Exploratory Data Analysis

```
# Required imports
import os
import json
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import cv2
from PIL import Image
import hashlib
import os
import cv2

# Set base directory for dataset
BASE_DIR = "/kaggle/input/cassava-leaf-disease-classification"

with
open("/kaggle/input/cassava-leaf-disease-classification/label_num_to_d
isease_map.json") as file:
    print("yes")
```

```
yes
```

```
# Step 1: Load and inspect label map (mapping from numerical labels to
disease names)
with open(os.path.join(BASE_DIR, "label_num_to_disease_map.json")) as
file:
    map_classes = json.loads(file.read())
    map_classes = {int(k): v for k, v in map_classes.items()}

# Display the mapping
print("Class Mapping: ")
print(json.dumps(map_classes, indent=4))
```

```
Class Mapping:
{
    "0": "Cassava Bacterial Blight (CBB)",
    "1": "Cassava Brown Streak Disease (CBSD)",
    "2": "Cassava Green Mottle (CGM)",
    "3": "Cassava Mosaic Disease (CMD)",
    "4": "Healthy"
}
```

```
os.listdir(os.path.join(BASE_DIR, "train_images"))
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'3887762313.jpg',
'1419604978.jpg',
'3567504840.jpg',
'1358792990.jpg',
'2611538307.jpg',
'3500950357.jpg',
'2139984567.jpg',
'1658205752.jpg',
'2000281372.jpg',
'2002346677.jpg',
'1218794118.jpg',
'3647482405.jpg',
'4274749483.jpg',
'4040861068.jpg',
'2042895796.jpg',
'3419507688.jpg',
'2318645335.jpg',
'91285032.jpg',
'385391871.jpg',
'2448870532.jpg',
'3276292509.jpg',
'785251696.jpg',
'3740700061.jpg',
'2689770530.jpg',
'2086436188.jpg',
'846824837.jpg',
'2623245968.jpg',
'2587436758.jpg',
'2606643559.jpg',
'1948267522.jpg',
'1436718296.jpg',
'3042292188.jpg',
'127776052.jpg',
```

```
'48153077.jpg',
'3964029612.jpg',
'2209303439.jpg',
'3373304739.jpg',
'2045580929.jpg',
'3440246067.jpg',
'1214627201.jpg',
'3979826725.jpg',
'639060341.jpg',
'849182498.jpg',
'4233882902.jpg',
'2047500718.jpg',
'161212223.jpg',
'3237441683.jpg',
'2405316066.jpg',
'1796222011.jpg',
'1909574970.jpg',
'598746218.jpg',
'3797289739.jpg',
'394451018.jpg',
'4284813323.jpg',
'1691647530.jpg',
'15982075.jpg',
'3197563521.jpg',
'1960012199.jpg',
'3870634420.jpg',
'2800300240.jpg',
'1561998426.jpg',
'2226045745.jpg',
'920623788.jpg',
'731084892.jpg',
'2137780185.jpg',
'4130557422.jpg',
'1639780135.jpg',
'4256968855.jpg',
'4170665280.jpg',
'1067379852.jpg',
'4038568741.jpg',
'3808794161.jpg',
'208826492.jpg',
'1474434656.jpg',
'1951683874.jpg',
'2597470760.jpg',
'3077845683.jpg',
'4116414929.jpg',
'2601706130.jpg',
'1826527887.jpg',
'4234605337.jpg',
'936775758.jpg',
```

```
'2941780886.jpg',
'2871575859.jpg',
'3058839740.jpg',
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'3567421807.jpg',
'701148586.jpg',
'2164873412.jpg',
'4261671268.jpg',
'4056070889.jpg',
'3121142461.jpg',
'1117199954.jpg',
'3602830290.jpg',
'1296168681.jpg',
'3044190781.jpg',
'910617288.jpg',
'1048581072.jpg',
'2476543961.jpg',
'2733802395.jpg',
'780779910.jpg',
'2583614987.jpg',
'2930575492.jpg',
'3951384519.jpg',
'1149596528.jpg',
'2978135052.jpg',
'133303828.jpg',
'3114522519.jpg',
'2213611476.jpg',
'2859411048.jpg',
'1805115397.jpg',
'2606136202.jpg',
'1829519358.jpg',
'1677822348.jpg',
'3977934674.jpg',
'2596954655.jpg',
'4522938.jpg',
'3464607854.jpg',
'3267434230.jpg',
'2146353282.jpg',
'1736448195.jpg',
'1723407805.jpg',
'2915309072.jpg',
'3436413534.jpg',
'472489554.jpg',
'4254213032.jpg',
'611507457.jpg',
'503224990.jpg',
'451261982.jpg',
'3766633636.jpg',
'639068838.jpg',
```

```
'557774617.jpg',
'1047894047.jpg',
'1546329958.jpg',
'3568729258.jpg',
'3633505917.jpg',
'2072537637.jpg',
'3667619405.jpg',
'3011700717.jpg',
'2818289247.jpg',
'424999624.jpg',
'3451069987.jpg',
'1476112995.jpg',
'3676837791.jpg',
'1472183727.jpg',
'2836107083.jpg',
'370989494.jpg',
'2633910453.jpg',
'1891182946.jpg',
'52672633.jpg',
'635279232.jpg',
'2740240477.jpg',
'3849865547.jpg',
'4215655540.jpg',
'3471618012.jpg',
'895910836.jpg',
'2240297228.jpg',
'2209356814.jpg',
'1365404548.jpg',
'4279248558.jpg',
'4018307313.jpg',
'2504965655.jpg',
'1809122626.jpg',
'2430296671.jpg',
'3964194408.jpg',
'2441927798.jpg',
'2097619367.jpg',
'1445369057.jpg',
'1515163743.jpg',
'2907186124.jpg',
'3680354956.jpg',
'2435254407.jpg',
'2543879211.jpg',
'2286124427.jpg',
'2059469005.jpg',
'2526623317.jpg',
'3811396790.jpg',
'1239825198.jpg',
'2027324099.jpg',
'335796643.jpg',
```

```
'2150392038.jpg',
'2752466458.jpg',
'673868311.jpg',
'854627770.jpg',
'3511001525.jpg',
'4205544766.jpg',
'2057007338.jpg',
'4135070493.jpg',
'1079224858.jpg',
'2587457959.jpg',
'2477858047.jpg',
'551875095.jpg',
'2872638305.jpg',
'2932008073.jpg',
'4228467711.jpg',
'2276509518.jpg',
'813060428.jpg',
'4096337072.jpg',
'1391911669.jpg',
'315046129.jpg',
'2321993342.jpg',
'2445348448.jpg',
'114081332.jpg',
'3684621874.jpg',
'248804719.jpg',
'2997295640.jpg',
'5511383.jpg',
'4114035268.jpg',
'2023813792.jpg',
'4121046251.jpg',
'4059993044.jpg',
'2338213285.jpg',
'2289989107.jpg',
'4120621808.jpg',
'3964080612.jpg',
'1735461481.jpg',
'2854111497.jpg',
'4020138210.jpg',
'4263725317.jpg',
'3638122648.jpg',
'745723934.jpg',
'2035397744.jpg',
'157149350.jpg',
'396528848.jpg',
'1399448037.jpg',
'3058038323.jpg',
'2949246528.jpg',
'3746522482.jpg',
'3020460837.jpg',
```

```
 '3345615928.jpg',
 '232481441.jpg',
 '1824113054.jpg',
 '1927144610.jpg',
 '3158054107.jpg',
 '2717129685.jpg',
 '3145516632.jpg',
 '1220365722.jpg',
 '2085011211.jpg',
 '1776880375.jpg',
 '3427476782.jpg',
 '80482467.jpg',
 '568226171.jpg',
 '1160075077.jpg',
 '3277409188.jpg',
 '4025247063.jpg',
 ...]
```

```
# Step 2: Load training image filenames and display the count
input_files = os.listdir(os.path.join(BASE_DIR, "train_images"))
print(f"Number of train images: {len(input_files)}")
```

```
Number of train images: 21397
```

```
# Step 3: Load train.csv and add a human-readable class name based on the mapping
df_train = pd.read_csv(os.path.join(BASE_DIR, "train.csv"))
df_train.head()
```

```
         image_id  label
0  1000015157.jpg      0
1  1000201771.jpg      3
2   100042118.jpg      1
3  1000723321.jpg      1
4  1000812911.jpg      3
```

```
df_train["class_name"] = df_train["label"].map(map_classes)
df_train
```

```
             image_id  label                              class_name
0      1000015157.jpg      0       Cassava Bacterial Blight (CBB)
1      1000201771.jpg      3         Cassava Mosaic Disease (CMD)
2       100042118.jpg      1  Cassava Brown Streak Disease (CBSD)
3      1000723321.jpg      1  Cassava Brown Streak Disease (CBSD)
4      1000812911.jpg      3         Cassava Mosaic Disease (CMD)
...                ...    ...                                  ...
21392   999068805.jpg      3         Cassava Mosaic Disease (CMD)
21393   999329392.jpg      3         Cassava Mosaic Disease (CMD)
21394   999474432.jpg      1  Cassava Brown Streak Disease (CBSD)
21395   999616605.jpg      4                             Healthy
21396   999998473.jpg      4                             Healthy
```

```
[21397 rows x 3 columns]
```

