2, 'nearest']				
11		[-1, 6]	1	0 ultralytics.nn.modules.conv.Concat
[1]				
12		-1	1	148224 ultralytics.nn.modules.block.C2f
[384, 128, 1]				
13		-1	1	0 torch.nn.modules.upsampling.Upsample
[None, 2, 'nearest']				
14		[-1, 4]	1	0 ultralytics.nn.modules.conv.Concat
[1]				
15		-1	1	37248 ultralytics.nn.modules.block.C2f
[192, 64, 1]				
16		-1	1	36992 ultralytics.nn.modules.conv.Conv
[64, 64, 3, 2]				

```

17           [-1, 12] 1          0 ultralytics.nn.modules.conv.Concat
[1]
18           -1 1    123648 ultralytics.nn.modules.block.C2f
[192, 128, 1]
19           -1 1    147712 ultralytics.nn.modules.conv.Conv
[128, 128, 3, 2]
20           [-1, 9] 1          0 ultralytics.nn.modules.conv.Concat
[1]
21           -1 1    493056 ultralytics.nn.modules.block.C2f
[384, 256, 1]
22           [15, 18, 21] 1    751507 ultralytics.nn.modules.head.Detect
[1, [64, 128, 256]]
Model summary: 225 layers, 3,011,043 parameters, 3,011,027 gradients, 8.2 GFLOPs

```

Transferred 319/355 items from pretrained weights

TensorBoard: Start with 'tensorboard --logdir runs/detect/train5', view at <http://localhost:6006/>

Freezing layer 'model.22.dfl.conv.weight'

AMP: running Automatic Mixed Precision (AMP) checks...

AMP: checks passed ✓

train: Scanning /content/gdrive/MyDrive/yolov8/ultralytics/brain_tumor_dataset_new_yolo/train/labels.cache... 210 images, 0 backgrounds, 0 corrupt: 100% 210/210 [00:00<?, ?it/s]

/usr/local/lib/python3.10/dist-packages/albumentations/_init__.py:24: UserWarning: A new version of Albumentations is available: 1.4.21 (you have 1.4.20). Upgrade using: pip install -U albumentations. To disable automatic update checks, set the environment variable NO_ALBUMENTATIONS_UPDATE to 1.

check_for_updates()

albumentations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01, blur_limit=(3, 7)), ToGray(p=0.01, num_output_channels=3, method='weighted_average'), CLAHE(p=0.01, clip_limit=(1.0, 4.0), tile_grid_size=(8, 8))

val: Scanning /content/gdrive/MyDrive/yolov8/ultralytics/brain_tumor_dataset_new_yolo/valid/labels.cache... 60 images, 1 backgrounds, 0 corrupt: 100% 60/60 [00:00<?, ?it/s]

Plotting labels to runs/detect/train5/labels.jpg...

optimizer: 'optimizer=auto' found, ignoring 'lr0=0.01' and 'momentum=0.937' and determining best 'optimizer', 'lr0' and 'momentum' automatically...

optimizer: AdamW(lr=0.002, momentum=0.9) with parameter groups 57 weight(decay=0.0), 64 weight(decay=0.0005), 63 bias(decay=0.0)

TensorBoard: model graph visualization added ✓

Image sizes 640 train, 640 val

Using 8 dataloader workers

Logging results to runs/detect/train5

Starting training for 10 epochs...

Closing dataloader mosaic

albumentations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01, blur_limit=(3, 7)), ToGray(p=0.01, num_output_channels=3, method='weighted_average'), CLAHE(p=0.01, clip_limit=(1.0, 4.0), tile_grid_size=(8, 8))

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
1/10	2.28G	1.849	4.216	2.012	2	640: 10
0% 14/14 [00:03<00:00, 4.36it/s]						
	Class	Images	Instances	Box(P)	R	mAP50 mA
P50-95): 100% 2/2 [00:11<00:00, 5.91s/it]						
	all	60	59	0.00322	0.983	0.421
0.173						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
2/10	2.09G	1.908	3.187	1.752	2	640: 10
0% 14/14 [00:01<00:00, 9.44it/s]						

	Class	Images	Instances	Box(P)	R	mAP50	mA
P50-95): 100% 2/2 [00:00<00:00, 6.14it/s]							
0.232	all	60	59	0.867	0.22	0.508	
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size	
3/10	2.1G	1.843	2.856	1.588	2	640: 10	
0% 14/14 [00:01<00:00, 9.65it/s]							
0.197	Class	Images	Instances	Box(P)	R	mAP50	mA
P50-95): 100% 2/2 [00:00<00:00, 6.75it/s]							
0.248	all	60	59	0.888	0.135	0.521	
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size	
4/10	2.11G	1.893	2.717	1.629	2	640: 10	
0% 14/14 [00:01<00:00, 10.00it/s]							
0.301	Class	Images	Instances	Box(P)	R	mAP50	mA
P50-95): 100% 2/2 [00:00<00:00, 6.47it/s]							
0.272	all	60	59	0.837	0.435	0.641	
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size	
5/10	2.1G	1.804	2.593	1.61	2	640: 10	
0% 14/14 [00:01<00:00, 10.57it/s]							
0.327	Class	Images	Instances	Box(P)	R	mAP50	mA
P50-95): 100% 2/2 [00:00<00:00, 6.79it/s]							
0.329	all	60	59	0.89	0.627	0.786	
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size	
6/10	2.11G	1.82	2.337	1.549	2	640: 10	
0% 14/14 [00:01<00:00, 10.43it/s]							
0.327	Class	Images	Instances	Box(P)	R	mAP50	mA
P50-95): 100% 2/2 [00:00<00:00, 6.19it/s]							
0.379	all	60	59	0.69	0.559	0.639	
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size	
7/10	2.1G	1.661	2.253	1.546	2	640: 10	
0% 14/14 [00:01<00:00, 10.85it/s]							
0.329	Class	Images	Instances	Box(P)	R	mAP50	mA
P50-95): 100% 2/2 [00:00<00:00, 7.04it/s]							
0.379	all	60	59	0.833	0.712	0.765	
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size	
8/10	2.11G	1.666	2.158	1.482	2	640: 10	
0% 14/14 [00:01<00:00, 9.98it/s]							
0.379	Class	Images	Instances	Box(P)	R	mAP50	mA
P50-95): 100% 2/2 [00:00<00:00, 6.23it/s]							
0.379	all	60	59	0.844	0.712	0.774	
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size	
9/10	2.1G	1.734	2.084	1.53	2	640: 10	
0% 14/14 [00:01<00:00, 10.63it/s]							
0.379	Class	Images	Instances	Box(P)	R	mAP50	mA
P50-95): 100% 2/2 [00:00<00:00, 6.08it/s]							
0.379	all	60	59	0.789	0.826	0.837	

```

Epoch      GPU_mem    box_loss    cls_loss    dfl_loss    Instances    Size
10/10      2.11G      1.668      2.014      1.48        2           640: 10
0% 14/14 [00:01<00:00, 10.65it/s]
          Class      Images    Instances    Box(P)      R      mAP50   mA
P50-95): 100% 2/2 [00:00<00:00, 6.21it/s]
          all       60         59        0.847      0.844      0.905
0.395

