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In [ ]: import os
import glob
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split      # dividing the data
from sklearn.preprocessing import LabelEncoder           # for converting str
from sklearn.metrics import confusion_matrix, classification_report
from sklearn.metrics import ConfusionMatrixDisplay
from PIL import Image
from collections import defaultdict
import matplotlib.pyplot as plt
import seaborn as sn
import random

os.environ['TF_CPP_MIN_LOG_LEVEL'] = '3'  # 0 = all messages, 1 = filter INFO
import tensorflow as tf
from tensorflow.keras.callbacks import EarlyStopping , ModelCheckpoint , Call
from tensorflow.keras import layers , models , optimizers # type: ignore
from tensorflow.keras.models import load_model # type: ignore
from tensorflow.keras.layers import GlobalAveragePooling2D # type: ignore
from tensorflow.keras.applications import EfficientNetB0 # type: ignore
import pathlib

import warnings
warnings.filterwarnings("ignore")
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In [ ]: ! pip install kaggle
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Requirement already satisfied: kaggle in /usr/local/lib/python3.10/dist-packages (1.6.17)
Requirement already satisfied: six>=1.10 in /usr/local/lib/python3.10/dist-packages (from kaggle) (1.16.0)
Requirement already satisfied: certifi>=2023.7.22 in /usr/local/lib/python3.10/dist-packages (from kaggle) (2024.8.30)
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Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-packages (from kaggle) (2.32.3)
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Requirement already satisfied: bleach in /usr/local/lib/python3.10/dist-packages (from kaggle) (6.2.0)
Requirement already satisfied: webencodings in /usr/local/lib/python3.10/dist-packages (from bleach->kaggle) (0.5.1)
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Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests->kaggle) (3.10)
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In [ ]: from google.colab import drive
drive.mount('/content/drive')
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Mounted at /content/drive

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In [ ]: ! mkdir ~/.kaggle
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In [ ]: ! cp /content/drive/MyDrive/kaggle/kaggle.json ~/.kaggle/kaggle.json
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In [ ]: #Change the file permissions to read/write to the owner only
! chmod 600 ~/.kaggle/kaggle.json
```

```
In [ ]: ! kaggle datasets download gunavenkatdoddi/eye-diseases-classification
```

Dataset URL: <https://www.kaggle.com/datasets/gunavenkatdoddi/eye-diseases-classification>

License(s): ODbL-1.0

Downloading eye-diseases-classification.zip to /content

100% 735M/736M [00:35<00:00, 23.9MB/s]

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In [ ]: ! unzip eye-diseases-classification.zip
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Archive: eye-diseases-classification.zip
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inflating: dataset/normal/3318_left.jpg
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inflating: dataset/normal/3321_left.jpg
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inflating: dataset/normal/3325_left.jpg
inflating: dataset/normal/3329_right.jpg
inflating: dataset/normal/3330_left.jpg
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inflating: dataset/normal/3332_right.jpg
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inflating: dataset/normal/3341_left.jpg
inflating: dataset/normal/3341_right.jpg
```

```
inflating: dataset/normal/3342_left.jpg
inflating: dataset/normal/3343_right.jpg
inflating: dataset/normal/3344_right.jpg
inflating: dataset/normal/3348_right.jpg
inflating: dataset/normal/3350_left.jpg
inflating: dataset/normal/3352_left.jpg
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inflating: dataset/normal/3362_left.jpg
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inflating: dataset/normal/3367_right.jpg
inflating: dataset/normal/3369_left.jpg
inflating: dataset/normal/3373_right.jpg
inflating: dataset/normal/3375_left.jpg
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inflating: dataset/normal/3380_right.jpg
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inflating: dataset/normal/3383_right.jpg
inflating: dataset/normal/3386_left.jpg
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inflating: dataset/normal/3391_right.jpg
inflating: dataset/normal/3392_left.jpg
inflating: dataset/normal/3392_right.jpg
inflating: dataset/normal/3393_left.jpg
inflating: dataset/normal/3394_right.jpg
inflating: dataset/normal/3395_left.jpg
inflating: dataset/normal/3397_left.jpg
inflating: dataset/normal/3398_left.jpg
```

```
inflating: dataset/normal/3399_left.jpg
inflating: dataset/normal/3399_right.jpg
inflating: dataset/normal/3403_left.jpg
inflating: dataset/normal/3404_left.jpg
inflating: dataset/normal/3405_left.jpg
inflating: dataset/normal/3405_right.jpg
inflating: dataset/normal/3406_right.jpg
inflating: dataset/normal/3407_right.jpg
inflating: dataset/normal/3408_left.jpg
inflating: dataset/normal/3408_right.jpg
inflating: dataset/normal/3410_left.jpg
inflating: dataset/normal/3411_left.jpg
inflating: dataset/normal/3411_right.jpg
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inflating: dataset/normal/3412_right.jpg
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inflating: dataset/normal/3437_left.jpg
inflating: dataset/normal/3438_right.jpg
inflating: dataset/normal/3441_left.jpg
inflating: dataset/normal/3442_left.jpg
inflating: dataset/normal/3442_right.jpg
inflating: dataset/normal/3443_left.jpg
inflating: dataset/normal/3444_right.jpg
inflating: dataset/normal/3445_left.jpg
inflating: dataset/normal/3446_left.jpg
```

```
inflating: dataset/normal/3446_right.jpg
inflating: dataset/normal/3448_right.jpg
inflating: dataset/normal/3485_left.jpg
inflating: dataset/normal/4290_right.jpg
inflating: dataset/normal/4637_left.jpg
inflating: dataset/normal/4637_right.jpg
inflating: dataset/normal/530_left.jpg
inflating: dataset/normal/530_right.jpg
inflating: dataset/normal/695_left.jpg
inflating: dataset/normal/695_right.jpg
inflating: dataset/normal/84_left.jpg
inflating: dataset/normal/84_right.jpg
inflating: dataset/normal/8_left.jpg
inflating: dataset/normal/8_right.jpg
inflating: dataset/normal/939_left.jpg
inflating: dataset/normal/939_right.jpg
inflating: dataset/normal/951_left.jpg
inflating: dataset/normal/951_right.jpg
```

To download specific files, instead of the entire data set

```
! kaggle datasets download gunavenkatdoddi/eye-diseases-
classification -f cataract/0_left.jpg
```

```
In [ ]: # Basic review of the photos directory

def dataset_analysis(path):
    subfolders = os.listdir(path)

    for subfolder in subfolders:
        subfolder_path = os.path.join(path, subfolder)
        if os.path.isdir(subfolder_path):
            files = os.listdir(subfolder_path)
            format_dimensions_counts = defaultdict(lambda: defaultdict(
                lambda: defaultdict(int)))

            for file in files:
                try:
                    file_path = os.path.join(subfolder_path, file)
                    with Image.open(file_path) as img:
                        image_type = img.format.upper() # Format (e.g., JPEG)
                        image_dimensions = img.size # (width, height)
                        image_mode = img.mode # Mode (e.g., RGB, L)

                        # Calculate bit depth
                        if image_mode == "1": # 1-bit pixels, black and white
                            bit_depth = 1
                        elif image_mode == "L": # 8-bit pixels, grayscale
                            bit_depth = 8
                        elif image_mode == "P": # 8-bit pixels, mapped to colors
                            bit_depth = 8
                        elif image_mode == "RGB": # 8-bit pixels, true color
                            bit_depth = 24 # 8 bits per channel
                        elif image_mode == "RGBA": # 8-bit pixels, true color
                            bit_depth = 32 # 8 bits per channel

                except IOError:
                    print(f"Error reading {file} in {subfolder} folder")
```

```

        elif image_mode == "CMYK": # 8-bit pixels, color set
            bit_depth = 32 # 8 bits per channel
        else:
            bit_depth = "Unknown"

    format_dimensions_counts[image_type][(image_dimensions, bit_depth)] += 1
except Exception as e:
    print(f"Exception processing '{file}' in '{subfolder}':

print('-----'*10)
print(f"Subfolder '{subfolder}' contains ({len(files)} files):")
for format, dimensions_counts in format_dimensions_counts.items():
    print(f"- {sum(sum(counts.values()))} for counts in dimensions_counts")
    for (dimensions, bit_depth), counts in dimensions_counts.items():
        for mode, count in counts.items():
            print(f" - {count} images with dimensions {dimensions}, bit depth {bit_depth}, mode {mode}")

```

path = r'/content/dataset'
dataset_path = path
dataset_analysis(dataset_path)

Subfolder 'normal' contains (1074 files):
- 1074 images of format JPEG:
- 1074 images with dimensions (512, 512), bit depth 24, mode RGB

Subfolder 'diabetic_retinopathy' contains (1098 files):
- 1098 images of format JPEG:
- 1098 images with dimensions (512, 512), bit depth 24, mode RGB

Subfolder 'cataract' contains (1038 files):
- 938 images of format JPEG:
- 640 images with dimensions (256, 256), bit depth 24, mode RGB
- 298 images with dimensions (512, 512), bit depth 24, mode RGB
- 100 images of format PNG:
- 76 images with dimensions (2592, 1728), bit depth 24, mode RGB
- 19 images with dimensions (2464, 1632), bit depth 24, mode RGB
- 5 images with dimensions (1848, 1224), bit depth 24, mode RGB

Subfolder 'glaucoma' contains (1007 files):
- 906 images of format JPEG:
- 600 images with dimensions (256, 256), bit depth 24, mode RGB
- 306 images with dimensions (512, 512), bit depth 24, mode RGB
- 101 images of format PNG:
- 22 images with dimensions (2464, 1632), bit depth 24, mode RGB
- 5 images with dimensions (1848, 1224), bit depth 24, mode RGB
- 74 images with dimensions (2592, 1728), bit depth 24, mode RGB