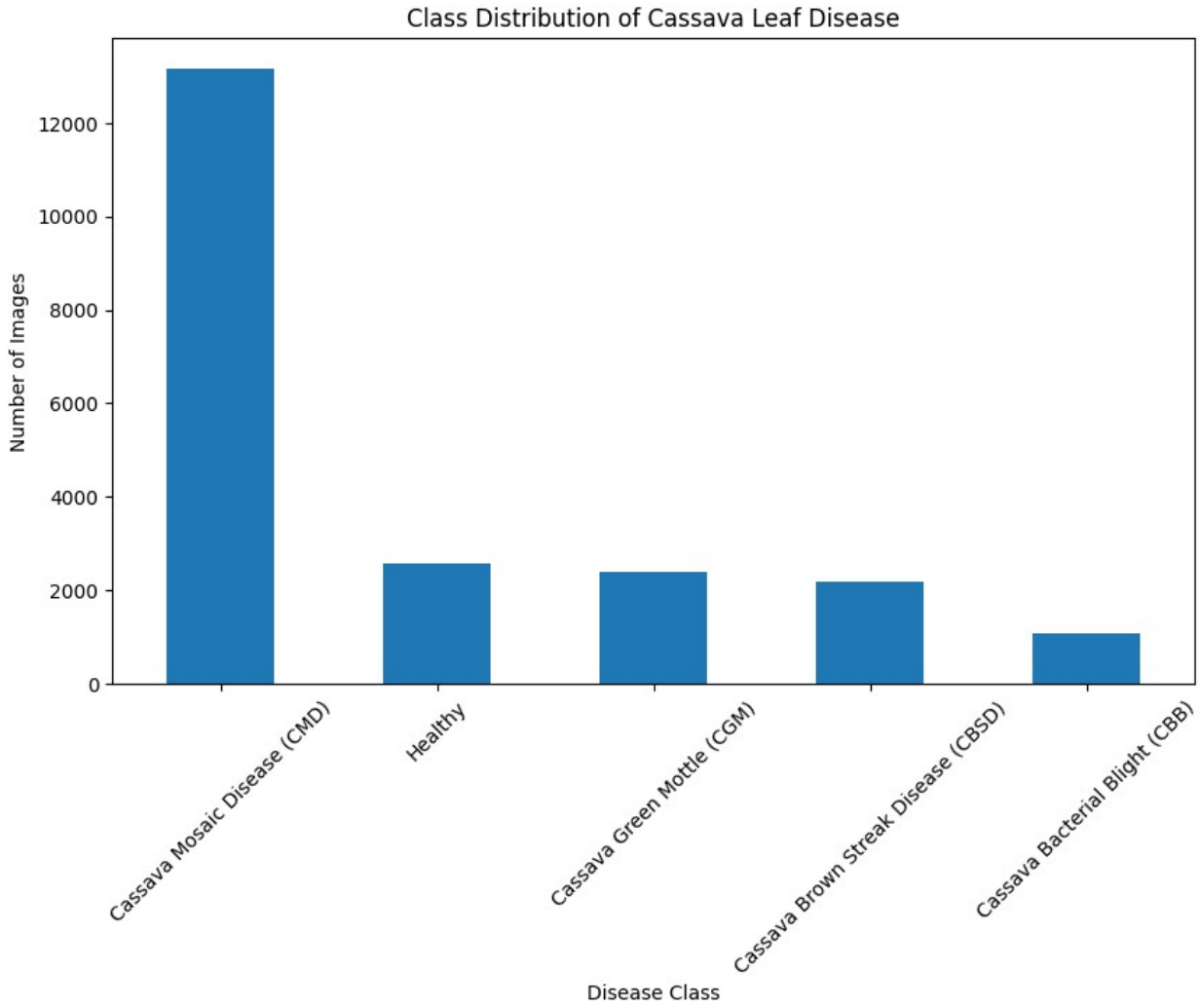
```
df_train['class_name'].value_counts()
```

```
class_name
Cassava Mosaic Disease (CMD)           13158
Healthy                                 2577
Cassava Green Mottle (CGM)              2386
Cassava Brown Streak Disease (CBSD)     2189
Cassava Bacterial Blight (CBB)          1087
Name: count, dtype: int64
```

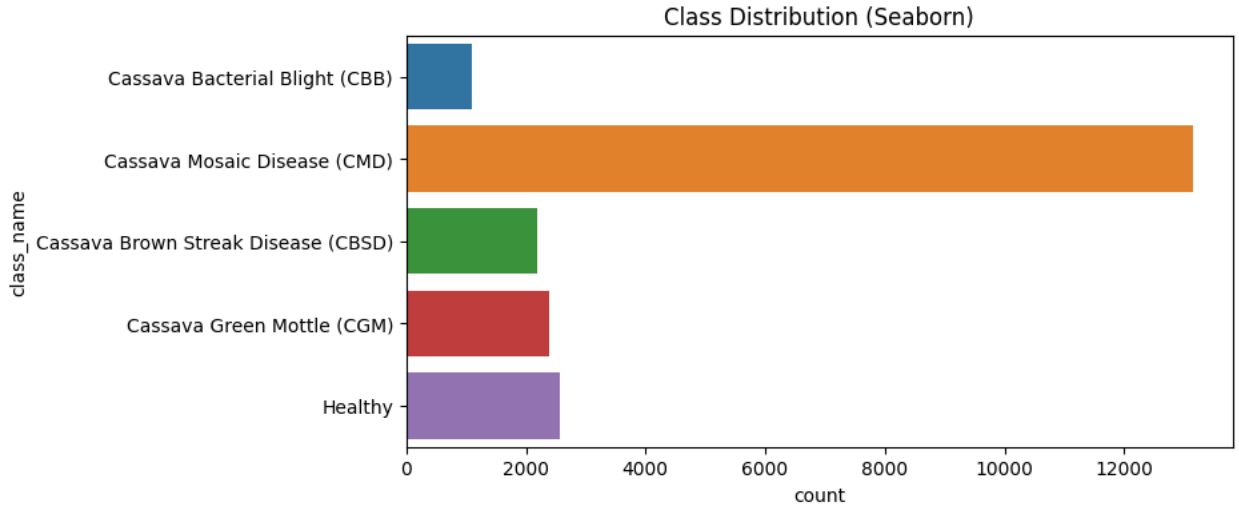
Techniques like transfer leanirng, you dont need to balance hte data. Internally model will handle. (Pre trained model)

Scratch - then you need to do somehting about imbalance..

```
# Step 4: Check class distribution
class_distribution = df_train['class_name'].value_counts()
# Plot the class distribution
plt.figure(figsize=(10, 6))
class_distribution.plot(kind='bar')
plt.title('Class Distribution of Cassava Leaf Disease')
plt.ylabel('Number of Images')
plt.xlabel('Disease Class')
plt.xticks(rotation=45)
plt.show()
```




```
# Alternatively, use seaborn for a countplot visualization
plt.figure(figsize=(8, 4))
sns.countplot(y="class_name", data=df_train)
plt.title('Class Distribution (Seaborn)')
plt.show()
```




```
# Step 5: Basic dataset exploration
# Show data info and summary statistics
print("Dataset Info:")
print(df_train.info())
```

```
Dataset Info:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 21397 entries, 0 to 21396
Data columns (total 3 columns):
 #   Column      Non-Null Count  Dtype 
---  ------      --------------  ----- 
 0   image_id    21397 non-null  object
 1   label       21397 non-null  int64 
 2   class_name  21397 non-null  object
dtypes: int64(1), object(2)
memory usage: 501.6+ KB
None
```

```
print("\nDataset Summary Statistics:")
print(df_train.describe())
```

```
Dataset Summary Statistics:
              label
count  21397.000000
mean       2.651914
std        0.988565
min        0.000000
25%        2.000000
50%        3.000000
75%        3.000000
max        4.000000
```

```
# Step 6: Check for missing values and duplicates
print(f"\nMissing values in each column:\n{df_train.isnull().sum()}")
print(f"Number of duplicate rows: {df_train.duplicated().sum()}")
```

```
Missing values in each column:
image_id      0
label         0
class_name    0
dtype: int64
Number of duplicate rows: 0
```

Images - let's check the shape of the images.

Images - 50*50 (very small pixels) it doesn't make any sense to upscale to 224*224 (mess up informaiton)

images 600 * 600 resize to may be 224 224 500 * 500

images size distributin you need to tune your resize image size.

```
path =
"/kaggle/input/cassava-leaf-disease-classification/train_images/1000015157.jpg"
path2 = "1000015157.jpg"


cv2.imread(path2)
```

```
[ WARN:0@638.540] global loadsave.cpp:241 findDecoder
imread_('1000015157.jpg'): can't open/read file: check file
path/integrity
```

```
cv2.imread(path2)
```

```
[ WARN:0@706.511] global loadsave.cpp:241 findDecoder
imread_('1000015157.jpg'): can't open/read file: check file
path/integrity
```

```
# Step 7: Analyze image shapes (size dimensions) for a sample of 300
images
# Dictionary to store image shapes and their counts
img_shapes = {}
for image_name in os.listdir(os.path.join(BASE_DIR, "train_images"))
[:1000]:
    image = cv2.imread(os.path.join(BASE_DIR, "train_images",
image_name))
    img_shapes[image.shape] = img_shapes.get(image.shape, 0) + 1

# Display image shapes
print("\nSample Image Shapes and their Frequencies (from 1000
```

```
images):")
print(img_shapes)
```

```
Sample Image Shapes and their Frequencies (from 1000 images):
{(600, 800, 3): 1000}
```