```

10 epochs completed in 0.012 hours.

Optimizer stripped from runs/detect/train5/weights/last.pt, 6.2MB
 Optimizer stripped from runs/detect/train5/weights/best.pt, 6.2MB

Validating runs/detect/train5/weights/best.pt...

Ultralytics 8.3.39 🚀 Python-3.10.12 torch-2.5.1+cu121 CUDA:0 (NVIDIA L4, 22700M iB)

```

Model summary (fused): 168 layers, 3,005,843 parameters, 0 gradients, 8.1 GFLOPs
          Class      Images    Instances    Box(P)      R      mAP50   mA
P50-95): 100% 2/2 [00:00<00:00, 5.63it/s]
          all       60         59        0.847      0.842      0.905
0.399

```

Speed: 0.2ms preprocess, 0.9ms inference, 0.0ms loss, 1.8ms postprocess per image
 Results saved to runs/detect/train5

💡 Learn more at <https://docs.ultralytics.com/modes/train>

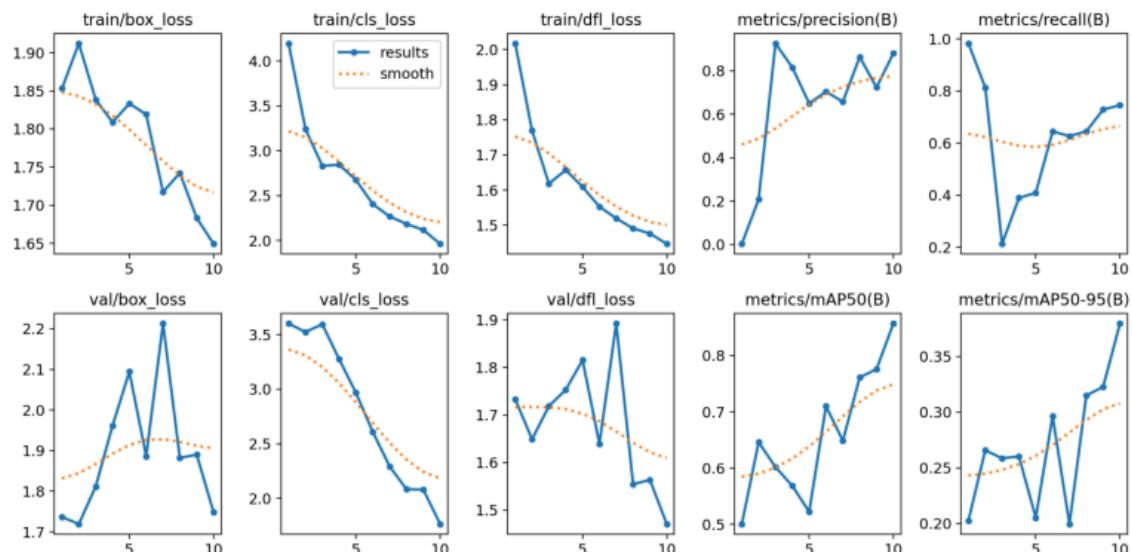
```
In [ ]: from PIL import Image
import matplotlib.pyplot as plt

# Define the path to the results image
img_path = "/content/gdrive/MyDrive/yolov8/ultralytics/runs/detect/train3/result"

# Load and display the image
img = Image.open(img_path)

plt.figure(figsize=(10, 10))
plt.imshow(img)
plt.axis("off")
plt.title("Training Results Overview")
plt.show()
```