In []: # Count the number of images in each directory
subfolders = os.listdir(path)

```

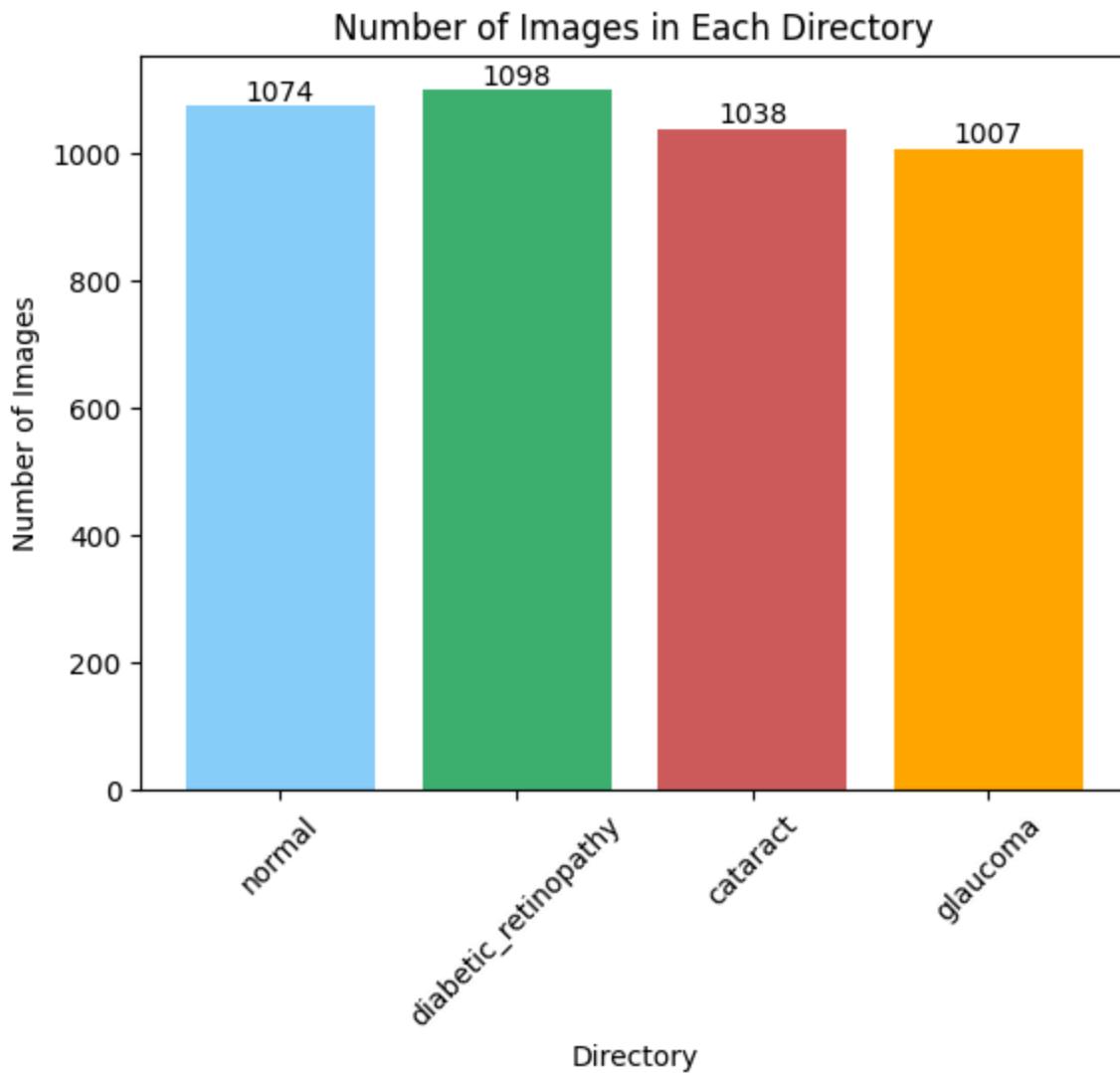
image_counts = []
for directory in subfolders:
    sub_dir = os.path.join(path, directory)
    if os.path.isdir(sub_dir):
        file_count = len(os.listdir(sub_dir))
        image_counts.append(file_count)

#Add value counts on each bar
for i in range(len(subfolders)):
    plt.text(i, image_counts[i], str(image_counts[i]), ha='center', va='bottom')

#Set some colors
colors = ['lightskyblue', 'mediumseagreen', 'indianred', 'orange']

# Plotting the results
plt.bar(subfolders, image_counts, color=colors)
plt.xlabel('Directory')
plt.xticks(rotation = 45)
plt.ylabel('Number of Images')
plt.title('Number of Images in Each Directory')
plt.show()

```



```
In [ ]: # Check the photos by size

def dataset_size_analysis(path):
    format_dimensions_counts = defaultdict(int)

    subfolders = os.listdir(path)
    for subfolder in subfolders:
        subfolder_path = os.path.join(path, subfolder)
        if os.path.isdir(subfolder_path):
            files = os.listdir(subfolder_path)

            for file in files:
                try:
                    file_path = os.path.join(subfolder_path, file)
                    with Image.open(file_path) as img:
                        image_dimensions = img.size
                        image_mode = img.mode

                        # Calculate bit depth
                        bit_depth = {
                            "1": 1,
                            "L": 8,
                            "P": 8,
                            "RGB": 24,
                            "RGBA": 32,
                            "CMYK": 32
                        }.get(image_mode, "Unknown")

                        # Update counts
                        format_dimensions_counts[(image_dimensions, bit_depth)] += 1

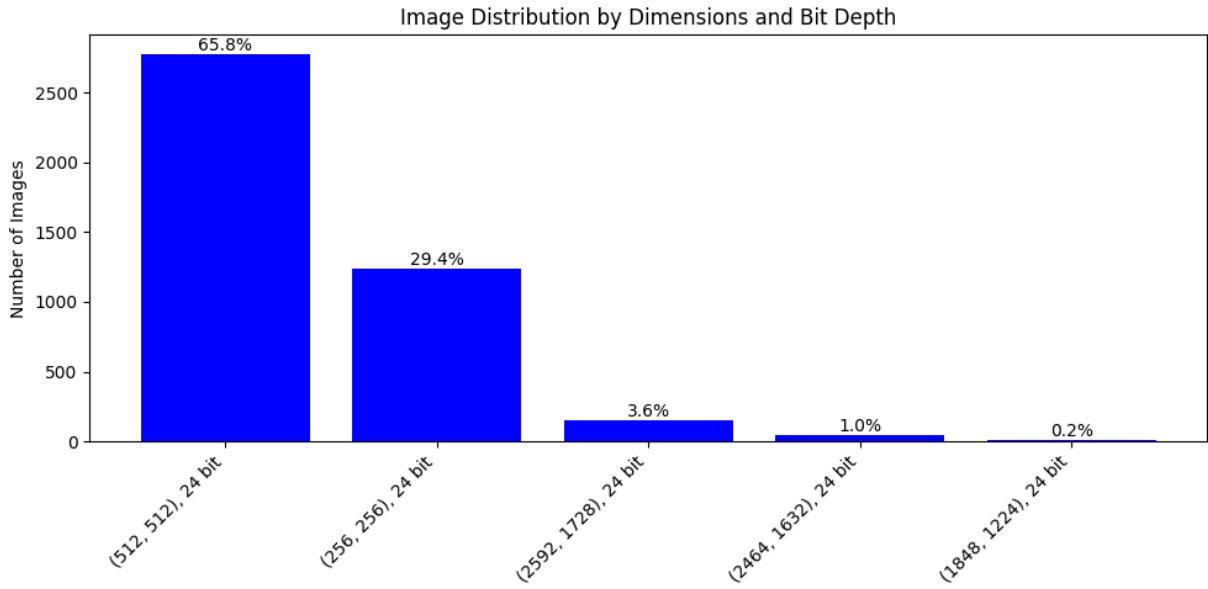
                except Exception as e:
                    print(f"Exception processing '{file}' in '{subfolder}'")

# Plotting dimensions and bit depths
plt.figure(figsize=(10, 5))
labels = [f"{dims}, {depth} bit" for (dims, depth) in format_dimensions_counts]
sizes = list(format_dimensions_counts.values())
total = sum(sizes)
bars = plt.bar(labels, sizes, color='blue')
plt.xticks(rotation=45, ha="right")
plt.ylabel('Number of Images')
plt.title('Image Distribution by Dimensions and Bit Depth')

# Adding percentage labels above the bars
for bar in bars:
    yval = bar.get_height()
    plt.text(bar.get_x() + bar.get_width()/2, yval, f'{100 * yval/total:.2f}%')

plt.tight_layout()
plt.show()

# Set the path to the dataset directory
dataset_size_analysis(path)
```



```
In [ ]: def dataset_size_analysis(path):
    # Dictionary to store counts: {subfolder: {image_size: count}}
    folder_size_counts = defaultdict(lambda: defaultdict(int))

    for subfolder in os.listdir(path):
        subfolder_path = os.path.join(path, subfolder)
        if os.path.isdir(subfolder_path):
            for file in os.listdir(subfolder_path):
                try:
                    file_path = os.path.join(subfolder_path, file)
                    with Image.open(file_path) as img:
                        dims = img.size
                        folder_size_counts[subfolder][dims] += 1
                except Exception as e:
                    print(f"Exception processing '{file}' in '{subfolder}'")

    # Create a single plot
    plt.figure(figsize=(15, 7))

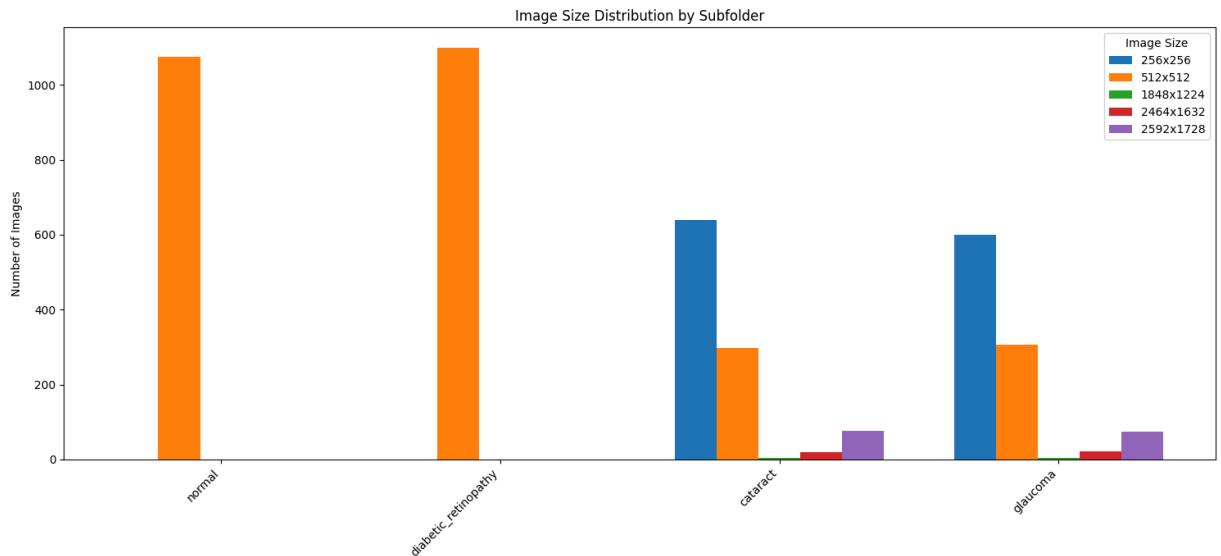
    # Determine unique image sizes across all folders for consistent coloring
    all_sizes = set(size for sizes in folder_size_counts.values() for size in sizes)
    all_sizes = sorted(all_sizes, key=lambda s: (s[0] * s[1])) # Sort by area

    subfolder_names = list(folder_size_counts.keys())
    bar_width = 0.15 # Width of bars
    indices = range(len(subfolder_names))

    for i, size in enumerate(all_sizes):
        counts = [folder_size_counts[subfolder].get(size, 0) for subfolder in subfolders]
        plt.bar([index + i * bar_width for index in indices], counts, bar_width)

    plt.xticks([index + (len(all_sizes) - 1) * bar_width / 2 for index in indices])
    plt.ylabel('Number of Images')
    plt.title('Image Size Distribution by Subfolder')
    plt.legend(title="Image Size")
    plt.tight_layout()
    plt.show()
```

```
# Set the path to the dataset directory
dataset_size_analysis(path)
```



```
In [ ]: # Preview photos

def random_photos_from_folders(base_folder):
    # Walk through all directories and files in the base_folder
    for root, dirs, files in os.walk(base_folder):
        # Filter to get only files that are images
        images = [file for file in files if file.lower().endswith('.png', '.jpg', '.jpeg')]

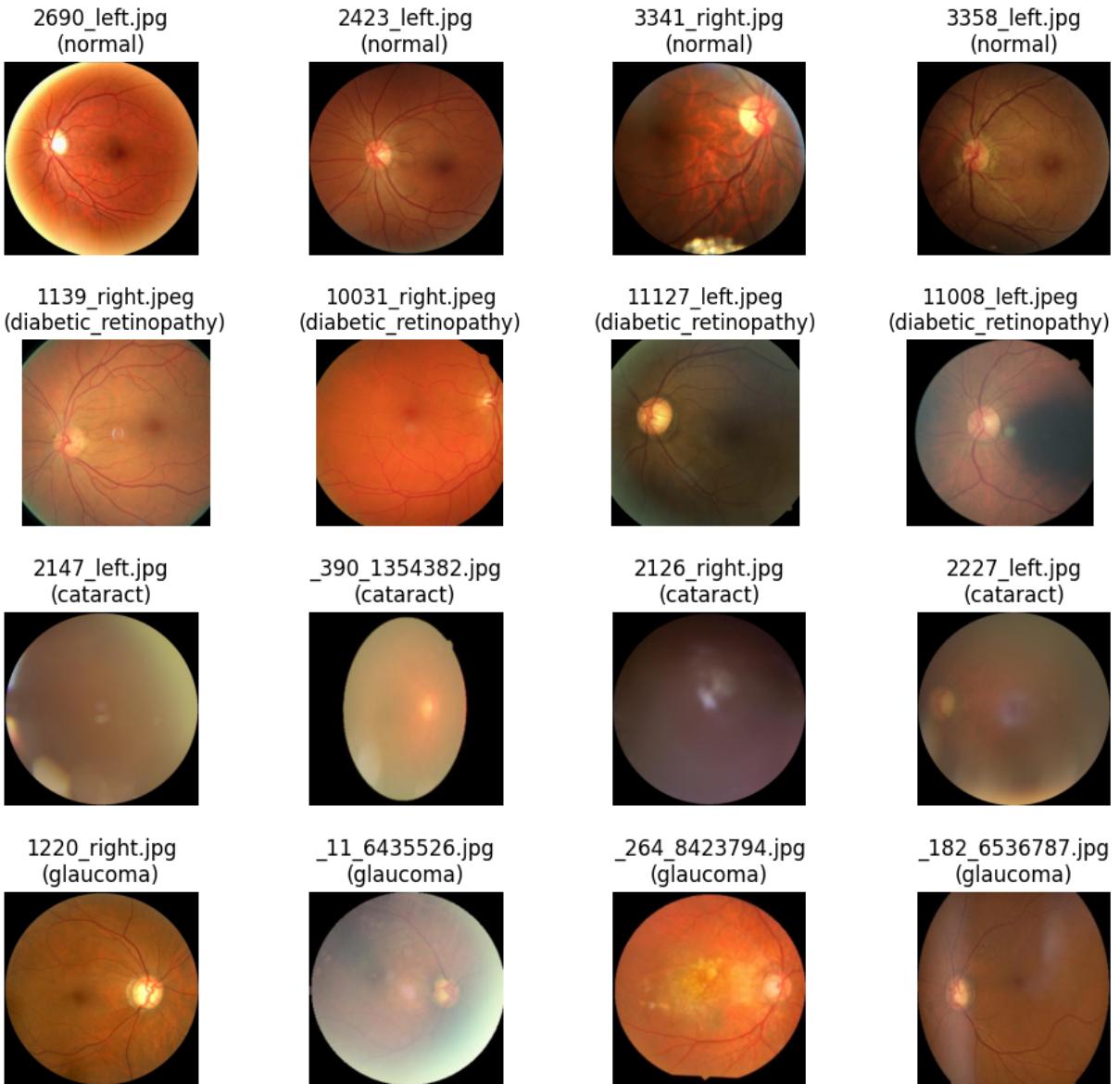
        if len(images) >= 4: # Ensure there are at least 4 images
            selected_images = random.sample(images, 4) # Randomly select 4

            # Display selected images
            fig, axs = plt.subplots(1, 4, figsize=(12, 2)) # Create a 1x4 grid
            for idx, img_name in enumerate(selected_images):
                img_path = os.path.join(root, img_name)
                img = Image.open(img_path)
                axs[idx].imshow(img)
                axs[idx].axis('off') # Hide axes

            # Extract sub-folder name from the root path
            subfolder_name = os.path.basename(root)
            # Set the title to include image name and sub-folder name
            axs[idx].set_title(f'{img_name}\n{subfolder_name}')

            plt.show()

# Path to the folder containing sub-folders with images
random_photos_from_folders(path)
```



```
In [ ]: # Getting the names of classes
class_dirs = [d for d in os.listdir(path) if os.path.isdir(os.path.join(path, d))]

# create data path and their labels
data = []
labels = []
extensions = ["jpg", "JPG", "jpeg", "JPEG", "png", "PNG", "bmp", "BMP", "gif"]

for i in class_dirs:
    class_label = i
    image_files = []
    for ext in extensions:
        # Search for files with each extension and extend the image_files list
        image_files.extend(glob.glob(os.path.join(path, i, f"*.{ext}")))
    data.extend(image_files)
    labels.extend([class_label] * len(image_files))

# Check if lists are still empty
if not data:
    Loading [MathJax]/extensions/Safe.js ("No files were found. Check your directory paths and file formats.")
```

```

else:
    print("Files found and listed.")

# Create a DataFrame with the image paths and labels
df = pd.DataFrame({
    'filename': data,
    'class': labels
})

# Shuffle the dataset by rows
df = df.sample(frac=1)