I have my images with the size 600 * 800 * 3 (rgb channels) color full image.

```
# Plot the image size distribution
img_shapes_df = pd.DataFrame(list(img_shapes.items()), columns=['Image
Shape', 'Count'])
plt.figure(figsize=(10, 6))
img_shapes_df.sort_values(by='Count',
ascending=False).plot(kind='bar', x='Image Shape', y='Count',
legend=False)
plt.title('Image Shape Distribution (Sample of 300 Images)')
plt.xlabel('Image Shape')
plt.ylabel('Number of Images')
plt.xticks(rotation=45)
plt.show()
```

```
<Figure size 1000x600 with 0 Axes>
```

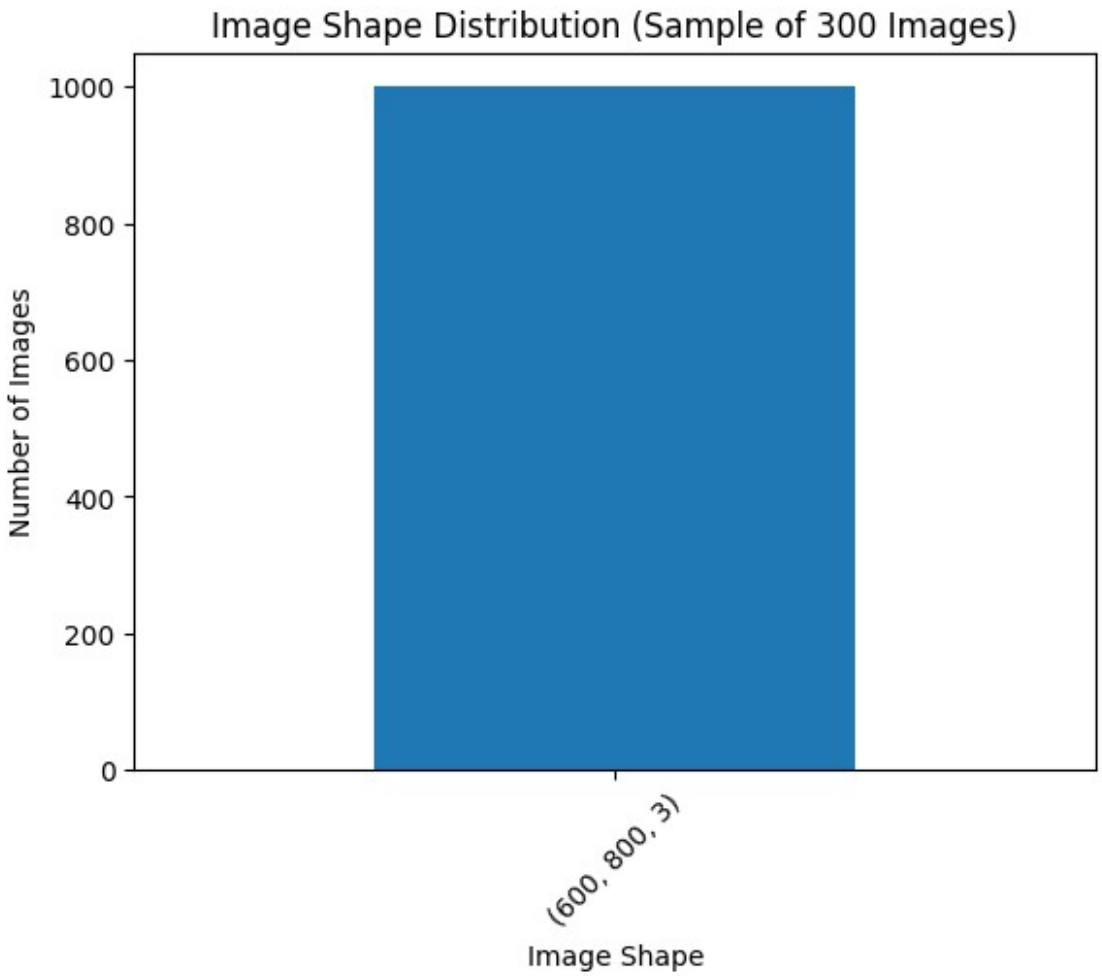


Image Shape Distribution (Sample of 300 Images)
Number of Images
1000
800
600
400
200
0
(600, 800, 3)
Image Shape

Loading data

shapes

info

null vlaues

describe

image shapes

```
df_train.head()
```

```
          image_id  label                              class_name
0  1000015157.jpg      0       Cassava Bacterial Blight (CBB)
1  1000201771.jpg      3         Cassava Mosaic Disease (CMD)
2   100042118.jpg      1  Cassava Brown Streak Disease (CBSD)
3  1000723321.jpg      1  Cassava Brown Streak Disease (CBSD)
4  1000812911.jpg      3         Cassava Mosaic Disease (CMD)
```

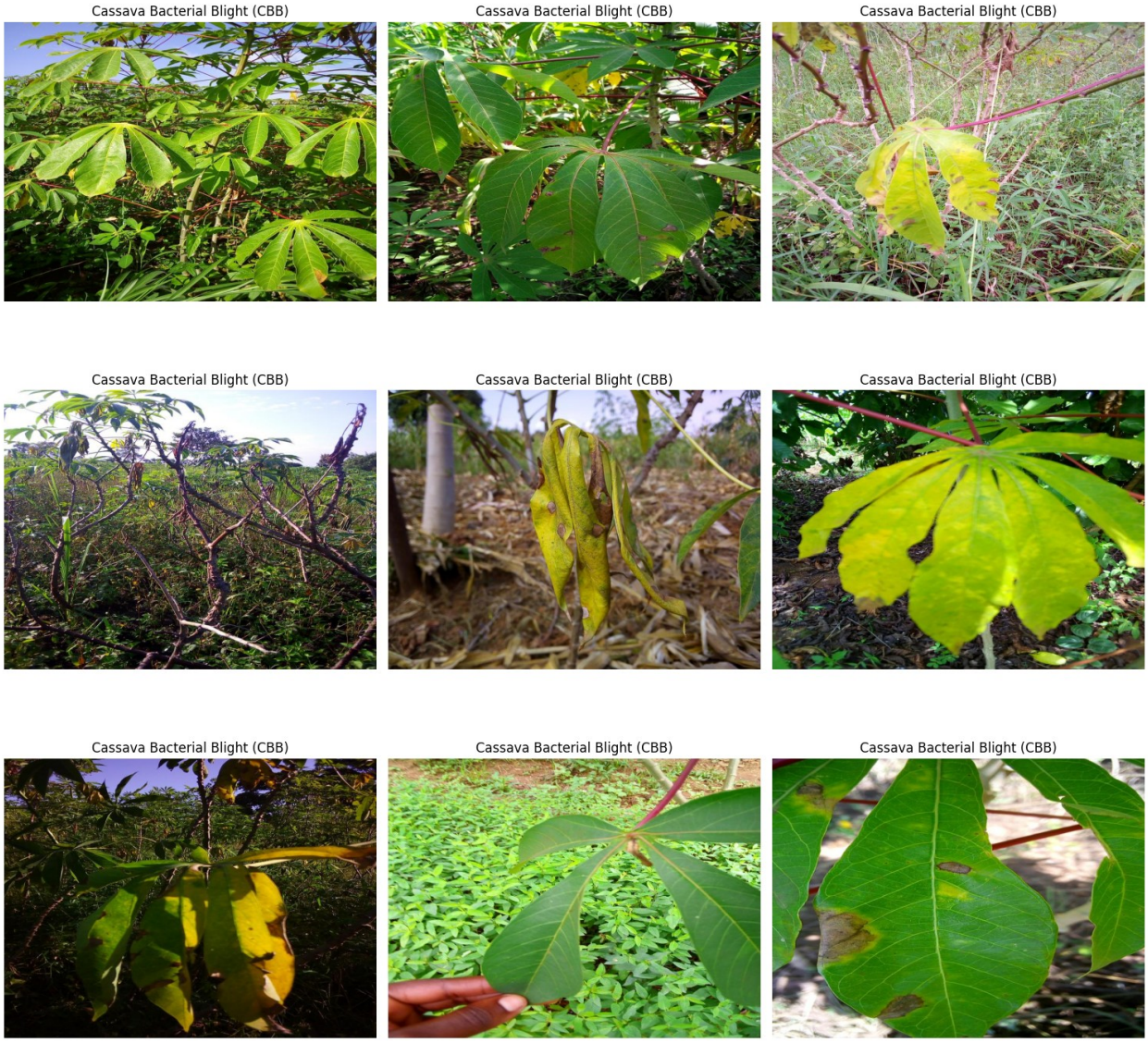
```
# Step 8: Function to plot sample images from a specific class
def plot_images_from_class(class_id, num_images=9):
    """
    Plot sample images from a specific class in a 3x3 grid.

    Parameters:
        class_id (int): The class label to filter images.
        num_images (int): The number of images to plot.
    """
    # Filter images for the specified class
    class_images = df_train[df_train['label'] == class_id]
    num_images = min(len(class_images), num_images)  # Adjust if fewer
images than requested

    plt.figure(figsize=(15, 15))  # Set figure size for better
visualization
    images = class_images.sample(num_images)  # Randomly sample images

    # Plot images in a 3x3 grid
```

```
    for i, (_, row) in enumerate(images.iterrows()):
        img_path = os.path.join(BASE_DIR, "train_images",
row['image_id'])
        img = Image.open(img_path)
        plt.subplot(3, 3, i + 1)
        plt.imshow(img)
        plt.title(map_classes[class_id])  # Use class name for the
title
        plt.axis('off')  # Hide axis for better visualization

    plt.tight_layout()  # Adjust layout to prevent overlap
    plt.show()
```