Training Results Overview



```
In [ ]: import pandas as pd

# Path to the results.csv file
csv_path = "/content/gdrive/MyDrive/yolov8/ultralytics/runs/detect/train3/result

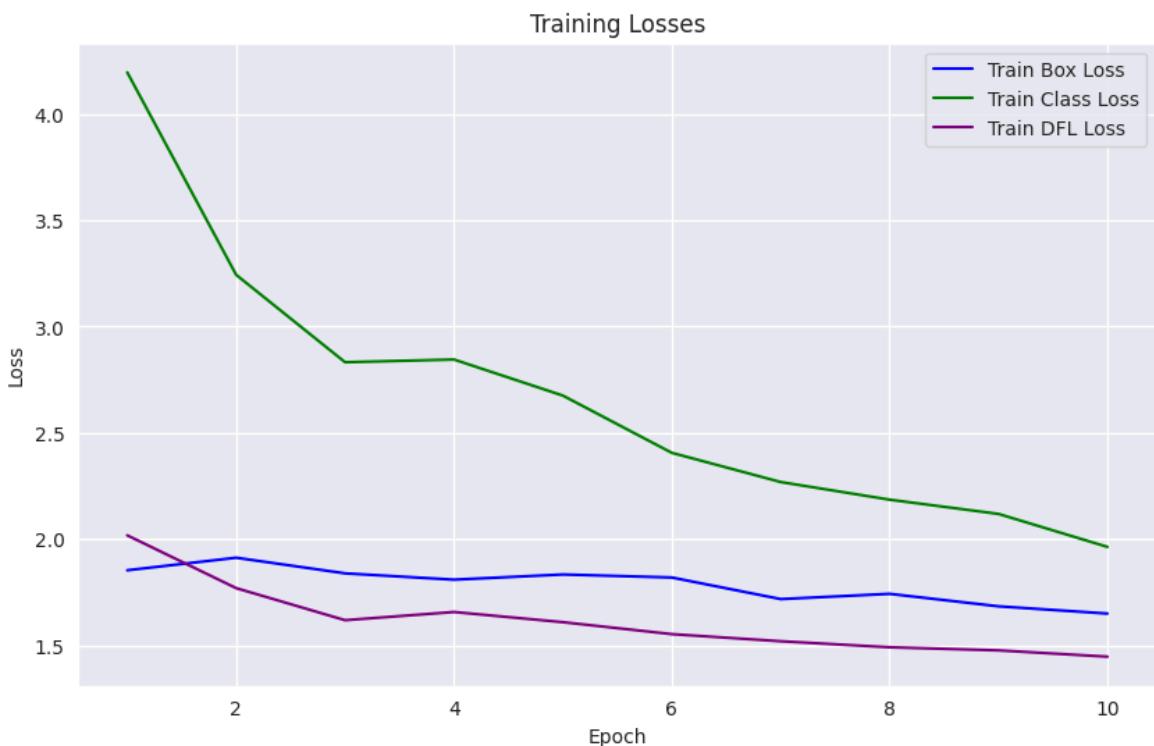
# Load the CSV
df = pd.read_csv(csv_path)

# Display the columns
print("Available columns in results.csv:")
print(df.columns)
```

Available columns in results.csv:

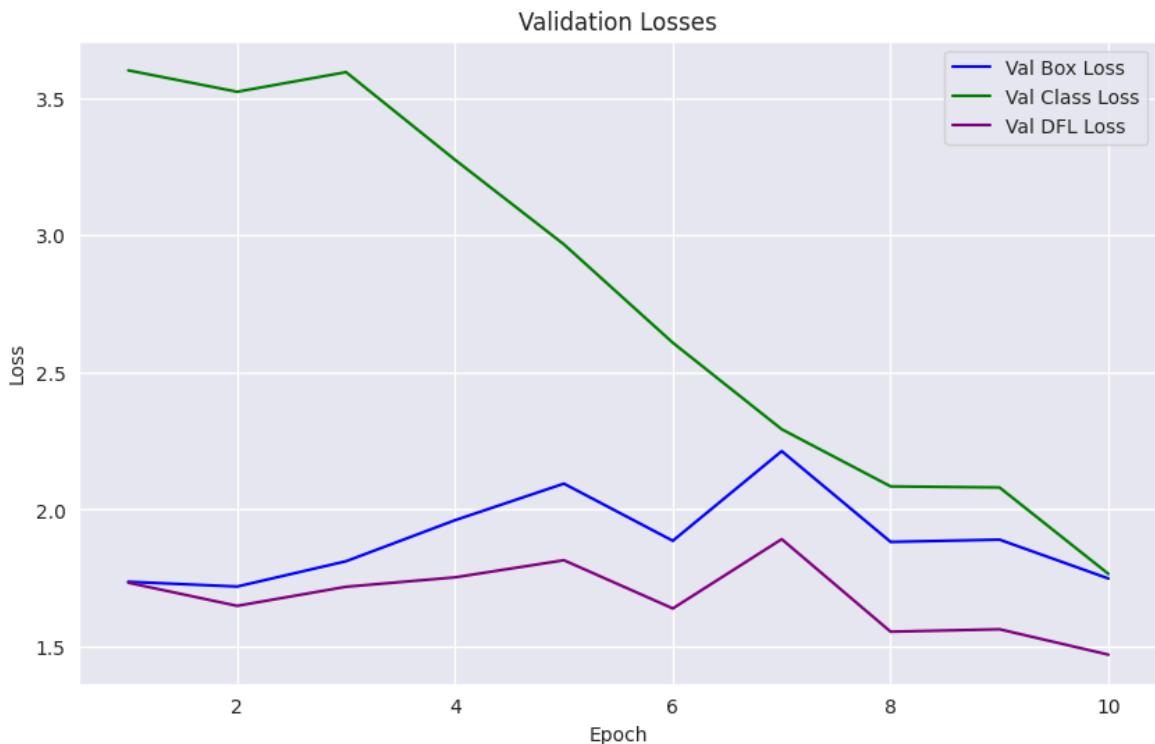
```
Index(['epoch', 'time', 'train/box_loss', 'train/cls_loss', 'train/dfl_loss',
       'metrics/precision(B)', 'metrics/recall(B)', 'metrics/mAP50(B)',
       'metrics/mAP50-95(B)', 'val/box_loss', 'val/cls_loss', 'val/dfl_loss',
       'lr/pg0', 'lr/pg1', 'lr/pg2'],
      dtype='object')
```

```
In [ ]: # Plot training losses
plt.figure(figsize=(10, 6))
plt.plot(df['epoch'], df['train/box_loss'], label='Train Box Loss', color='blue')
plt.plot(df['epoch'], df['train/cls_loss'], label='Train Class Loss', color='green')
plt.plot(df['epoch'], df['train/dfl_loss'], label='Train DFL Loss', color='purple')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Training Losses')
plt.legend()
plt.grid(True)
plt.show()
```