```

Files found and listed.

In []: `display(df)`

		filename	class
2605		/content/dataset/cataract/_120_3067914.jpg	cataract
1844		/content/dataset/diabetic_retinopathy/102_righ...	diabetic_retinopathy
3750		/content/dataset/glaucoma/_326_7155812.jpg	glaucoma
1138		/content/dataset/diabetic_retinopathy/1017_rig...	diabetic_retinopathy
1493		/content/dataset/diabetic_retinopathy/11037_ri...	diabetic_retinopathy
...	
3481		/content/dataset/glaucoma/_161_5855059.jpg	glaucoma
422		/content/dataset/normal/2418_right.jpg	normal
2587		/content/dataset/cataract/_246_8777337.jpg	cataract
2731		/content/dataset/cataract/_93_7584804.jpg	cataract
3463		/content/dataset/glaucoma/_123_6574789.jpg	glaucoma

4217 rows × 2 columns

In []: `# Convert labels to one-hot encodings`

```

label_encoder = LabelEncoder()
label = label_encoder.fit_transform(df['class'])
df['class'] = label

# check number assigned to each class
# Get the class names and corresponding integer encodings
class_names = label_encoder.classes_
class_numbers = label_encoder.transform(label_encoder.classes_)

# Print class names with the assigned numbers
class_dict = dict(zip(class_names, class_numbers))
print(class_dict)

```

File contents: 'cataract': 0, 'diabetic_retinopathy': 1, 'glaucoma': 2, 'normal': 3}

Loading [MathJax]/extensions/Safe.js

```
In [ ]: display(df)
```

		filename	class
2605		/content/dataset/cataract/_120_3067914.jpg	0
1844		/content/dataset/diabetic_retinopathy/102_righ...	1
3750		/content/dataset/glaucoma/_326_7155812.jpg	2
1138		/content/dataset/diabetic_retinopathy/1017_rig...	1
1493		/content/dataset/diabetic_retinopathy/11037_ri...	1
...	
3481		/content/dataset/glaucoma/_161_5855059.jpg	2
422		/content/dataset/normal/2418_right.jpg	3
2587		/content/dataset/cataract/_246_8777337.jpg	0
2731		/content/dataset/cataract/_93_7584804.jpg	0
3463		/content/dataset/glaucoma/_123_6574789.jpg	2

4217 rows × 2 columns

```
In [ ]: # Check the balance of the classes
print(df['class'].value_counts(normalize=True))
print('-----'*10)

# Split the data into train+validation and test sets
train_plus_val, test = train_test_split(df, test_size=0.2, stratify=df['class'])

# Split the train+validation set into train and validation sets
train, val = train_test_split(train_plus_val, test_size=0.25, stratify=train['class'])

# Now you have:
# train: 60% of the data
# val: 20% of the data
# test: 20% of the data

# Confirm the distribution across splits
print("Training set:")
print(train['class'].value_counts(normalize=True))
print('-----'*10)

print("Validation set:")
print(val['class'].value_counts(normalize=True))
print('-----'*10)

print("Test set:")
print(test['class'].value_counts(normalize=True))
```

```

class
1    0.260375
3    0.254683
0    0.246147
2    0.238795
Name: proportion, dtype: float64
-----
Training set:
class
1    0.260182
3    0.254646
0    0.245947
2    0.239225
Name: proportion, dtype: float64
-----
Validation set:
class
1    0.260664
3    0.254739
0    0.246445
2    0.238152
Name: proportion, dtype: float64
-----
Test set:
class
1    0.260664
3    0.254739
0    0.246445
2    0.238152
Name: proportion, dtype: float64

```

```
In [ ]: train_links, train_labels = train['filename'].values , train['class'].values
val_links , val_labels = val['filename'].values , val['class'].values
test_links, test_labels = test['filename'].values , test['class'].values
```

```
In [ ]: # Create a Function to Load and Preprocess Images
# tf.cond is a TensorFlow operation that allows for conditional execution based on a boolean condition

def load_and_preprocess_image(path, label, data_augmentation=True):
    # Read the image file
    image = tf.io.read_file(path)

    # Extract file extension
    file_extension = tf.strings.split(path, '.')[-1]

    # Decode based on file extension using tf.cond
    def decode_jpeg():
        return tf.image.decode_jpeg(image, channels=3)

    def decode_png():
        return tf.image.decode_png(image, channels=3)

    def decode_bmp():
        return tf.image.decode_bmp(image, channels=3)
```

```

def decode_gif():
    # Decode GIF and take the first frame
    return tf.squeeze(tf.image.decode_gif(image), axis=0)

# Handle each format
image = tf.cond(tf.math.equal(file_extension, 'jpg'), decode_jpeg,
               lambda: tf.cond(tf.math.equal(file_extension, 'jpeg'), decode_jpg,
                               lambda: tf.cond(tf.math.equal(file_extension, 'png'), decode_png,
                                               lambda: tf.cond(tf.math.equal(file_extension, 'bmp'), decode_bmp,
                                                               lambda: tf.cond(tf.math.equal(file_extension, 'gif'), decode_gif,
                                                               decode_jpeg)))))

# Resize and normalize
image = tf.image.resize(image, [256, 256])
image = image / 255.0 # Normalize to [0, 1] range

# Apply data augmentation if in training mode
if data_augmentation == True:
    # Randomly flip the image horizontally
    image = tf.image.random_flip_left_right(image)

    # Randomly flip the image vertically
    image = tf.image.random_flip_up_down(image)

    # Randomly rotate the image
    image = tf.image.rot90(image, k=tf.random.uniform(shape=[], minval=0,
                                                       maxval=4))

    # Randomly adjust brightness
    image = tf.image.random_brightness(image, max_delta=0.1)

    # Randomly zoom in
    image = tf.image.resize_with_crop_or_pad(image, 266, 266) # Zoom in
    image = tf.image.random_crop(image, size=[256, 256, 3])

    # Randomly adjust contrast
    image = tf.image.random_contrast(image, lower=0.8, upper=1.2)

return image, label