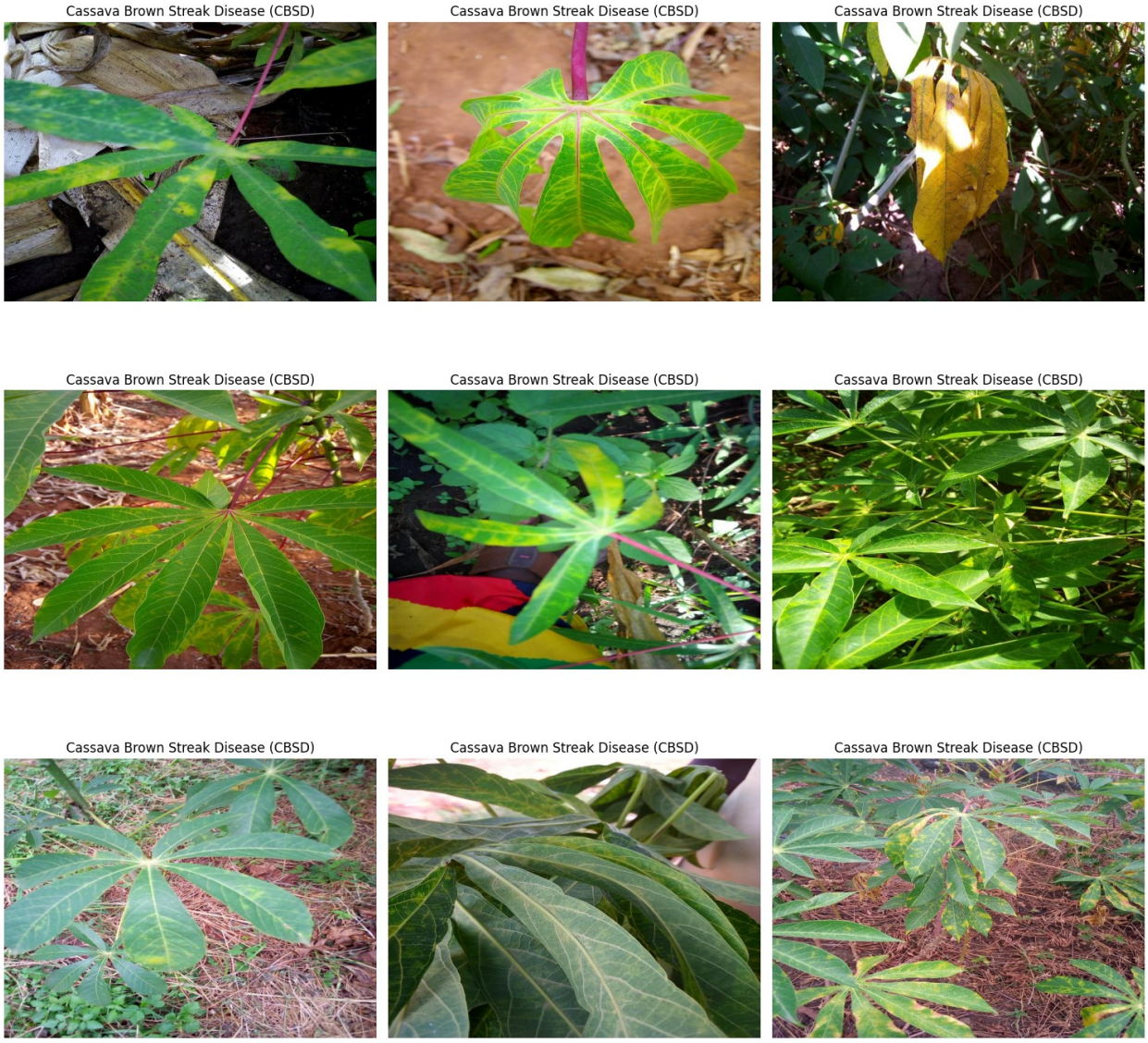
012345

```
plot_images_from_class(0)
```

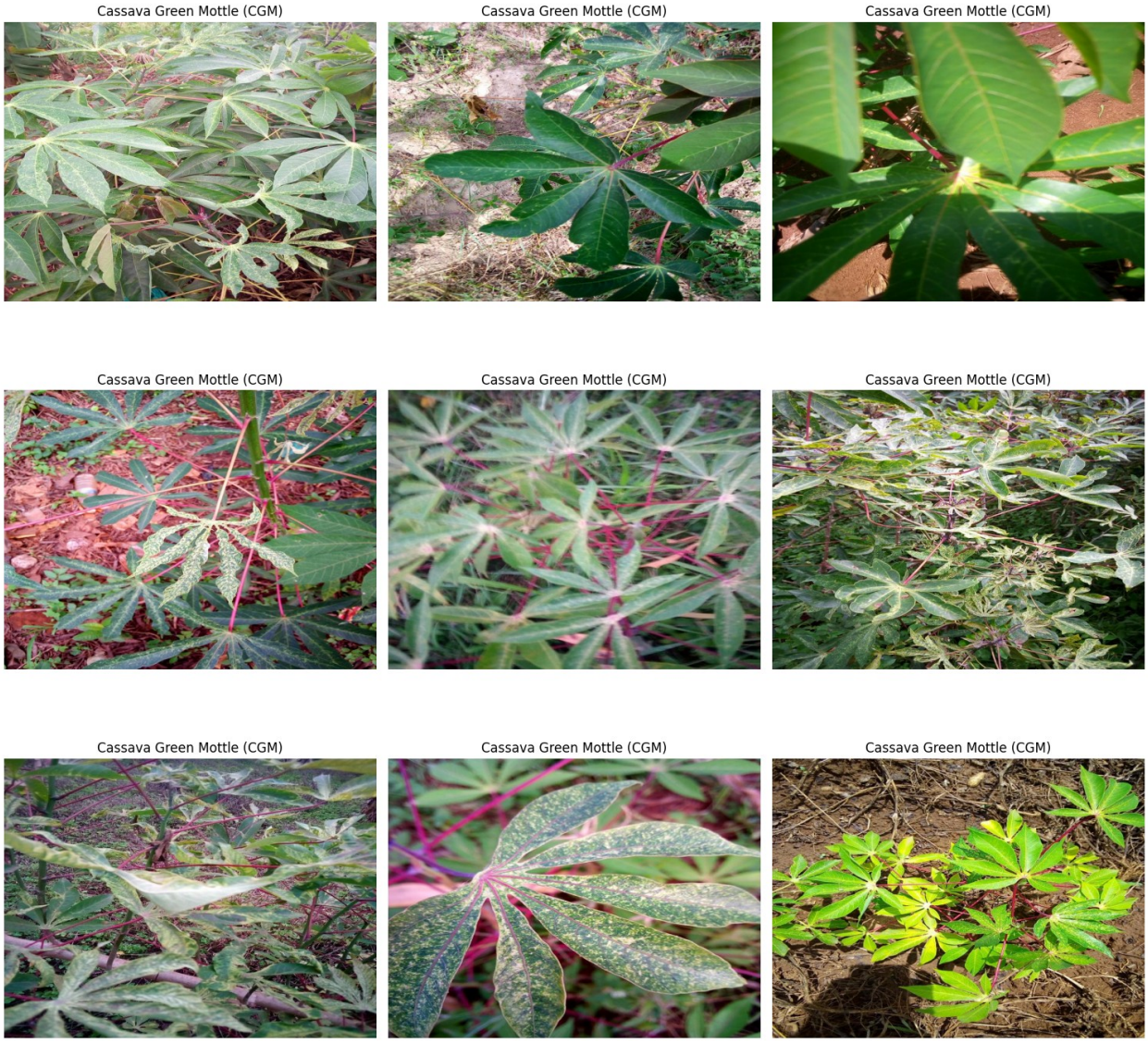

```
# Step 9: Visualize sample images for each class (0 to 4)
for i in range(5):
    print(f"Displaying sample images for class: {map_classes[i]}")
    plot_images_from_class(i)

Displaying sample images for class: Cassava Bacterial Blight (CBB)
```