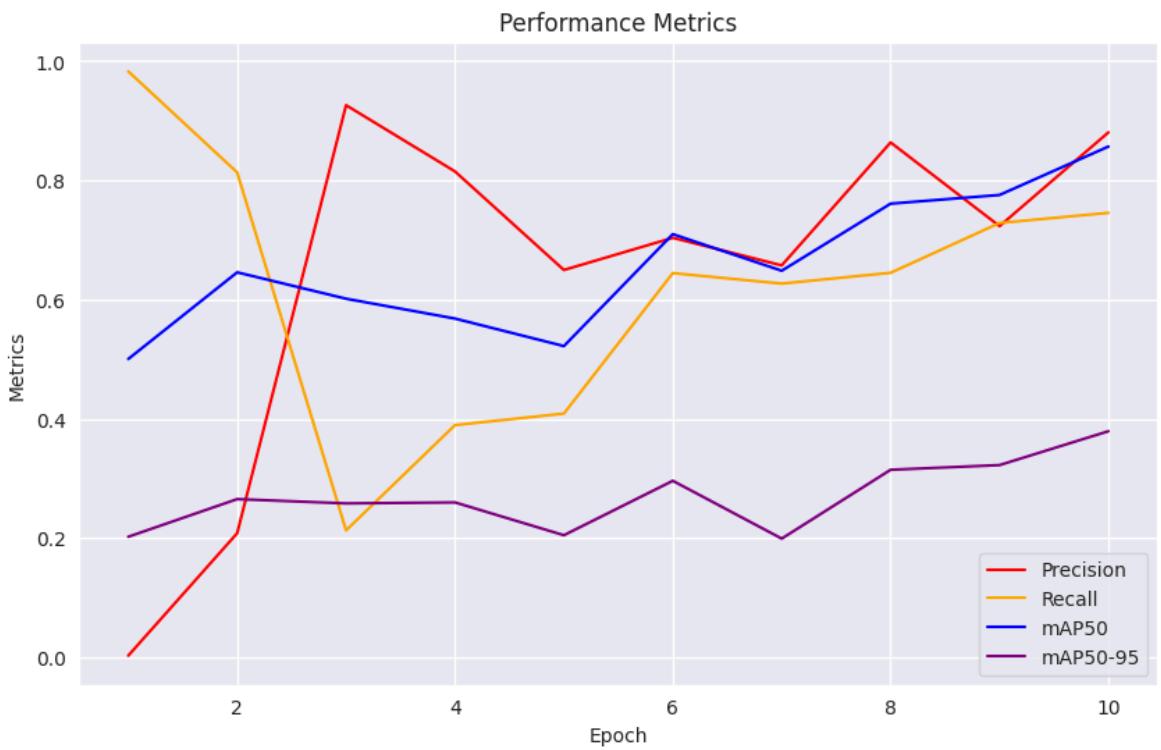


```
In [ ]: # Plot validation losses
plt.figure(figsize=(10, 6))
plt.plot(df['epoch'], df['val/box_loss'], label='Val Box Loss', color='blue')
plt.plot(df['epoch'], df['val/cls_loss'], label='Val Class Loss', color='green')
plt.plot(df['epoch'], df['val/dfl_loss'], label='Val DFL Loss', color='purple')
```

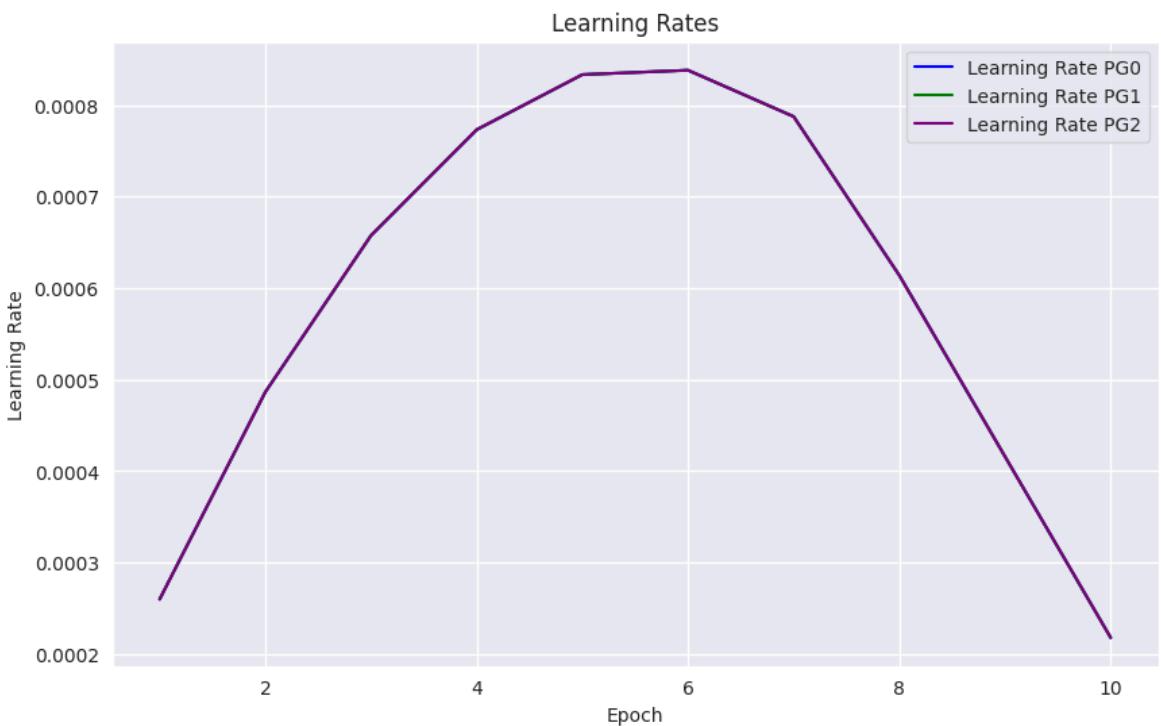
```
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Validation Losses')
plt.legend()
plt.grid(True)
plt.show()
```



```
In [ ]: # Plot precision, recall, and mAP metrics
plt.figure(figsize=(10, 6))
plt.plot(df['epoch'], df['metrics/precision(B)'], label='Precision', color='red')
plt.plot(df['epoch'], df['metrics/recall(B)'], label='Recall', color='orange')
plt.plot(df['epoch'], df['metrics/mAP50(B)'], label='mAP50', color='blue')
plt.plot(df['epoch'], df['metrics/mAP50-95(B)'], label='mAP50-95', color='purple')
plt.xlabel('Epoch')
plt.ylabel('Metrics')
plt.title('Performance Metrics')
plt.legend()
plt.grid(True)
plt.show()
```



```
In [ ]: # Plot Learning rates
plt.figure(figsize=(10, 6))
plt.plot(df['epoch'], df['lr/pg0'], label='Learning Rate PG0', color='blue')
plt.plot(df['epoch'], df['lr/pg1'], label='Learning Rate PG1', color='green')
plt.plot(df['epoch'], df['lr/pg2'], label='Learning Rate PG2', color='purple')
plt.xlabel('Epoch')
plt.ylabel('Learning Rate')
plt.title('Learning Rates')
plt.legend()
plt.grid(True)
plt.show()
```