```

```

In [ ]: # create TensorFlow datasets for each split
# When loading datasets, pass the data_augmentation flag True or False to apply data augmentation
train_dataset = tf.data.Dataset.from_tensor_slices( (train_links , train_labels) )
train_dataset = train_dataset.map(lambda x, y: load_and_preprocess_image(x, y, data_augmentation=True))

val_dataset = tf.data.Dataset.from_tensor_slices( (val_links , val_labels) )
val_dataset = val_dataset.map(lambda x, y: load_and_preprocess_image(x, y, data_augmentation=False))

test_dataset = tf.data.Dataset.from_tensor_slices( (test_links , test_labels) )
test_dataset = test_dataset.map(lambda x, y: load_and_preprocess_image(x, y, data_augmentation=False))

```

```

In [ ]: # Iterate over the dataset and print the first few elements
for data_element, label_element in train_dataset.take(1): # Adjust the number of elements to print
    print(f"Data: {data_element.numpy()}, Label: {label_element.numpy()}")

```

```

Data: [[[ -0.0467025 -0.02004027 -0.00261218]
[-0.0467025 -0.02004027 -0.00261218]
[-0.0467025 -0.02004027 -0.00261218]

...
[-0.0467025 -0.02004027 -0.00261218]
[-0.0467025 -0.02004027 -0.00261218]
[-0.0467025 -0.02004027 -0.00261218]]]

[[[-0.0467025 -0.02004027 -0.00261218]
[-0.16063404 -0.13397183 -0.11654373]
[-0.16063404 -0.13397183 -0.11654373]

...
[-0.16063404 -0.13397183 -0.11654373]
[-0.15862602 -0.1319638 -0.1145357 ]
[-0.16063404 -0.13397183 -0.11654373]]]

[[[-0.0467025 -0.02004027 -0.00261218]
[-0.16063404 -0.13063706 -0.11654373]
[-0.16063404 -0.13397183 -0.11654373]

...
[-0.16063404 -0.13081634 -0.11338827]
[-0.16063404 -0.13397183 -0.11654373]
[-0.15973762 -0.13307537 -0.11564729]]]

...

[[[-0.0467025 -0.02004027 -0.00261218]
[-0.15633115 -0.12941793 -0.11198983]
[-0.15891287 -0.13225065 -0.11482257]

...
[-0.15661803 -0.12995578 -0.11252768]
[-0.16063404 -0.13397183 -0.11654373]
[-0.16063404 -0.12938206 -0.11195397]]]

[[[-0.0467025 -0.02004027 -0.00261218]
[-0.16063404 -0.13397183 -0.11654373]
[-0.1560443 -0.12938206 -0.11195397]

...
[-0.16063404 -0.13397183 -0.11654373]
[-0.15891287 -0.13225065 -0.11482257]
[-0.16063404 -0.13397183 -0.11654373]]]

[[[-0.0467025 -0.02004027 -0.00261218]
[-0.16063404 -0.13214308 -0.11654373]
[-0.15776545 -0.13110322 -0.11367513]

...
[-0.1589846 -0.12938206 -0.11489429]
[-0.16063404 -0.13397183 -0.11654373]
[-0.16063404 -0.13110322 -0.11367513]], Label: 2

```

```

In [ ]: # Iterate over the dataset and print the first few elements
for data_element, label_element in train_dataset.take(1): # Adjust the number
    print(f"Data: {data_element.numpy().shape}, Label: {label_element.numpy()}

Data: (256, 256, 3), Label: 2

```

```
In [ ]: #prepare your datasets for model training and evaluation

batch_size = 16

train_dataset = train_dataset.batch(batch_size)
train_dataset = train_dataset.prefetch(buffer_size= tf.data.AUTOTUNE)

val_dataset = val_dataset.batch(batch_size)
val_dataset = val_dataset.prefetch(buffer_size= tf.data.AUTOTUNE)

test_dataset = test_dataset.batch(batch_size)
test_dataset = test_dataset.prefetch(buffer_size= tf.data.AUTOTUNE)
```

```
In [ ]: model = models.Sequential([
    # First Block
    layers.Conv2D(128, (3, 3), activation='relu', input_shape=(256, 256, 3),
    layers.Conv2D(128, (3, 3), activation='relu', padding='same'),
    layers.MaxPooling2D((2, 2)),
    layers.BatchNormalization(),

    # Second Block
    layers.Conv2D(256, (3, 3), activation='relu', padding='valid'),
    layers.Conv2D(256, (3, 3), activation='relu', padding='valid'),
    layers.MaxPooling2D((2, 2)),
    layers.BatchNormalization(),

    # Second Block
    layers.Conv2D(256, (3, 3), activation='relu', padding='valid'),
    layers.Conv2D(256, (3, 3), activation='relu', padding='valid'),
    layers.MaxPooling2D((2, 2)),
    layers.BatchNormalization(),

    # Global Average Pooling instead of Flatten
    layers.GlobalAveragePooling2D(),

    # Fully Connected Layers
    layers.Dense(512,activation='relu'),
    layers.Dropout(0.5),
    layers.Dense(len(class_names), activation='softmax') # Output layer
])

model.summary()
```

Model: "sequential"

Layer (type)	Output Shape
conv2d (Conv2D)	(None, 256, 256, 128)
conv2d_1 (Conv2D)	(None, 256, 256, 128)
max_pooling2d (MaxPooling2D)	(None, 128, 128, 128)
batch_normalization (BatchNormalization)	(None, 128, 128, 128)
conv2d_2 (Conv2D)	(None, 126, 126, 256)
conv2d_3 (Conv2D)	(None, 124, 124, 256)
max_pooling2d_1 (MaxPooling2D)	(None, 62, 62, 256)
batch_normalization_1 (BatchNormalization)	(None, 62, 62, 256)
conv2d_4 (Conv2D)	(None, 60, 60, 256)
conv2d_5 (Conv2D)	(None, 58, 58, 256)
max_pooling2d_2 (MaxPooling2D)	(None, 29, 29, 256)
batch_normalization_2 (BatchNormalization)	(None, 29, 29, 256)
conv2d_6 (Conv2D)	(None, 27, 27, 256)
conv2d_7 (Conv2D)	(None, 25, 25, 256)
max_pooling2d_3 (MaxPooling2D)	(None, 12, 12, 256)
batch_normalization_3 (BatchNormalization)	(None, 12, 12, 256)
global_average_pooling2d (GlobalAveragePooling2D)	(None, 256)
dense (Dense)	(None, 512)
dropout (Dropout)	(None, 512)
dense_1 (Dense)	(None, 4)

Total params: 3,533,956 (13.48 MB)

Trainable params: 3,532,164 (13.47 MB)

Non-trainable params: 1,792 (7.00 KB)

```
In [ ]: # Define the EarlyStopping callback to monitor the validation accuracy
early_stopping = EarlyStopping(
    monitor='val_accuracy', # Monitoring validation accuracy
    patience=12, # Number of epochs with no improvement after which training
    verbose=1,
```

```
        mode='max', # Stops training when the quantity monitored has stopped increasing
        restore_best_weights=True # Restores model weights from the epoch with the best metric
    )

# Define the ModelCheckpoint callback
model_checkpoint = ModelCheckpoint(
    filepath=r'/kaggle/working/best_model_custom.keras', # Path to save the model
    monitor='val_loss', # Change to val_loss to monitor the validation loss
    verbose=1,
    save_best_only=True, # Save only the best model
    mode='min' # Save the model when the monitored metric has minimized
)

model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

# Fit the model
history = model.fit(
    x = train_dataset,
    validation_data = val_dataset,
    epochs = 20,
    callbacks=[early_stopping , model_checkpoint] # Add the EarlyStopping callback
)
```