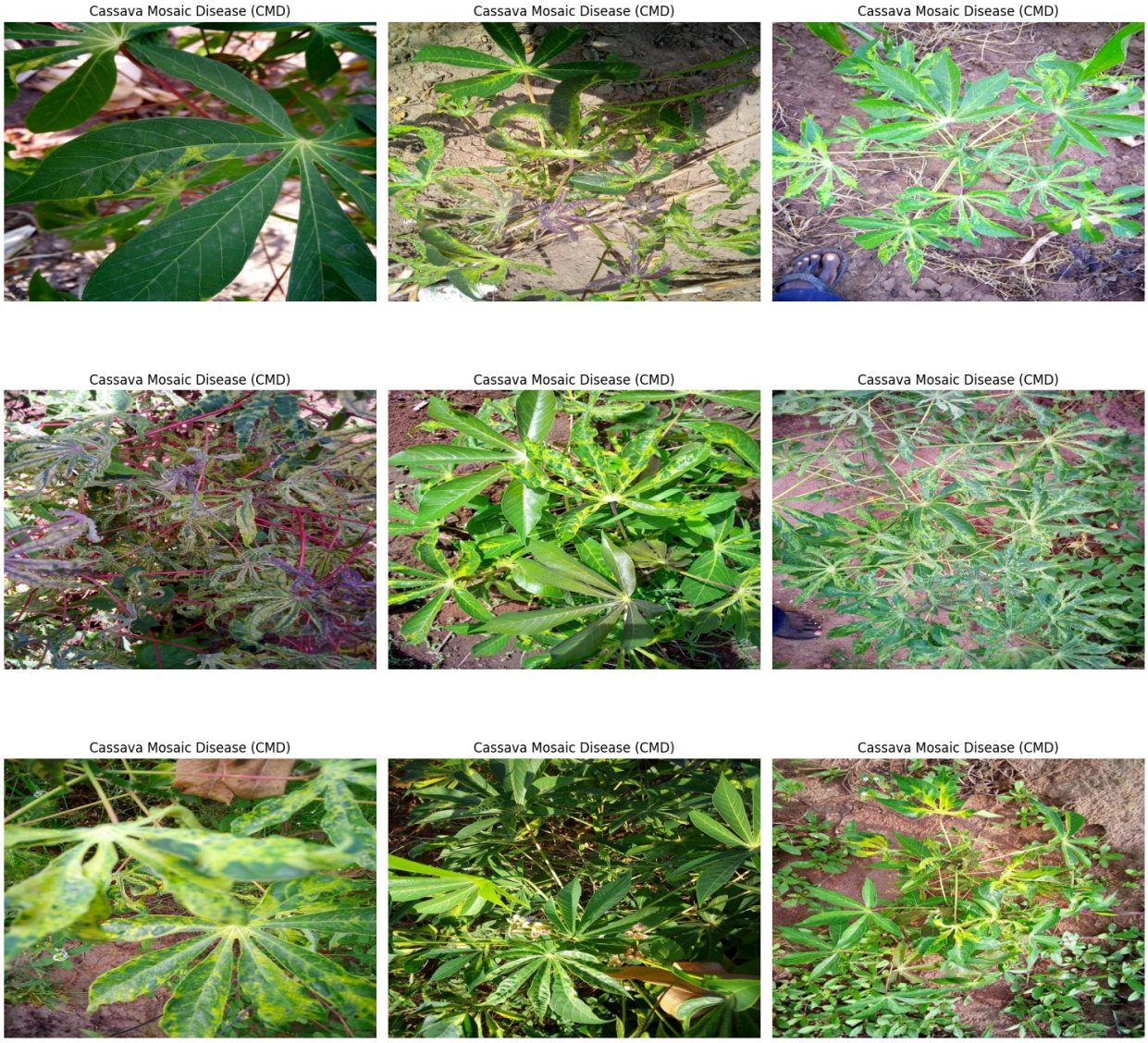

```
Displaying sample images for class: Cassava Brown Streak Disease
(CBSD)
```




```
Displaying sample images for class: Cassava Green Mottle (CGM)
```




```
Displaying sample images for class: Cassava Mosaic Disease (CMD)
```

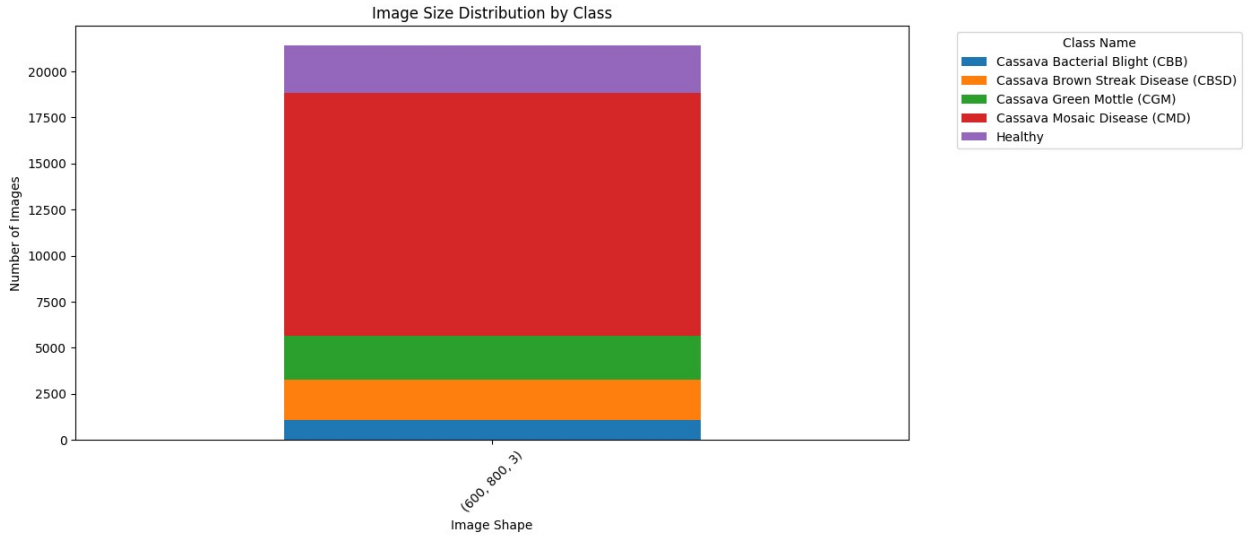



```
Displaying sample images for class: Healthy
```

we are leaf doctors

```
# Step 10: Check image shapes for the entire dataset
df_train['image_shape'] = df_train['image_id'].apply(lambda x:
cv2.imread(os.path.join(BASE_DIR, "train_images", x)).shape)

# Group by class and image shape to see if there's a pattern in image
size by disease type
shape_class_dist = df_train.groupby(['class_name',
'image_shape']).size().unstack(fill_value=0)

# Plot the distribution of image sizes for each class
shape_class_dist.T.plot(kind='bar', stacked=True, figsize=(12, 6))
plt.title('Image Size Distribution by Class')
plt.xlabel('Image Shape')
plt.ylabel('Number of Images')
```

```
plt.legend(title='Class Name', bbox_to_anchor=(1.05, 1), loc='upper
left')
plt.xticks(rotation=45)
plt.show()
```



Step 1 : Analyzing the Patient¶ What would be a first step that a Leaf doctor should do before anything considering the fact that his client can't speak ? The answer is simple right , analyze what's wrong by looking at the patient

But how does a doctor understands if something is wrong by just looking at it? For this as a doctor , he should know what a normal Patient/Leaf looks like and observe deviations (in pattern ,color, texture,etc) from the normal behavior to separate the healthy patients from infected ones . Now to further classify the infected ones into specific class of diseases doctor should also know how the patient/leaf condition looks like in different diseases

With these pointers in mind let's start with basic familarity

This can help you understand if certain classes are more commonly associated with specific image sizes, which might indicate that certain images were taken under different conditions or with different devices.

```
df_train.head()
```

```
         image_id  label                              class_name
image_shape
0  1000015157.jpg      0       Cassava Bacterial Blight (CBB)  (600,
800, 3)
1  1000201771.jpg      3         Cassava Mosaic Disease (CMD)  (600,
800, 3)
2   100042118.jpg      1  Cassava Brown Streak Disease (CBSD)  (600,
800, 3)
3  1000723321.jpg      1  Cassava Brown Streak Disease (CBSD)  (600,
800, 3)
```

```
4  1000812911.jpg      3         Cassava Mosaic Disease (CMD)  (600,
800, 3)
```

```
df_train['label_names'] = df_train['label'].map(map_classes)
```

Duplicate Images

```
# Finding Duplicate Images
# Identifying Exact Duplicate Images

def get_image_hash(image_path):
    """Generate an MD5 hash for the image."""
    with open(image_path, "rb") as f:
        file_hash = hashlib.md5(f.read()).hexdigest()
    return file_hash

# Dictionary to store image hashes and their file names
image_hashes = {}

# Check for duplicate images
duplicate_images = []

for image_name in os.listdir(os.path.join(BASE_DIR, "train_images")):
    image_path = os.path.join(BASE_DIR, "train_images", image_name)
    image_hash = get_image_hash(image_path)

    if image_hash in image_hashes:
        duplicate_images.append((image_name,
image_hashes[image_hash]))  # Image is a duplicate
    else:
        image_hashes[image_hash] = image_name  # Store the hash

print(f"Found {len(duplicate_images)} exact duplicate images.")
for dup in duplicate_images:
    print(f"Duplicate pair: {dup[0]} and {dup[1]}")
```

```
Found 0 exact duplicate images.
```

```
len(image_hashes)
```

```
21397
```