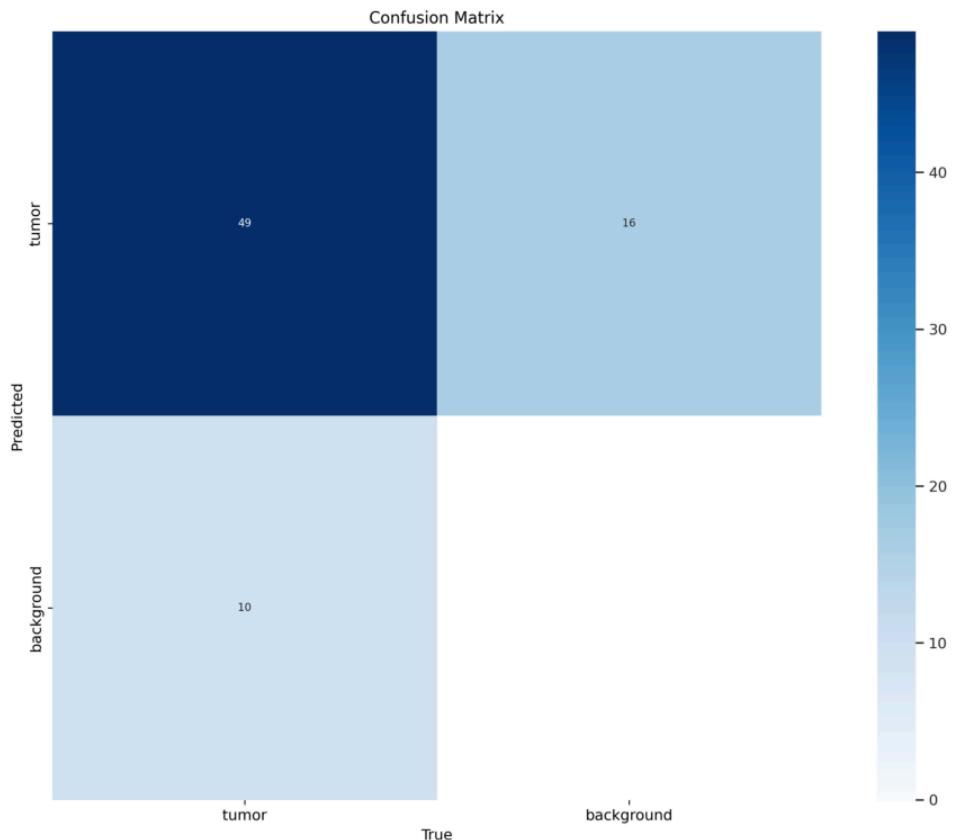
```
In [ ]: def imshow(path):
    import cv2
```

```
import matplotlib.pyplot as plt
%matplotlib inline

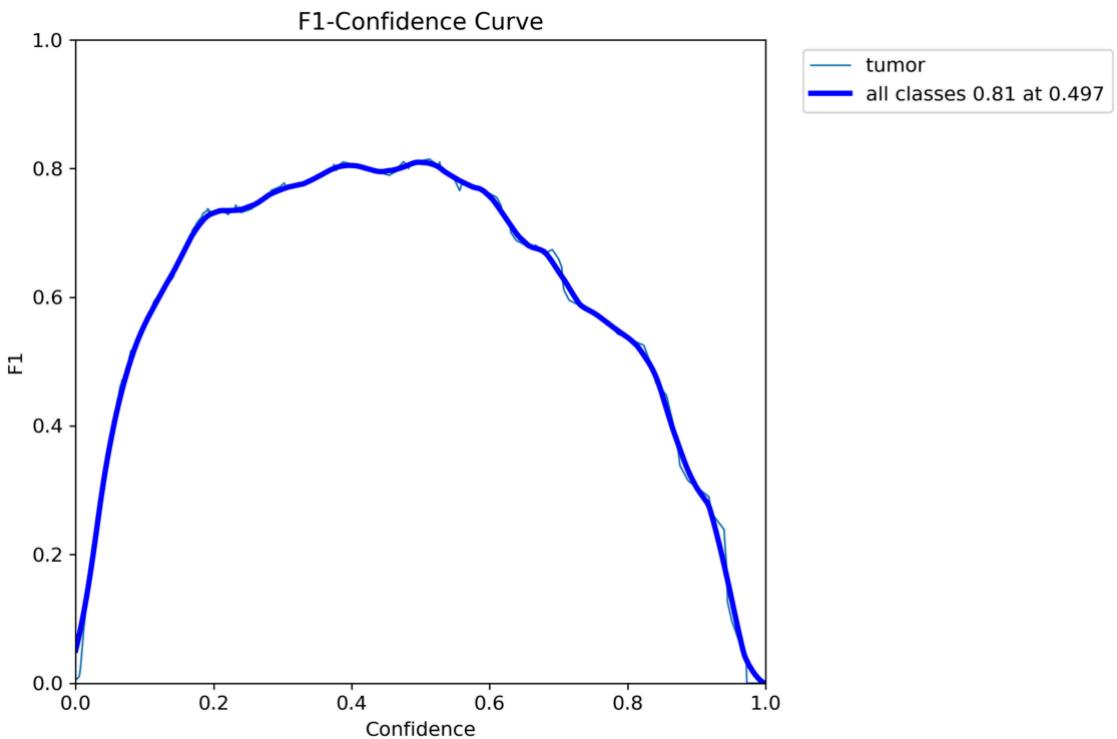
image = cv2.imread(path)
height, width = image.shape[:2]
resized_image = cv2.resize(image,(3*width, 3*height), interpolation = cv2.INTER_CUBIC)

fig = plt.gcf()
fig.set_size_inches(18, 10)
plt.axis("off")
plt.imshow(cv2.cvtColor(resized_image, cv2.COLOR_BGR2RGB))
plt.show()
```