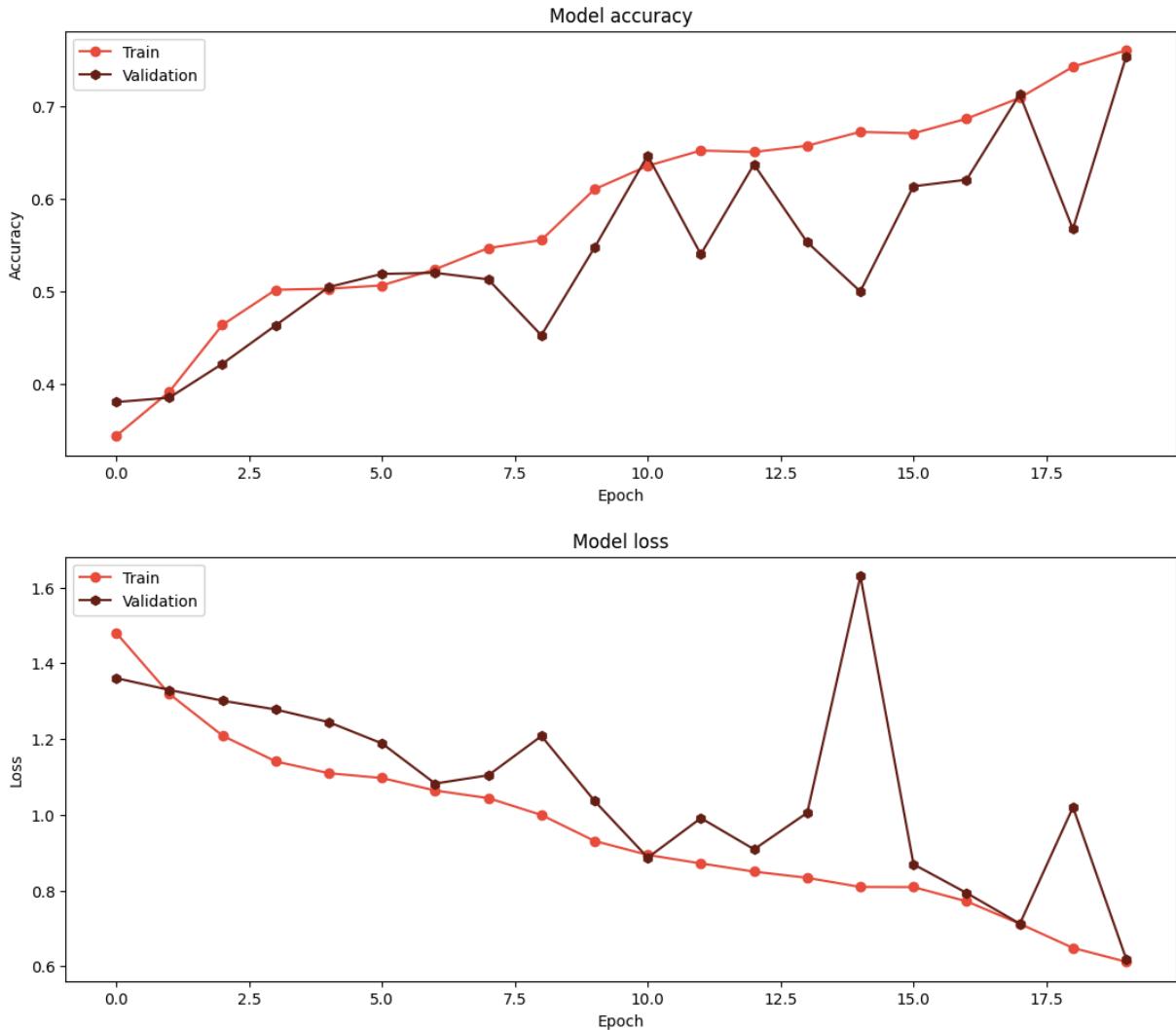
```
Epoch 1/20
159/159 0s 449ms/step - accuracy: 0.3237 - loss: 1.5304
Epoch 1: val_loss improved from inf to 1.36084, saving model to /kaggle/working/best_model_custom.keras
159/159 156s 712ms/step - accuracy: 0.3238 - loss: 1.5301 - val_accuracy: 0.3803 - val_loss: 1.3608
Epoch 2/20
158/159 0s 401ms/step - accuracy: 0.3676 - loss: 1.3511
Epoch 2: val_loss improved from 1.36084 to 1.32952, saving model to /kaggle/working/best_model_custom.keras
159/159 121s 438ms/step - accuracy: 0.3679 - loss: 1.3507 - val_accuracy: 0.3851 - val_loss: 1.3295
Epoch 3/20
158/159 0s 414ms/step - accuracy: 0.4579 - loss: 1.2265
Epoch 3: val_loss improved from 1.32952 to 1.30120, saving model to /kaggle/working/best_model_custom.keras
159/159 85s 459ms/step - accuracy: 0.4580 - loss: 1.2263 - val_accuracy: 0.4218 - val_loss: 1.3012
Epoch 4/20
158/159 0s 416ms/step - accuracy: 0.4954 - loss: 1.1402
Epoch 4: val_loss improved from 1.30120 to 1.27796, saving model to /kaggle/working/best_model_custom.keras
159/159 81s 451ms/step - accuracy: 0.4955 - loss: 1.1403 - val_accuracy: 0.4633 - val_loss: 1.2780
Epoch 5/20
158/159 0s 412ms/step - accuracy: 0.5034 - loss: 1.1096
Epoch 5: val_loss improved from 1.27796 to 1.24438, saving model to /kaggle/working/best_model_custom.keras
159/159 76s 476ms/step - accuracy: 0.5034 - loss: 1.1096 - val_accuracy: 0.5047 - val_loss: 1.2444
Epoch 6/20
158/159 0s 413ms/step - accuracy: 0.5092 - loss: 1.0820
Epoch 6: val_loss improved from 1.24438 to 1.18827, saving model to /kaggle/working/best_model_custom.keras
159/159 72s 454ms/step - accuracy: 0.5092 - loss: 1.0821 - val_accuracy: 0.5190 - val_loss: 1.1883
Epoch 7/20
158/159 0s 412ms/step - accuracy: 0.5257 - loss: 1.0599
Epoch 7: val_loss improved from 1.18827 to 1.08230, saving model to /kaggle/working/best_model_custom.keras
159/159 72s 452ms/step - accuracy: 0.5257 - loss: 1.0599 - val_accuracy: 0.5201 - val_loss: 1.0823
Epoch 8/20
158/159 0s 415ms/step - accuracy: 0.5484 - loss: 1.0480
Epoch 8: val_loss did not improve from 1.08230
159/159 82s 452ms/step - accuracy: 0.5484 - loss: 1.0479 - val_accuracy: 0.5130 - val_loss: 1.1042
Epoch 9/20
158/159 0s 412ms/step - accuracy: 0.5642 - loss: 0.9887
Epoch 9: val_loss did not improve from 1.08230
159/159 76s 475ms/step - accuracy: 0.5641 - loss: 0.9888 - val_accuracy: 0.4526 - val_loss: 1.2079
Epoch 10/20
158/159 0s 415ms/step - accuracy: 0.6140 - loss: 0.9474
Epoch 10: val_loss improved from 1.08230 to 1.03608, saving model to /kaggle/working/best_model_custom.keras
```

```
159/159 83s 479ms/step - accuracy: 0.6139 - loss: 0.947
2 - val_accuracy: 0.5474 - val_loss: 1.0361
Epoch 11/20
158/159 0s 416ms/step - accuracy: 0.6438 - loss: 0.8939
Epoch 11: val_loss improved from 1.03608 to 0.88659, saving model to /kaggle/working/best_model_custom.keras
159/159 78s 452ms/step - accuracy: 0.6437 - loss: 0.893
9 - val_accuracy: 0.6469 - val_loss: 0.8866
Epoch 12/20
158/159 0s 413ms/step - accuracy: 0.6577 - loss: 0.8755
Epoch 12: val_loss did not improve from 0.88659
159/159 71s 448ms/step - accuracy: 0.6577 - loss: 0.875
5 - val_accuracy: 0.5403 - val_loss: 0.9910
Epoch 13/20
158/159 0s 415ms/step - accuracy: 0.6502 - loss: 0.8561
Epoch 13: val_loss did not improve from 0.88659
159/159 87s 478ms/step - accuracy: 0.6502 - loss: 0.856
0 - val_accuracy: 0.6374 - val_loss: 0.9086
Epoch 14/20
158/159 0s 416ms/step - accuracy: 0.6563 - loss: 0.8347
Epoch 14: val_loss did not improve from 0.88659
159/159 78s 450ms/step - accuracy: 0.6564 - loss: 0.834
7 - val_accuracy: 0.5533 - val_loss: 1.0052
Epoch 15/20
158/159 0s 413ms/step - accuracy: 0.6762 - loss: 0.8113
Epoch 15: val_loss did not improve from 0.88659
159/159 76s 475ms/step - accuracy: 0.6762 - loss: 0.811
3 - val_accuracy: 0.5000 - val_loss: 1.6304
Epoch 16/20
158/159 0s 413ms/step - accuracy: 0.6697 - loss: 0.8125
Epoch 16: val_loss improved from 0.88659 to 0.86898, saving model to /kaggle/working/best_model_custom.keras
159/159 76s 477ms/step - accuracy: 0.6697 - loss: 0.812
5 - val_accuracy: 0.6137 - val_loss: 0.8690
Epoch 17/20
158/159 0s 416ms/step - accuracy: 0.6788 - loss: 0.7850
Epoch 17: val_loss improved from 0.86898 to 0.79307, saving model to /kaggle/working/best_model_custom.keras
159/159 82s 480ms/step - accuracy: 0.6789 - loss: 0.784
9 - val_accuracy: 0.6209 - val_loss: 0.7931
Epoch 18/20
158/159 0s 416ms/step - accuracy: 0.6911 - loss: 0.7289
Epoch 18: val_loss improved from 0.79307 to 0.71205, saving model to /kaggle/working/best_model_custom.keras
159/159 82s 480ms/step - accuracy: 0.6914 - loss: 0.728
7 - val_accuracy: 0.7133 - val_loss: 0.7121
Epoch 19/20
158/159 0s 416ms/step - accuracy: 0.7397 - loss: 0.6552
Epoch 19: val_loss did not improve from 0.71205
159/159 77s 451ms/step - accuracy: 0.7398 - loss: 0.655
1 - val_accuracy: 0.5675 - val_loss: 1.0198
Epoch 20/20
158/159 0s 415ms/step - accuracy: 0.7617 - loss: 0.6142
Epoch 20: val_loss improved from 0.71205 to 0.61925, saving model to /kaggle/working/best_model_custom.keras
159/159 82s 451ms/step - accuracy: 0.7617 - loss: 0.614
```

```
2 - val_accuracy: 0.7536 - val_loss: 0.6192
Restoring model weights from the end of the best epoch: 20.
```

```
In [ ]: # Plot training & validation accuracy values
plt.figure(figsize=(13,5))
plt.plot(history.history['accuracy'], color="#E74C3C", marker='o')
plt.plot(history.history['val_accuracy'], color='#641E16', marker='h')
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()

# Plot training & validation loss values
plt.figure(figsize=(13,5))
plt.plot(history.history['loss'], color="#E74C3C", marker='o')
plt.plot(history.history['val_loss'], color='#641E16', marker='h')
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()
```



```
In [ ]: # Load the saved model
# If the best model is captured by the early stopping mechanism then best_model = model

best_model = load_model(r'/kaggle/working/best_model_custom.keras')

# Evaluate the model
train_loss, train_accuracy = best_model.evaluate(train_dataset)
val_loss, val_accuracy = best_model.evaluate(val_dataset)
test_loss, test_accuracy = best_model.evaluate(test_dataset)

print(f"train loss: {train_loss}")
print(f"train accuracy: {train_accuracy}")
print('----'*6)
print(f"val loss: {val_loss}")
print(f"val accuracy: {val_accuracy}")
print('----'*6)
print(f"Test loss: {test_loss}")
print(f"Test accuracy: {test_accuracy}")

159/159 ━━━━━━━━━━ 26s 146ms/step - accuracy: 0.7099 - loss: 0.699
7
53/53 ━━━━━━━━━━ 7s 134ms/step - accuracy: 0.7577 - loss: 0.6065
53/53 ━━━━━━━━━━ 6s 117ms/step - accuracy: 0.7519 - loss: 0.6151
train loss: 0.68248450756073
train accuracy: 0.7133254408836365
-----
val loss: 0.61924809217453
val accuracy: 0.7535545229911804
-----
Test loss: 0.6317344903945923
Test accuracy: 0.7274881601333618
```

```
In [ ]: # Assuming best_model is your trained Keras model

# Get the predicted labels from the model
y_pred = np.argmax(best_model.predict(test_dataset), axis=1) # Convert pr
y_true = test_labels

# Compute confusion matrix
conf_mat = confusion_matrix(y_true, y_pred)

print("Confusion Matrix:")
print(conf_mat)

# Get the class labels from the LabelEncoder
class_labels = label_encoder.classes_

# Compute classification report
report = classification_report(y_true, y_pred, target_names=class_labels)

print("\nClassification Report:")
print(report)
```