Model -- 1 : Let's train Base Model

```
import tensorflow as tf
from tensorflow.keras import layers, models
```

```
# Define the CNN model architecture
model = models.Sequential()

# 1st Convolutional block
model.add(layers.Conv2D(32, (3, 3), activation='relu',
input_shape=(224, 224, 3)))
model.add(layers.BatchNormalization())
model.add(layers.MaxPooling2D((2, 2)))

# 2nd Convolutional block
model.add(layers.Conv2D(64, (3, 3), activation='relu'))
model.add(layers.BatchNormalization())
model.add(layers.MaxPooling2D((2, 2)))

# 3rd Convolutional block
model.add(layers.Conv2D(128, (3, 3), activation='relu'))
model.add(layers.BatchNormalization())
model.add(layers.MaxPooling2D((2, 2)))

# 4th Convolutional block
model.add(layers.Conv2D(256, (3, 3), activation='relu'))
model.add(layers.BatchNormalization())
model.add(layers.MaxPooling2D((2, 2)))

# Flatten the output to feed it into fully connected layers
model.add(layers.Flatten())

# Dense layer with 512 units
model.add(layers.Dense(512, activation='relu'))
model.add(layers.BatchNormalization())
model.add(layers.Dropout(0.5))

# Output layer for classification (assuming 5 classes)
model.add(layers.Dense(5, activation='softmax'))

# Compile the model
model.compile(optimizer='adam',
              loss='categorical_crossentropy',  # Assuming sparse
labels (integers)
              metrics=['accuracy'])

# Model summary
model.summary()
```

```
/opt/conda/lib/python3.10/site-packages/keras/src/layers/
convolutional/base_conv.py:107: UserWarning: Do not pass an
`input_shape`/`input_dim` argument to a layer. When using Sequential
models, prefer using an `Input(shape)` object as the first layer in
the model instead.
```

```
  super().__init__(activity_regularizer=activity_regularizer,
**kwargs)

Model: "sequential"

┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━┓
┃ Layer (type)                    ┃ Output Shape           ┃
Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━┩
│ conv2d (Conv2D)                 │ (None, 222, 222, 32)   │
896 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ batch_normalization             │ (None, 222, 222, 32)   │
128 │
│ (BatchNormalization)            │                        │
│
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ max_pooling2d (MaxPooling2D)    │ (None, 111, 111, 32)   │
0 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ conv2d_1 (Conv2D)               │ (None, 109, 109, 64)   │
18,496 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ batch_normalization_1           │ (None, 109, 109, 64)   │
256 │
│ (BatchNormalization)            │                        │
│
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ max_pooling2d_1 (MaxPooling2D)  │ (None, 54, 54, 64)     │
0 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ conv2d_2 (Conv2D)               │ (None, 52, 52, 128)    │
73,856 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ batch_normalization_2           │ (None, 52, 52, 128)    │
512 │
│ (BatchNormalization)            │                        │
│
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ max_pooling2d_2 (MaxPooling2D)  │ (None, 26, 26, 128)    │
```

```
0 │
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ conv2d_3 (Conv2D)                    │ (None, 24, 24, 256)         │
295,168 │
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ batch_normalization_3                │ (None, 24, 24, 256)         │
1,024 │
│ (BatchNormalization)                 │                             │
│
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ max_pooling2d_3 (MaxPooling2D)       │ (None, 12, 12, 256)         │
0 │
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ flatten (Flatten)                    │ (None, 36864)               │
0 │
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ dense (Dense)                        │ (None, 512)                 │
18,874,880 │
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ batch_normalization_4                │ (None, 512)                 │
2,048 │
│ (BatchNormalization)                 │                             │
│
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ dropout (Dropout)                    │ (None, 512)                 │
0 │
├──────────────────────────────────────┼─────────────────────────────┼──────────
──────┤
│ dense_1 (Dense)                      │ (None, 5)                   │
2,565 │
└──────────────────────────────────────┴─────────────────────────────┴──────────
──────┘

 Total params: 19,269,829 (73.51 MB)

 Trainable params: 19,267,845 (73.50 MB)

 Non-trainable params: 1,984 (7.75 KB)

df_train.head()

         image_id  label                              class_name
image_shape  \
```

```
0  1000015157.jpg      0       Cassava Bacterial Blight (CBB)  (600,
800, 3)
1  1000201771.jpg      3         Cassava Mosaic Disease (CMD)  (600,
800, 3)
2   100042118.jpg      1  Cassava Brown Streak Disease (CBSD)  (600,
800, 3)
3  1000723321.jpg      1  Cassava Brown Streak Disease (CBSD)  (600,
800, 3)
4  1000812911.jpg      3         Cassava Mosaic Disease (CMD)  (600,
800, 3)

                           label_names
0       Cassava Bacterial Blight (CBB)
1         Cassava Mosaic Disease (CMD)
2  Cassava Brown Streak Disease (CBSD)
3  Cassava Brown Streak Disease (CBSD)
4         Cassava Mosaic Disease (CMD)
```

Deprecated Techniques.

```
images_dir =
'/kaggle/input/cassava-leaf-disease-classification/train_images'

from tensorflow.keras.preprocessing.image import ImageDataGenerator
# Create an ImageDataGenerator to preprocess images
datagen = ImageDataGenerator(rescale=1./255,
                             validation_split=0.2)  # Normalize pixel
values

images_dir =
'/kaggle/input/cassava-leaf-disease-classification/train_images'

# Generate training and validation datasets
train_dataset = datagen.flow_from_dataframe(
    dataframe=df_train,
    directory=images_dir,
    x_col="image_id",  # Assuming the image path column is named
"image_path"
    y_col="class_name",
    target_size=(224, 224),  # Adjust image size as needed
    batch_size=32,
    class_mode="categorical",
    subset="training",
    shuffle=True
)

val_dataset = datagen.flow_from_dataframe(
    dataframe=df_train,
```

```
    directory=images_dir,
    x_col="image_id",
    y_col="class_name",
    target_size=(224, 224),
    batch_size=32,
    class_mode="categorical",
    subset="validation",
    shuffle=True
)
```

```
Found 17118 validated image filenames belonging to 5 classes.
Found 4279 validated image filenames belonging to 5 classes.
```

```
# Train the model for 10 epochs
history = model.fit(
    train_dataset,   # Assumed preprocessed training dataset
    validation_data=val_dataset,  # Assumed preprocessed validation
dataset
    epochs=1
)
```

```
/opt/conda/lib/python3.10/site-packages/keras/src/trainers/
data_adapters/py_dataset_adapter.py:121: UserWarning: Your `PyDataset`
class should call `super().__init__(**kwargs)` in its constructor.
`**kwargs` can include `workers`, `use_multiprocessing`,
`max_queue_size`. Do not pass these arguments to `fit()`, as they will
be ignored.
  self._warn_if_super_not_called()
WARNING: All log messages before absl::InitializeLog() is called are
written to STDERR
I0000 00:00:1726408133.649689     184 service.cc:145] XLA service
0x7bbbfc0165b0 initialized for platform CUDA (this does not guarantee
that XLA will be used). Devices:
I0000 00:00:1726408133.649758     184 service.cc:153]   StreamExecutor
device (0): Tesla T4, Compute Capability 7.5
I0000 00:00:1726408133.649763     184 service.cc:153]   StreamExecutor
device (1): Tesla T4, Compute Capability 7.5

  2/535 ━━━━━━━━━━━━━━━━━━━━ 43s 81ms/step - accuracy: 0.2734 - loss:
3.4142

I0000 00:00:1726408142.126726     184 device_compiler.h:188] Compiled
cluster using XLA!  This line is logged at most once for the lifetime
of the process.

535/535 ━━━━━━━━━━━━━━━━━━━━ 122s 204ms/step - accuracy: 0.4949 -
loss: 1.6661 - val_accuracy: 0.6244 - val_loss: 1.0734
```

```
# Train the model for 10 epochs
history = model.fit(
    train_dataset,   # Assumed preprocessed training dataset
```

```
    validation_data=val_dataset,  # Assumed preprocessed validation
dataset
    epochs=10
)

Epoch 1/10

/opt/conda/lib/python3.10/site-packages/keras/src/trainers/
data_adapters/py_dataset_adapter.py:121: UserWarning: Your `PyDataset`
class should call `super().__init__(**kwargs)` in its constructor.
`**kwargs` can include `workers`, `use_multiprocessing`,
`max_queue_size`. Do not pass these arguments to `fit()`, as they will
be ignored.
  self._warn_if_super_not_called()
WARNING: All log messages before absl::InitializeLog() is called are
written to STDERR
I0000 00:00:1726310729.097077     172 service.cc:145] XLA service
0x7f9b812d7e30 initialized for platform CUDA (this does not guarantee
that XLA will be used). Devices:
I0000 00:00:1726310729.097144     172 service.cc:153]   StreamExecutor
device (0): Tesla T4, Compute Capability 7.5
I0000 00:00:1726310729.097150     172 service.cc:153]   StreamExecutor
device (1): Tesla T4, Compute Capability 7.5

  2/535 ━━━━━━━━━━━━━━━━━━━━ 42s 80ms/step - accuracy: 0.2578 - loss:
2.8330

I0000 00:00:1726310738.154399     172 device_compiler.h:188] Compiled
cluster using XLA!  This line is logged at most once for the lifetime
of the process.

535/535 ━━━━━━━━━━━━━━━━━━━━ 122s 203ms/step - accuracy: 0.4931 -
loss: 1.6367 - val_accuracy: 0.1358 - val_loss: 3.2566
Epoch 2/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 98s 180ms/step - accuracy: 0.6455 - loss:
0.9746 - val_accuracy: 0.4288 - val_loss: 1.3975
Epoch 3/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 98s 182ms/step - accuracy: 0.6913 - loss:
0.8239 - val_accuracy: 0.6413 - val_loss: 1.0349
Epoch 4/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 97s 180ms/step - accuracy: 0.7269 - loss:
0.7433 - val_accuracy: 0.7097 - val_loss: 0.7598
Epoch 5/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 139s 174ms/step - accuracy: 0.7536 -
loss: 0.6656 - val_accuracy: 0.6586 - val_loss: 1.1666
Epoch 6/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 98s 180ms/step - accuracy: 0.7515 - loss:
0.6782 - val_accuracy: 0.7062 - val_loss: 0.8929
Epoch 7/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 97s 179ms/step - accuracy: 0.8047 - loss:
```

```
0.5223 - val_accuracy: 0.7184 - val_loss: 0.7765
Epoch 8/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 96s 178ms/step - accuracy: 0.7986 - loss:
0.5452 - val_accuracy: 0.6284 - val_loss: 1.2401
Epoch 9/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 96s 177ms/step - accuracy: 0.8219 - loss:
0.4828 - val_accuracy: 0.7214 - val_loss: 0.8700
Epoch 10/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 95s 175ms/step - accuracy: 0.9100 - loss:
0.2516 - val_accuracy: 0.5901 - val_loss: 1.3391
```

CONCULTIOSN - Model overfitting

Complete the traiing for more epochs 20

Do model plots

Confusiton matrix, multi class

Model Evaluation.