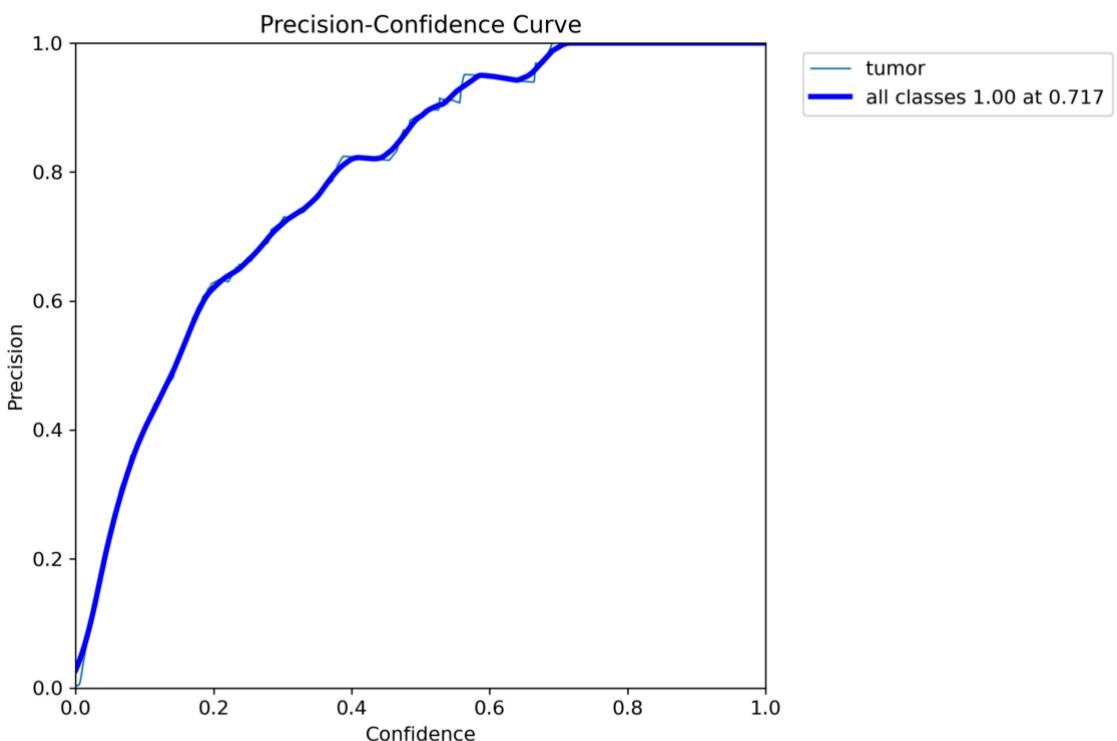
```
In [ ]: imshow("runs/detect/train3/confusion_matrix.png")
```



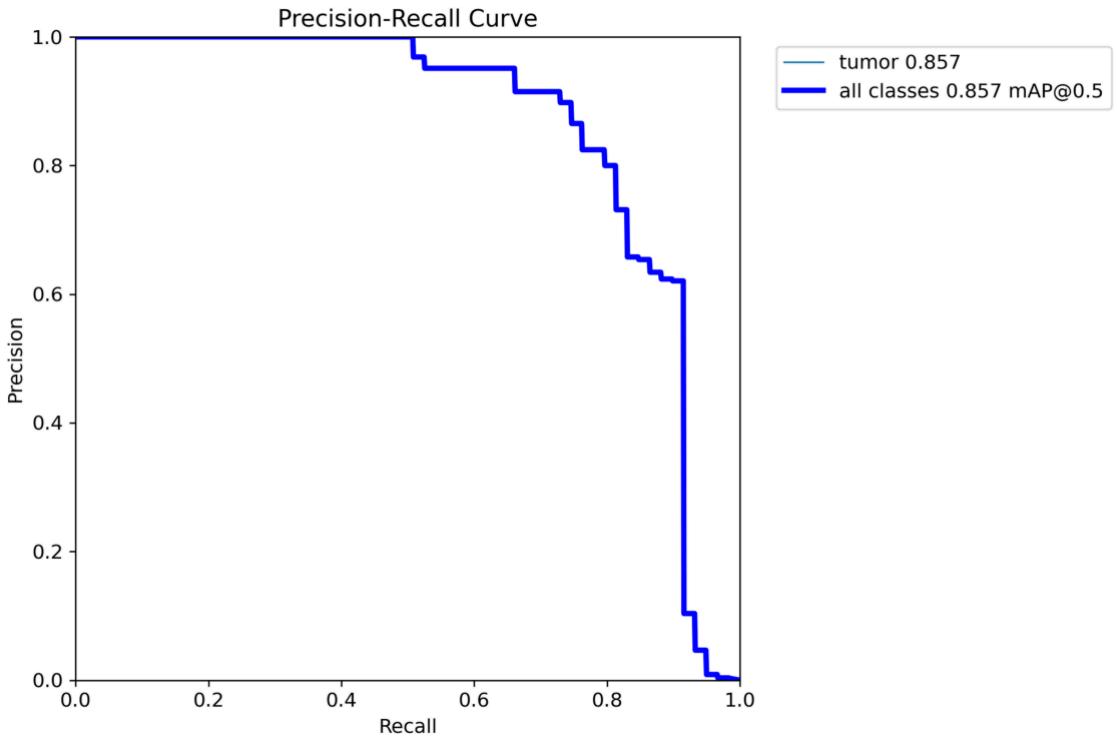
```
In [ ]: imshow("runs/detect/train3/F1_curve.png")
```