53/53 ————— 12s 215ms/step

Confusion Matrix:

```
[[192  0  4 12]
 [ 2 203  5 10]
 [ 62 27 66 46]
 [ 23 34  5 153]]
```

Classification Report:

	precision	recall	f1-score	support
cataract	0.69	0.92	0.79	208
diabetic_retinopathy	0.77	0.92	0.84	220
glaucoma	0.82	0.33	0.47	201
normal	0.69	0.71	0.70	215
accuracy			0.73	844
macro avg	0.74	0.72	0.70	844
weighted avg	0.74	0.73	0.70	844

```
In [ ]: #Confusion matrix
print('Total Number Of Test data: ', len(test_labels))

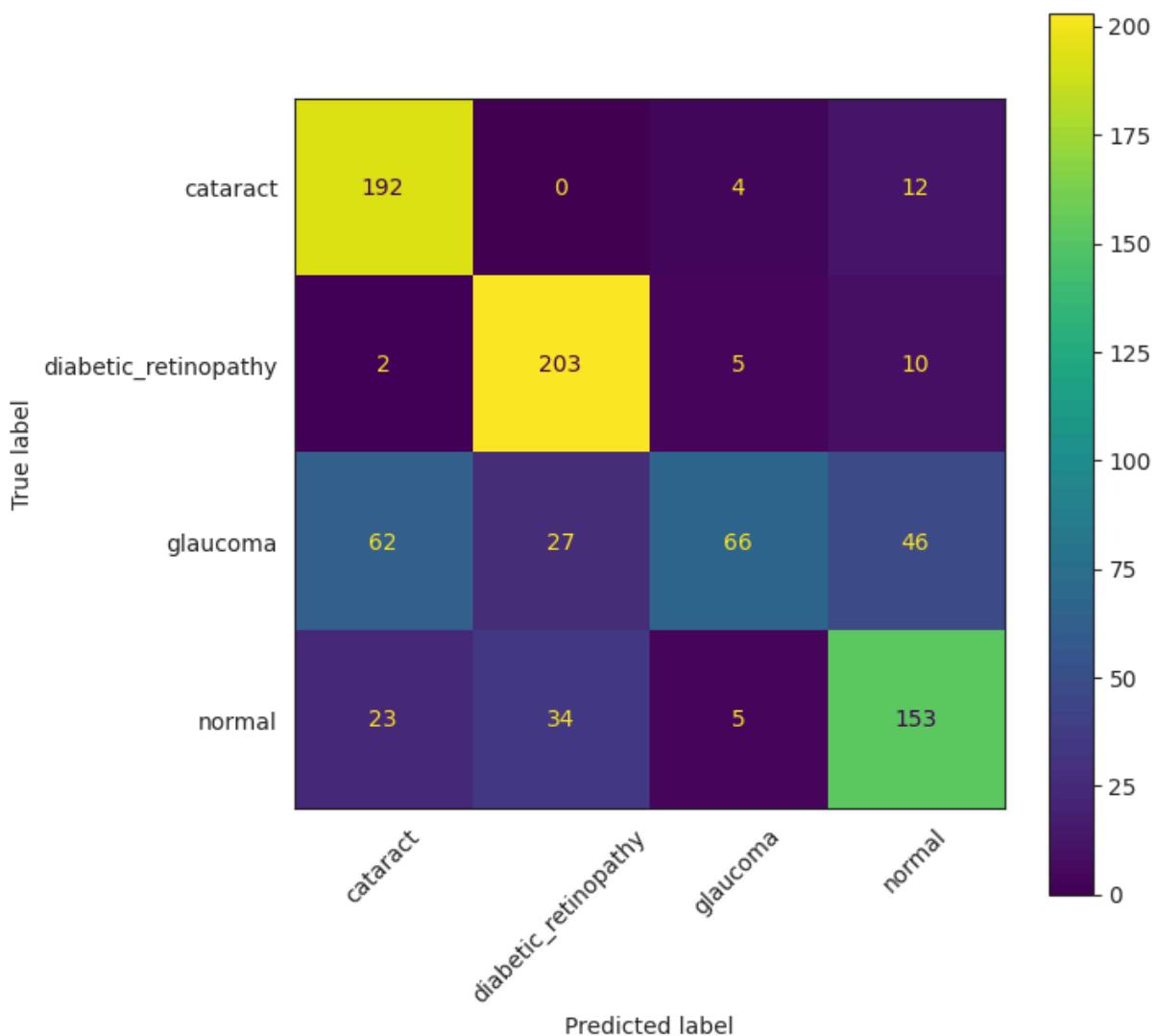
sn.set_style("white")
def plot_confusion_matrix(conf_mat, classes):
    """
    This function prints and plots the confusion matrix.
    """
    fig, ax = plt.subplots(figsize=(7,7)) # change the plot size
    disp = ConfusionMatrixDisplay(confusion_matrix=conf_mat, display_labels=)
    disp = disp.plot(include_values=True,cmap='viridis', ax=ax, xticks_roat
plt.show()

# Get your confusion matrix
conf_mat = conf_mat

# Using label_encoder.classes_ guarantees that class_names matches
# the order that was used during the one-hot encoding process
class_names = label_encoder.classes_

# Now plot using the function
plot_confusion_matrix(conf_mat, class_names)
```

Total Number Of Test data: 844



```
In [ ]: # probability explanation in below function:  
# For example, if the model predicts an image as class B with a probability  
# the plot will show "Probability: 70%".  
# This means the model is 70% confident that the image belongs to class B.  
  
def plot_test_predictions(model, test_dataset, class_labels, num_images=20):  
    """  
        Plots the predictions of a model on the test dataset.  
  
    Parameters:  
        - model: Trained Keras model to be used for prediction.  
        - test_dataset: TensorFlow dataset containing the test images and labels  
        - class_labels: List of class labels.  
        - num_images: Number of test images to plot (default is 20).  
    """  
  
    # Initialize lists to accumulate images and labels  
    images = []  
    true_labels = []  
    pred_labels = []  
    pred_probs = []
```

```

for batch_images, batch_labels in test_dataset:
    # Predict on the batch
    batch_pred_probs = model.predict(batch_images)
    batch_pred_labels = np.argmax(batch_pred_probs, axis=1)

    # Accumulate images and labels
    images.extend(batch_images)
    true_labels.extend(batch_labels)
    pred_labels.extend(batch_pred_labels)
    pred_probs.extend(np.max(batch_pred_probs, axis=1) * 100)

    if len(images) >= num_images:
        break

# Plot the images with predictions
plt.figure(figsize=(15, 20))
for i in range(num_images):
    plt.subplot(5, 5, i + 1)
    plt.imshow(images[i])
    actual_label = class_labels[true_labels[i]]
    predicted_label = class_labels[pred_labels[i]]
    probability = pred_probs[i] # Probability of the predicted class

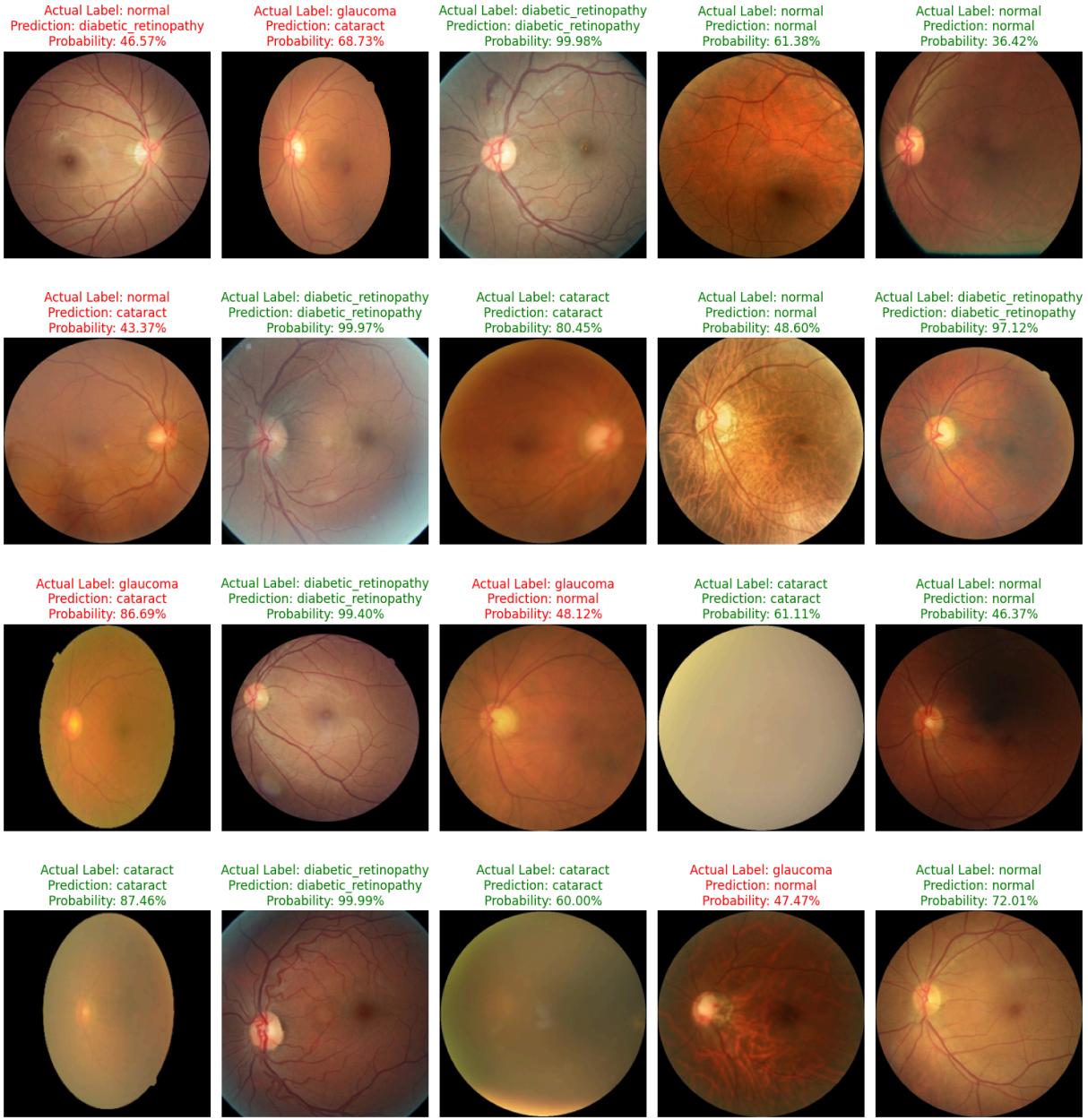
    color = 'green' if actual_label == predicted_label else 'red'
    plt.title(f"Actual Label: {actual_label}\nPrediction: {predicted_label}\nProbability: {probability:.2f}", color=color, fontsize=12)
    plt.axis('off')

plt.tight_layout()
plt.show()

# Use the function
plot_test_predictions(best_model, test_dataset, class_labels=class_names, num_images=25)