Method 2 -- Using Tensorlfow Dataset

```
df_train.head()
```

	image_id	label	class_name	image_shape
0	/kaggle/input/cassava-leaf-disease-classificat...	0	Cassava Bacterial Blight (CBB)	(600, 800, 3)
1	/kaggle/input/cassava-leaf-disease-classificat...	3	Cassava Mosaic Disease (CMD)	(600, 800, 3)
2	/kaggle/input/cassava-leaf-disease-classificat...	1	Cassava Brown Streak Disease (CBSD)	(600, 800, 3)
3	/kaggle/input/cassava-leaf-disease-classificat...	1	Cassava Brown Streak Disease (CBSD)	(600, 800, 3)
4	/kaggle/input/cassava-leaf-disease-classificat...	3	Cassava Mosaic Disease (CMD)	(600, 800, 3)

```
                            label_names
0       Cassava Bacterial Blight (CBB)
1         Cassava Mosaic Disease (CMD)
2  Cassava Brown Streak Disease (CBSD)
3  Cassava Brown Streak Disease (CBSD)
4         Cassava Mosaic Disease (CMD)
```

```
# Option 1: Using pandas' vectorized string operations
df_train['image_id'] = "/kaggle/input/cassava-leaf-disease-
classification/train_images/" + df_train['image_id']
df_train.head()
```

```
                                            image_id  label  \
0  /kaggle/input/cassava-leaf-disease-classificat...      0
1  /kaggle/input/cassava-leaf-disease-classificat...      3
2  /kaggle/input/cassava-leaf-disease-classificat...      1
3  /kaggle/input/cassava-leaf-disease-classificat...      1
4  /kaggle/input/cassava-leaf-disease-classificat...      3

                           class_name    image_shape  \
0       Cassava Bacterial Blight (CBB)  (600, 800, 3)
1         Cassava Mosaic Disease (CMD)  (600, 800, 3)
2  Cassava Brown Streak Disease (CBSD)  (600, 800, 3)
3  Cassava Brown Streak Disease (CBSD)  (600, 800, 3)
4         Cassava Mosaic Disease (CMD)  (600, 800, 3)

                            label_names
0       Cassava Bacterial Blight (CBB)
1         Cassava Mosaic Disease (CMD)
2  Cassava Brown Streak Disease (CBSD)
3  Cassava Brown Streak Disease (CBSD)
4         Cassava Mosaic Disease (CMD)
```

```
from sklearn.model_selection import train_test_split

# Define the validation split ratio
VALIDATION_SPLIT = 0.2  # 20% for validation

# Perform stratified split to maintain class distribution
train_df, val_df = train_test_split(
    df_train,
    test_size=VALIDATION_SPLIT,
    stratify=df_train['label'],
    random_state=42
)

print(f"Training samples: {len(train_df)}")
print(f"Validation samples: {len(val_df)}")
```

```
Training samples: 17117
Validation samples: 4280
```

```
print("Training class distribution:")
print(train_df['label'].value_counts())

print("\nValidation class distribution:")
print(val_df['label'].value_counts())
```

```
Training class distribution:
label
3    10526
4     2061
2     1909
1     1751
0      870
Name: count, dtype: int64

Validation class distribution:
label
3    2632
4     516
2     477
1     438
0     217
Name: count, dtype: int64
```

```
# Image dimensions
IMG_HEIGHT = 224
IMG_WIDTH = 224
CHANNELS = 3

# Batch size
BATCH_SIZE = 32

# Buffer size for shuffling
BUFFER_SIZE = 1000

# AUTOTUNE for performance optimization
AUTOTUNE = tf.data.AUTOTUNE

def process_image(file_path, label):
    # Read the image from disk
    image = tf.io.read_file(file_path)

    # Decode the image (assuming JPEG format)
    image = tf.image.decode_jpeg(image, channels=CHANNELS)

    # Resize the image
    image = tf.image.resize(image, [IMG_HEIGHT, IMG_WIDTH])
```

```
    # Normalize pixel values to [0,1]
    image = image / 255.0

    return image, label

df_train.head()
```

```
                                              image_id  label  \
0  /kaggle/input/cassava-leaf-disease-classificat...      0
1  /kaggle/input/cassava-leaf-disease-classificat...      3
2  /kaggle/input/cassava-leaf-disease-classificat...      1
3  /kaggle/input/cassava-leaf-disease-classificat...      1
4  /kaggle/input/cassava-leaf-disease-classificat...      3

                          class_name    image_shape  \
0      Cassava Bacterial Blight (CBB)  (600, 800, 3)
1        Cassava Mosaic Disease (CMD)  (600, 800, 3)
2  Cassava Brown Streak Disease (CBSD)  (600, 800, 3)
3  Cassava Brown Streak Disease (CBSD)  (600, 800, 3)
4        Cassava Mosaic Disease (CMD)  (600, 800, 3)

                          label_names
0      Cassava Bacterial Blight (CBB)
1        Cassava Mosaic Disease (CMD)
2  Cassava Brown Streak Disease (CBSD)
3  Cassava Brown Streak Disease (CBSD)
4        Cassava Mosaic Disease (CMD)
```

```
# Create TensorFlow Dataset from training DataFrame
train_ds =
tf.data.Dataset.from_tensor_slices((train_df['image_id'].values,
train_df['label'].values))

# Map the processing function to each (image, label) pair
train_ds = train_ds.map(process_image, num_parallel_calls=AUTOTUNE)

# Data Augmentation (optional but recommended)
data_augmentation = tf.keras.Sequential([
    layers.RandomFlip('horizontal'),
    layers.RandomRotation(0.1),
    layers.RandomZoom(0.18),
    layers.RandomContrast(0.2),
])

def augment(image, label):
    image = data_augmentation(image)
    return image, label

train_ds = train_ds.map(augment, num_parallel_calls=AUTOTUNE)

# Shuffle, batch, and prefetch
```

```
train_ds =
train_ds.shuffle(BUFFER_SIZE).batch(BATCH_SIZE).prefetch(AUTOTUNE)

# Create TensorFlow Dataset from validation DataFrame
val_ds =
tf.data.Dataset.from_tensor_slices((val_df['image_id'].values,
val_df['label'].values))

# Map the processing function
val_ds = val_ds.map(process_image, num_parallel_calls=AUTOTUNE)

# Batch and prefetch
val_ds = val_ds.batch(BATCH_SIZE).prefetch(AUTOTUNE)

from tensorflow.keras import regularizers

num_classes = 5
# Define the CNN model architecture
def create_cnn_model(input_shape=(IMG_HEIGHT, IMG_WIDTH, CHANNELS),
num_classes=5):
    model = models.Sequential([
        # 1st Convolutional block
        layers.Input(shape=input_shape),
        layers.Conv2D(32, (3, 3), activation='relu', padding='same'),
        layers.BatchNormalization(),
        layers.MaxPooling2D((2, 2)),

        # 2nd Convolutional block
        layers.Conv2D(64, (3, 3), activation='relu', padding='same'),
        layers.BatchNormalization(),
        layers.MaxPooling2D((2, 2)),

        # 3rd Convolutional block
        layers.Conv2D(128, (3, 3), activation='relu', padding='same'),
        layers.BatchNormalization(),
        layers.MaxPooling2D((2, 2)),

        # 4th Convolutional block
        layers.Conv2D(256, (3, 3), activation='relu', padding='same'),
        layers.BatchNormalization(),
        layers.MaxPooling2D((2, 2)),

        # Flatten and Dense layers
        layers.Flatten(),
        layers.Dense(512, activation='relu'),
        layers.BatchNormalization(),
        layers.Dropout(0.5),

        # Output layer
        layers.Dense(5, activation='softmax')
```

```
    ])

    return model

# Instantiate the model
model = create_cnn_model(input_shape=(IMG_HEIGHT, IMG_WIDTH,
CHANNELS), num_classes=num_classes)

# Display the model architecture
model.summary()
```

```
Model: "sequential_3"
```

```
┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━
┓
┃ Layer (type)                         ┃ Output Shape                ┃
Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━
┩
│ conv2d_8 (Conv2D)                    │ (None, 224, 224, 32)        │
896 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────
┤
│ batch_normalization_10               │ (None, 224, 224, 32)        │
128 │
│ (BatchNormalization)                 │                             │
│
├──────────────────────────────────────┼─────────────────────────────┼─────────────────
┤
│ max_pooling2d_8 (MaxPooling2D)       │ (None, 112, 112, 32)        │
0 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────
┤
│ conv2d_9 (Conv2D)                    │ (None, 112, 112, 64)        │
18,496 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────
┤
│ batch_normalization_11               │ (None, 112, 112, 64)        │
256 │
│ (BatchNormalization)                 │                             │
│
├──────────────────────────────────────┼─────────────────────────────┼─────────────────
┤
│ max_pooling2d_9 (MaxPooling2D)       │ (None, 56, 56, 64)          │
0 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────
┤
│ conv2d_10 (Conv2D)                   │ (None, 56, 56, 128)         │
73,856 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────
```

```
──────┤
| batch_normalization_12          | (None, 56, 56, 128)    |
512 |
| (BatchNormalization)            |                        |
|
├─────────────────────────────────┼────────────────────────┼──────────
──────┤
| max_pooling2d_10 (MaxPooling2D) | (None, 28, 28, 128)    |
0 |
├─────────────────────────────────┼────────────────────────┼──────────
──────┤
| conv2d_11 (Conv2D)              | (None, 28, 28, 256)    |
295,168 |
├─────────────────────────────────┼────────────────────────┼──────────
──────┤
| batch_normalization_13          | (None, 28, 28, 256)    |
1,024 |
| (BatchNormalization)            |                        |
|
├─────────────────────────────────┼────────────────────────┼──────────
──────┤
| max_pooling2d_11 (MaxPooling2D) | (None, 14, 14, 256)    |
0 |
├─────────────────────────────────┼────────────────────────┼──────────
──────┤
| flatten_2 (Flatten)             | (None, 50176)          |
0 |
├─────────────────────────────────┼────────────────────────┼──────────
──────┤
| dense_4 (Dense)                 | (None, 512)            |
25,690,624 |
├─────────────────────────────────┼────────────────────────┼──────────
──────┤
| batch_normalization_14          | (None, 512)            |
2,048 |
| (BatchNormalization)            |                        |
|
├─────────────────────────────────┼────────────────────────┼──────────
──────┤
| dropout_2 (Dropout)             | (None, 512)            |
0 |
├─────────────────────────────────┼────────────────────────┼──────────
──────┤
| dense_5 (Dense)                 | (None, 5)              |
2,565 |
└─────────────────────────────────┴────────────────────────┴──────────
──────┘

 Total params: 26,085,573 (99.51 MB)
```

```
 Trainable params: 26,083,589 (99.50 MB)

 Non-trainable params: 1,984 (7.75 KB)
```

```
# Compile the model
model.compile(
    optimizer='adam',  # You can experiment with different optimizers
    loss='categorical_crossentropy',  # Suitable for integer-encoded
labels
    metrics=['accuracy']
)

from tensorflow.keras.callbacks import EarlyStopping, ModelCheckpoint,
ReduceLROnPlateau

# Early stopping to prevent overfitting
early_stop = EarlyStopping(
    monitor='val_loss',
    patience=3,
    restore_best_weights=True,
    verbose=1
)

# Model checkpoint to save the best model
checkpoint = ModelCheckpoint(
    'best_cnn_model.keras',
    monitor='val_accuracy',
    save_best_only=True,
    verbose=1
)

# Reduce learning rate when a metric has stopped improving
reduce_lr = ReduceLROnPlateau(
    monitor='val_loss',
    factor=0.2,
    patience=3,
    verbose=1,
    min_lr=1e-6
)

# Combine callbacks
callbacks = [early_stop, checkpoint, reduce_lr]

val_dataset
```

```
<keras.src.legacy.preprocessing.image.DataFrameIterator at
0x7bbd305ec250>
```