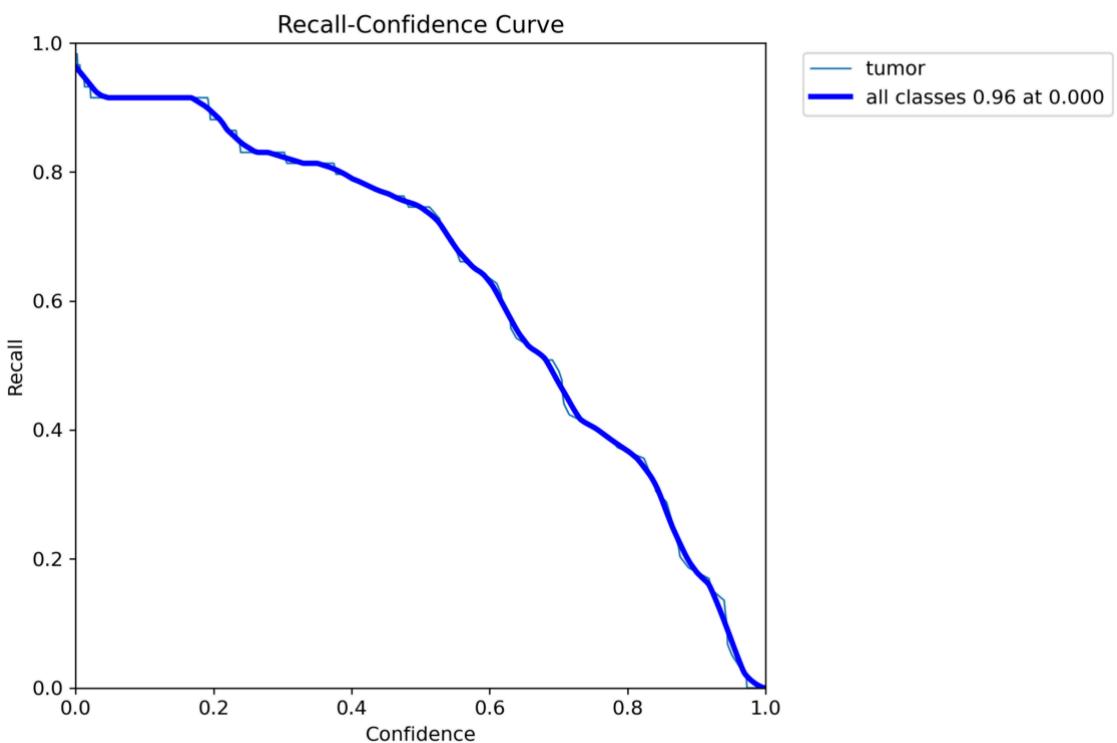
```
In [ ]: imshow("runs/detect/train3/P_curve.png")
```



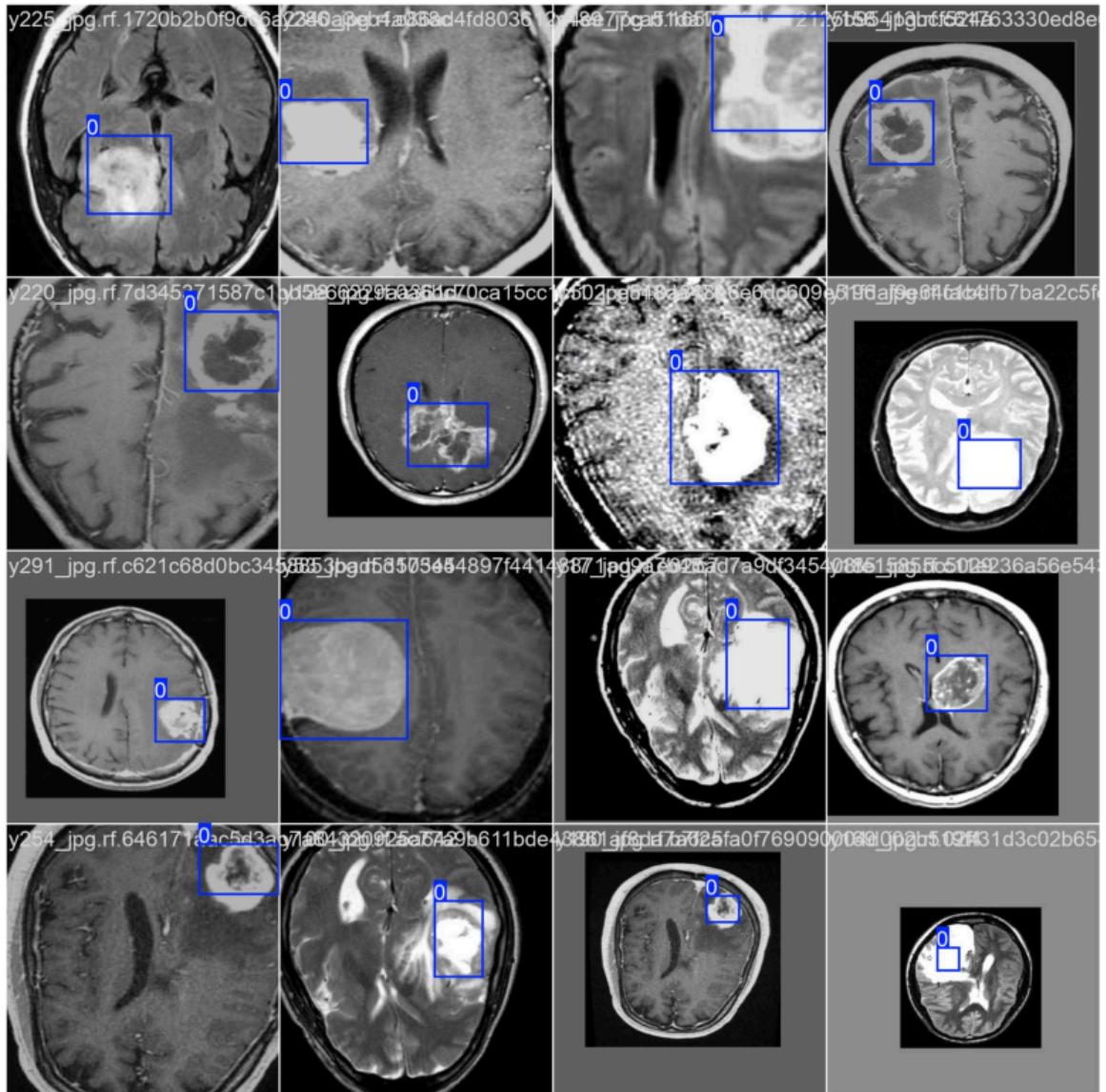
```
In [ ]: imshow("runs/detect/train3/PR_curve.png")
```