```

1/1 ━━━━━━━━ 1s 1s/step
 1/1 ━━━━━━━━ 0s 53ms/step



```
In [ ]: # Load the model pre-trained on EfficientNetB0, without the top layers
base_model = EfficientNetB0(input_shape=(256, 256, 3), include_top=False, we
# set True >>> makes all the layers in the base model trainable
base_model.trainable = True

# Create your own model on top of the pre-trained model
model = models.Sequential([
    base_model,
    layers.BatchNormalization(),
    layers.MaxPool2D(2,2),
    layers.GlobalAveragePooling2D(),
    layers.Dense(512, activation='relu'),
    layers.Dropout(0.4),
    layers.Dense(len(class_names), activation='softmax')
])
```

```
model.summary()
```

Downloading data from https://storage.googleapis.com/keras-applications/efficientnetb0_notop.h5
16705208/16705208 ━━━━━━━━ 2s 0us/step
Model: "sequential_1"

Layer (type)	Output Shape
efficientnetb0 (Functional)	(None, 8, 8, 1280)
batch_normalization_4 (BatchNormalization)	(None, 8, 8, 1280)
max_pooling2d_4 (MaxPooling2D)	(None, 4, 4, 1280)
global_average_pooling2d_1 (GlobalAveragePooling2D)	(None, 1280)
dense_2 (Dense)	(None, 512)
dropout_1 (Dropout)	(None, 512)
dense_3 (Dense)	(None, 4)

Total params: 4,712,615 (17.98 MB)

Trainable params: 4,668,032 (17.81 MB)

Non-trainable params: 44,583 (174.16 KB)

```
In [ ]: #-----  
  
class CustomEarlyStoppingAndCheckpoint(Callback):  
    def __init__(self, save_path, patience=12, verbose=1, save_best_only=True):  
        super(CustomEarlyStoppingAndCheckpoint, self).__init__()  
        self.save_path = save_path  
        self.patience = patience  
        self.verbose = verbose  
        self.save_best_only = save_best_only  
        self.best_weights = None  
        self.best_acc = -np.Inf  
        self.best_loss = np.Inf  
        self.wait = 0  
        self.stopped_epoch = 0  
  
    def on_epoch_end(self, epoch, logs=None):  
        val_loss = logs.get('val_loss')  
        val_acc = logs.get('val_accuracy')  
        if val_acc is None or val_loss is None:  
            return  
  
        # Checkpoint for best loss  
        if val_loss < self.best_loss:  
            self.best_loss = val_loss  
            if self.save_best_only:  
                self.model.save(self.save_path, include_optimizer=True)
```

```

        if self.verbose > 0:
            print(f"\nEpoch {epoch + 1}: val_loss improved to {val_l}

    # Early stopping for best accuracy
    if val_acc > self.best_acc:
        self.best_acc = val_acc
        self.best_weights = self.model.get_weights()
        self.wait = 0
    else:
        self.wait += 1
        if self.wait >= self.patience:
            self.stopped_epoch = epoch
            self.model.stop_training = True
            if self.verbose > 0:
                print(f"\nEpoch {epoch + 1}: early stopping")
            if self.best_weights is not None:
                self.model.set_weights(self.best_weights)
            if self.verbose > 0:
                print("Restoring model weights from the end of the best epoch")

    def on_train_end(self, logs=None):
        if self.stopped_epoch > 0 and self.verbose > 0:
            print(f"Epoch {self.stopped_epoch + 1}: early stopping triggered

#-----#
# Usage of the custom callback
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accuracy'])

callbacks = [
    CustomEarlyStoppingAndCheckpoint(
        save_path=r'/kaggle/working/best_model_transfer.h5',
        patience=12,
        verbose=1,
        save_best_only=True
    )
]

# Fit the model
history = model.fit(
    x = train_dataset,
    validation_data = val_dataset,
    epochs = 20,
    callbacks= callbacks # Add the EarlyStopping callback
)

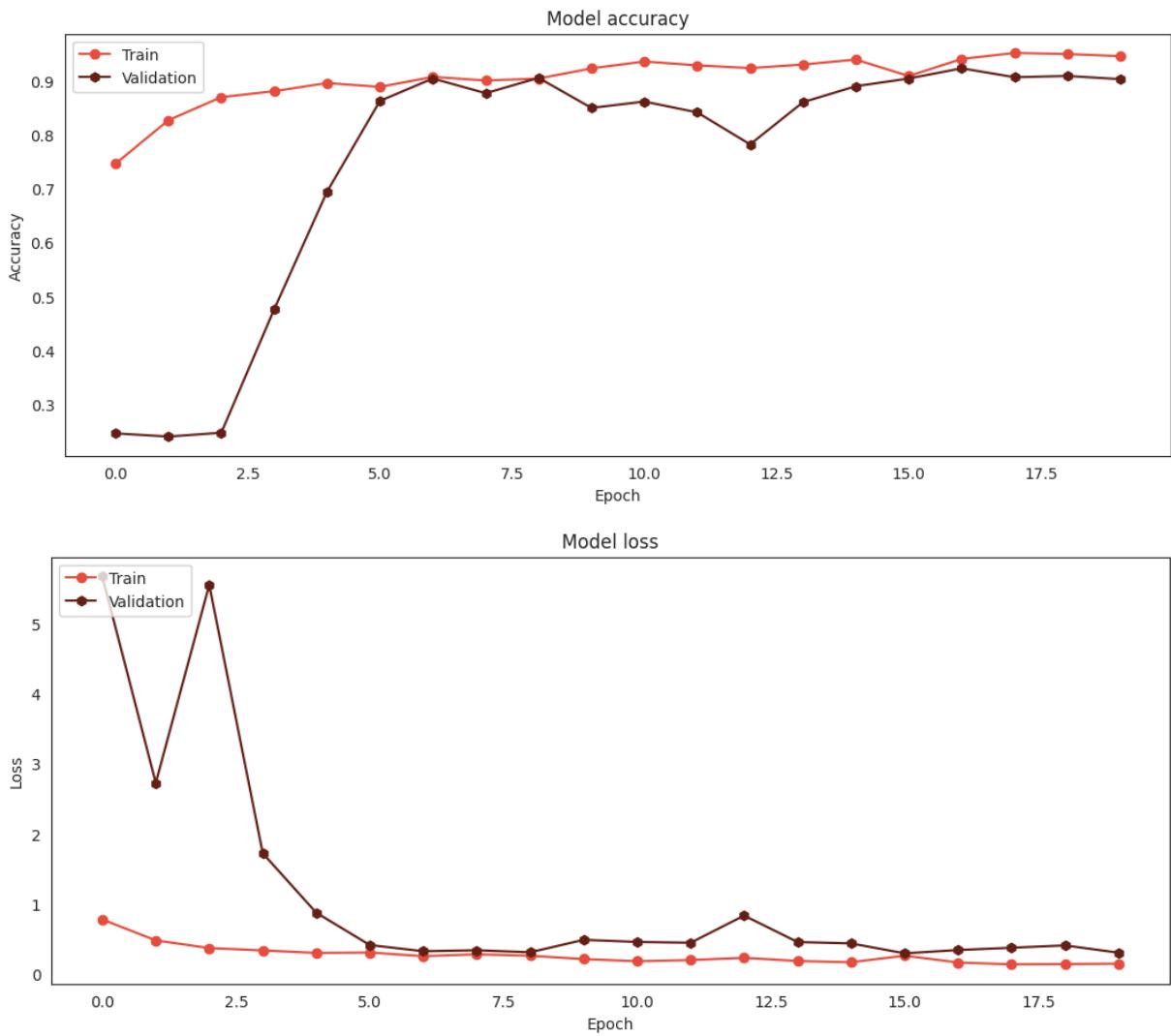
```

Epoch 1/20
159/159 ————— 0s 360ms/step - accuracy: 0.6445 - loss: 1.1540

WARNING:absl:You are saving your model as an HDF5 file via `model.save()` or `keras.saving.save_model(model)`. This file format is considered legacy. We recommend using instead the native Keras format, e.g. `model.save('my_model.keras')` or `keras.saving.save_model(model, 'my_model.keras')`.


```
In [ ]: # Plot training & validation accuracy values
plt.figure(figsize=(13,5))
plt.plot(history.history['accuracy'], color="#E74C3C", marker='o')
plt.plot(history.history['val_accuracy'], color="#641E16", marker='h')
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()

# Plot training & validation loss values
plt.figure(figsize=(13,5))
plt.plot(history.history['loss'], color="#E74C3C", marker='o')
plt.plot(history.history['val_loss'], color="#641E16", marker='h')
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()
```



```
In [ ]: # Load the saved model
# If the best model is captured by the early stopping mechanism then best_model = model
# best_model = model

best_model = load_model(r'/kaggle/working/best_model_transfer.h5')
best_model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accuracy'])

# Evaluate the model
train_loss, train_accuracy = best_model.evaluate(train_dataset)
val_loss, val_accuracy = best_model.evaluate(val_dataset)
test_loss, test_accuracy = best_model.evaluate(test_dataset)

print(f"train loss: {train_loss}")
print(f"train accuracy: {train_accuracy}")
print('----'*6)
print(f"val loss: {val_loss}")
print(f"val accuracy: {val_accuracy}")
print('----'*6)
print(f"Test loss: {test_loss}")
print(f"Test accuracy: {test_accuracy}")
```

```

WARNING:absl:Compiled the loaded model, but the compiled metrics have yet to
be built. `model.compile_metrics` will be empty until you train or evaluate
the model.
159/159 ━━━━━━━━ 30s 137ms/step - accuracy: 0.9098 - loss: 0.237
8
53/53 ━━━━━━━━ 7s 137ms/step - accuracy: 0.9067 - loss: 0.2736
53/53 ━━━━━━ 6s 104ms/step - accuracy: 0.8763 - loss: 0.3474
train loss: 0.22449705004692078
train accuracy: 0.9157769680023193
-----
val loss: 0.294607013463974
val accuracy: 0.9040284156799316
-----
Test loss: 0.35813987255096436
Test accuracy: 0.8803317546844482

```

```

In [ ]: # Assuming best_model is your trained Keras model

# Get the predicted labels from the model
y_pred = np.argmax( best_model.predict(test_dataset) , axis=1 ) # Convert pr
y_true = test_labels

# Compute confusion matrix
conf_mat = confusion_matrix(y_true, y_pred)

print("Confusion Matrix:")
print(conf_mat)

# Get the class labels from the LabelEncoder
class_labels = label_encoder.classes_

# Compute classification report
report = classification_report(y_true, y_pred, target_names=class_labels)

print("\nClassification Report:")
print(report)

```

53/53 ━━━━━━━━ 18s 178ms/step

Confusion Matrix:

```

[[192  0  5 11]
 [ 1 219  0  0]
 [ 26  0 131 44]
 [  4  3  7 201]]