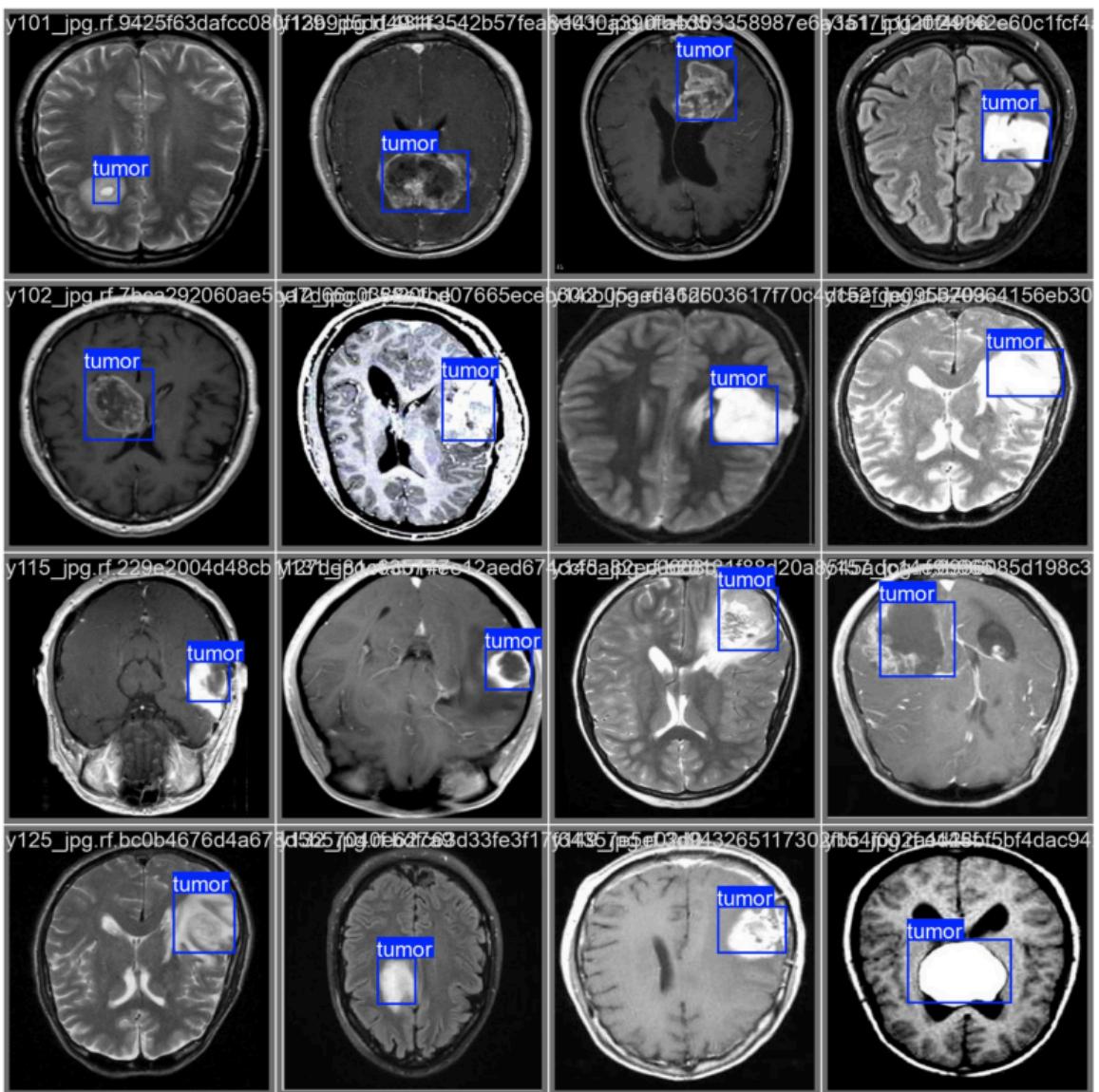
```
In [ ]: imshow("runs/detect/train3/R_curve.png")
```



```
In [ ]: imshow("runs/detect/train3/train_batch2.jpg")
```



```
In [ ]: imshow("runs/detect/train3/val_batch0_labels.jpg")
```



```
In [ ]: imshow("runs/detect/train3/val_batch1_labels.jpg")
```