```

Classification Report:

	precision	recall	f1-score	support
cataract	0.86	0.92	0.89	208
diabetic_retinopathy	0.99	1.00	0.99	220
glaucoma	0.92	0.65	0.76	201
normal	0.79	0.93	0.85	215
accuracy			0.88	844
macro avg	0.89	0.88	0.87	844
weighted avg	0.89	0.88	0.88	844

```
In [ ]: #Confusion matrix
print('Total Number Of Test data: ', len(test_labels))

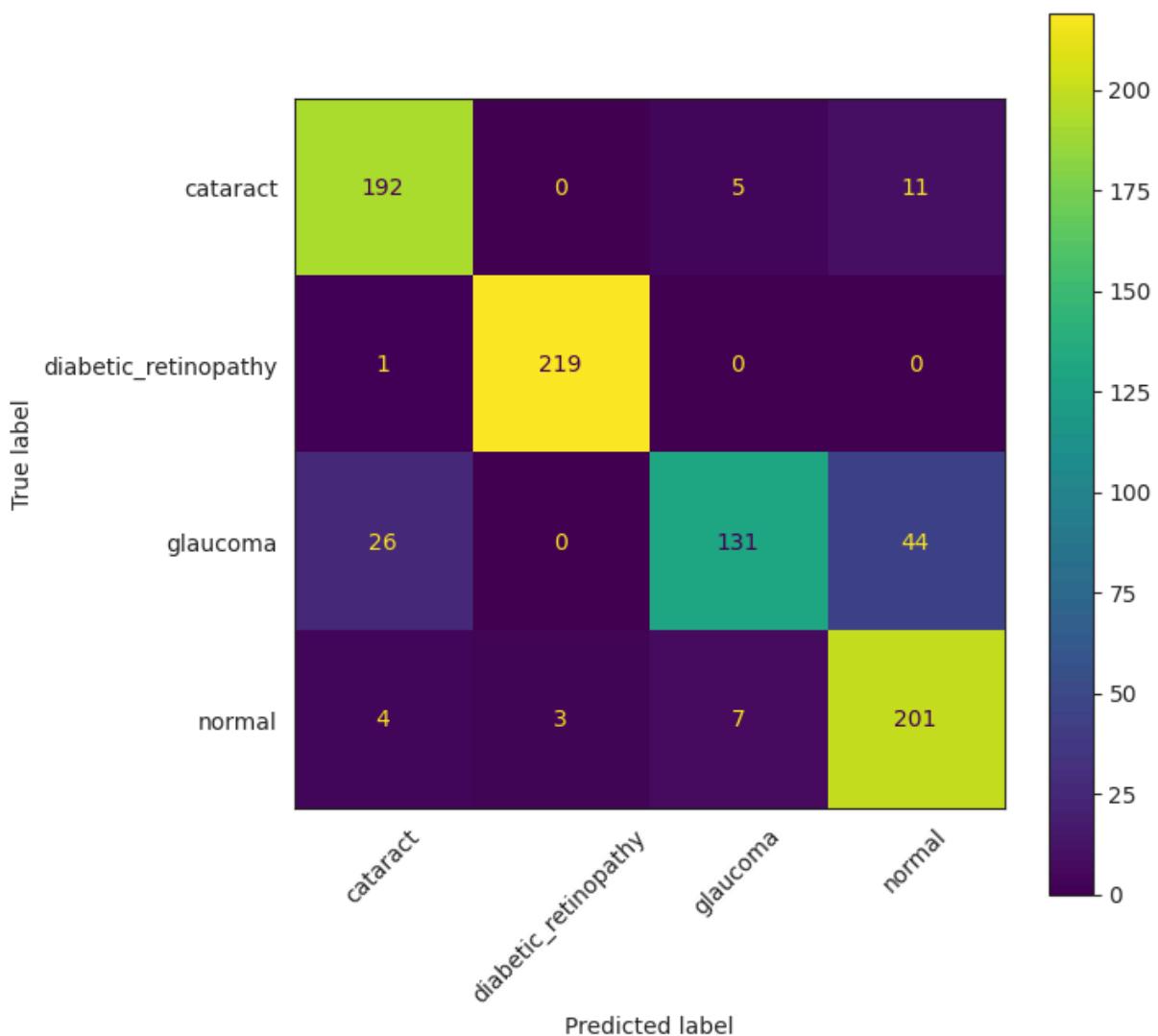
sn.set_style("white")
def plot_confusion_matrix(conf_mat, classes):
    """
    This function prints and plots the confusion matrix.
    """
    fig, ax = plt.subplots(figsize=(7,7)) # change the plot size
    disp = ConfusionMatrixDisplay(confusion_matrix=conf_mat, display_labels=
    disp = disp.plot(include_values=True,cmap='viridis', ax=ax, xticks_roat
    plt.show()

# Get your confusion matrix
conf_mat = conf_mat

# Using label_encoder.classes_ guarantees that class_names matches
# the order that was used during the one-hot encoding process
class_names = label_encoder.classes_

# Now plot using the function
plot_confusion_matrix(conf_mat, class_names)
```

Total Number Of Test data: 844



```
In [ ]: # probability explanation in below function:  
# For example, if the model predicts an image as class B with a probability  
# the plot will show "Probability: 70%".  
# This means the model is 70% confident that the image belongs to class B.  
  
def plot_test_predictions(model, test_dataset, class_labels, num_images=20):  
    """  
    Plots the predictions of a model on the test dataset.  
  
    Parameters:  
    - model: Trained Keras model to be used for prediction.  
    - test_dataset: TensorFlow dataset containing the test images and labels.  
    - class_labels: List of class labels.  
    - num_images: Number of test images to plot (default is 20).  
    """  
  
    # Initialize lists to accumulate images and labels  
    images = []  
    true_labels = []  
    pred_labels = []  
    pred_probs = []
```

```

for batch_images, batch_labels in test_dataset:
    # Predict on the batch
    batch_pred_probs = model.predict(batch_images)
    batch_pred_labels = np.argmax(batch_pred_probs, axis=1)

    # Accumulate images and labels
    images.extend(batch_images)
    true_labels.extend(batch_labels)
    pred_labels.extend(batch_pred_labels)
    pred_probs.extend(np.max(batch_pred_probs, axis=1) * 100)

    if len(images) >= num_images:
        break

# Plot the images with predictions
plt.figure(figsize=(15, 20))
for i in range(num_images):
    plt.subplot(5, 5, i + 1)
    plt.imshow(images[i])
    actual_label = class_labels[true_labels[i]]
    predicted_label = class_labels[pred_labels[i]]
    probability = pred_probs[i] # Probability of the predicted class

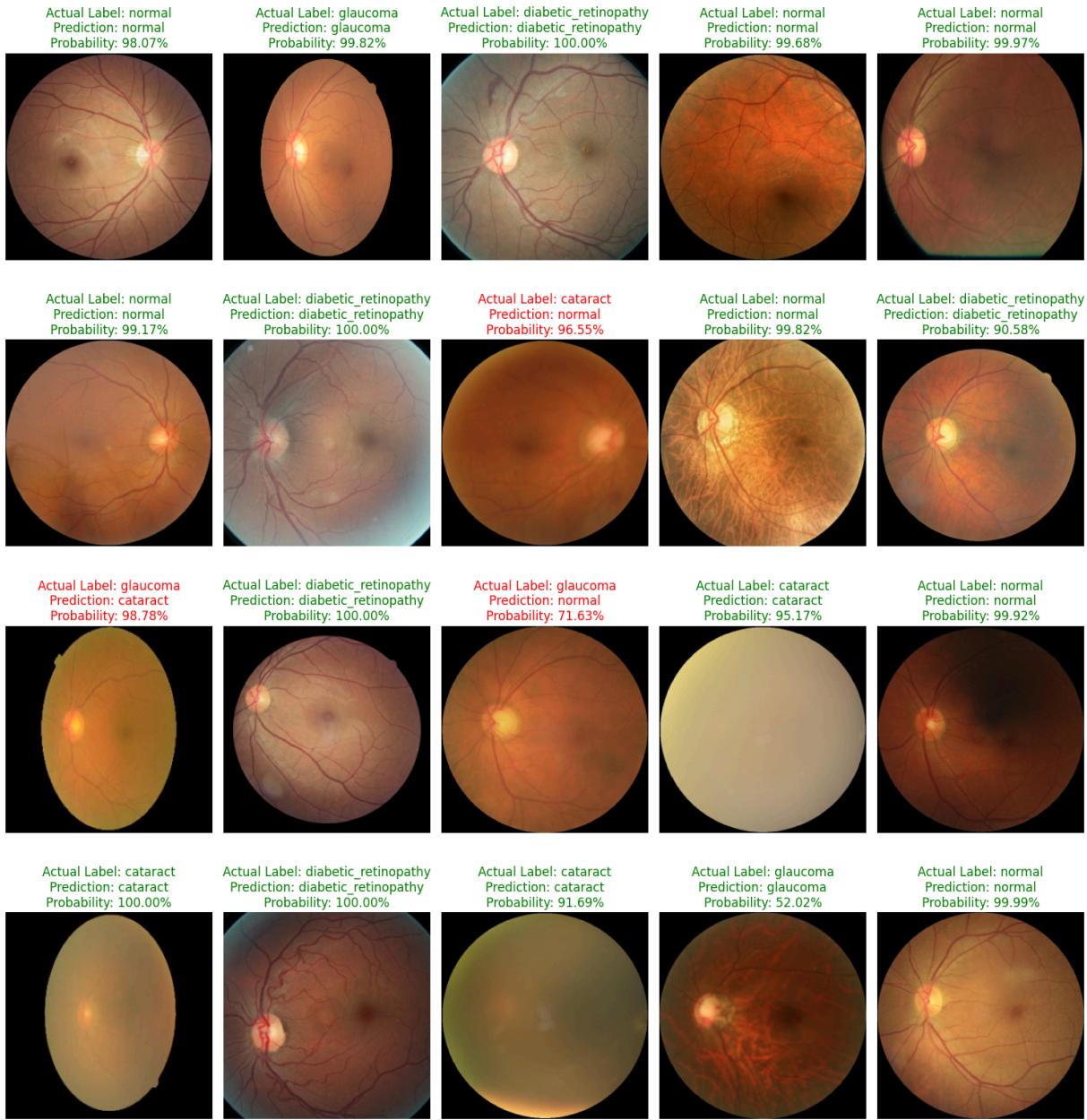
    color = 'green' if actual_label == predicted_label else 'red'
    plt.title(f"Actual Label: {actual_label}\nPrediction: {predicted_label}")
        color=color, fontsize=12)
    plt.axis('off')

plt.tight_layout()
plt.show()

# Use the function
plot_test_predictions(best_model, test_dataset, class_labels=class_names, nu

```

1/1 ━━━━━━━━ **6s** 6s/step
 1/1 ━━━━━━━━ **0s** 38ms/step



In []:

This notebook was converted with convert.ploomber.io