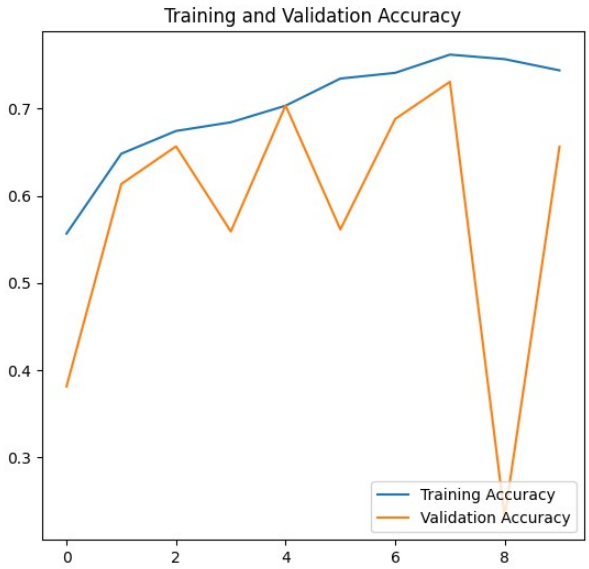
```
# Train the model for 10 epochs
history = model.fit(
    train_dataset,   # Assumed preprocessed training dataset
```

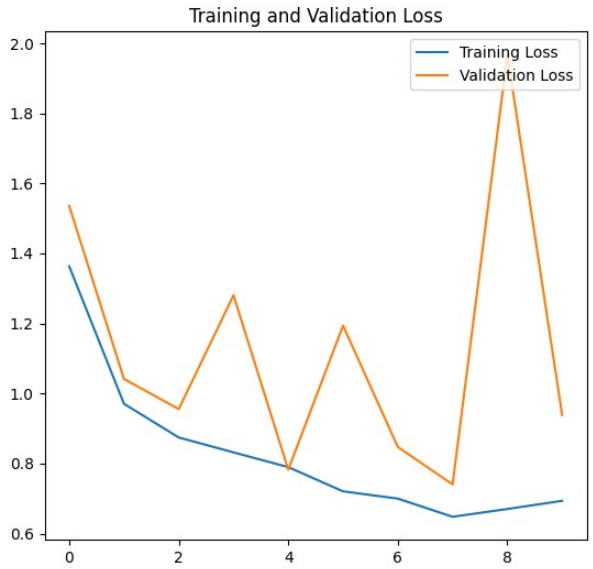
```
    validation_data=val_dataset,  # Assumed preprocessed validation
dataset
    epochs=1
)

535/535 ━━━━━━━━━━━━━━━━━━━━ 148s 253ms/step - accuracy: 0.4954 -
loss: 1.6679 - val_accuracy: 0.6392 - val_loss: 1.0716

# Define the number of epochs
EPOCHS = 10  # Adjust based on your requirements

# Train the model
history = model.fit(
    train_ds,
    validation_data=val_ds,
    epochs=EPOCHS,
    callbacks=callbacks
)

Epoch 1/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 0s 258ms/step - accuracy: 0.4856 - loss:
1.6838
Epoch 1: val_accuracy improved from -inf to 0.38131, saving model to
best_cnn_model.keras
535/535 ━━━━━━━━━━━━━━━━━━━━ 165s 277ms/step - accuracy: 0.4857 -
loss: 1.6832 - val_accuracy: 0.3813 - val_loss: 1.5359 -
learning_rate: 0.0010
Epoch 2/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 0s 233ms/step - accuracy: 0.6354 - loss:
1.0151
Epoch 2: val_accuracy improved from 0.38131 to 0.61355, saving model
to best_cnn_model.keras
535/535 ━━━━━━━━━━━━━━━━━━━━ 142s 255ms/step - accuracy: 0.6354 -
loss: 1.0150 - val_accuracy: 0.6136 - val_loss: 1.0416 -
learning_rate: 0.0010
Epoch 3/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 0s 232ms/step - accuracy: 0.6684 - loss:
0.8863
Epoch 3: val_accuracy improved from 0.61355 to 0.65678, saving model
to best_cnn_model.keras
535/535 ━━━━━━━━━━━━━━━━━━━━ 137s 246ms/step - accuracy: 0.6684 -
loss: 0.8863 - val_accuracy: 0.6568 - val_loss: 0.9554 -
learning_rate: 0.0010
Epoch 4/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 0s 233ms/step - accuracy: 0.6813 - loss:
0.8348
Epoch 4: val_accuracy did not improve from 0.65678
535/535 ━━━━━━━━━━━━━━━━━━━━ 136s 244ms/step - accuracy: 0.6813 -
loss: 0.8348 - val_accuracy: 0.5591 - val_loss: 1.2806 -
learning_rate: 0.0010
```

```
Epoch 5/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 0s 232ms/step - accuracy: 0.6964 - loss:
0.7986
Epoch 5: val_accuracy improved from 0.65678 to 0.70374, saving model
to best_cnn_model.keras
535/535 ━━━━━━━━━━━━━━━━━━━━ 137s 246ms/step - accuracy: 0.6964 -
loss: 0.7986 - val_accuracy: 0.7037 - val_loss: 0.7824 -
learning_rate: 0.0010
Epoch 6/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 0s 232ms/step - accuracy: 0.7239 - loss:
0.7384
Epoch 6: val_accuracy did not improve from 0.70374
535/535 ━━━━━━━━━━━━━━━━━━━━ 138s 246ms/step - accuracy: 0.7239 -
loss: 0.7384 - val_accuracy: 0.5614 - val_loss: 1.1939 -
learning_rate: 0.0010
Epoch 7/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 0s 232ms/step - accuracy: 0.7412 - loss:
0.7004
Epoch 7: val_accuracy did not improve from 0.70374
535/535 ━━━━━━━━━━━━━━━━━━━━ 135s 243ms/step - accuracy: 0.7412 -
loss: 0.7004 - val_accuracy: 0.6881 - val_loss: 0.8473 -
learning_rate: 0.0010
Epoch 8/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 0s 232ms/step - accuracy: 0.7599 - loss:
0.6557
Epoch 8: val_accuracy improved from 0.70374 to 0.73084, saving model
to best_cnn_model.keras
535/535 ━━━━━━━━━━━━━━━━━━━━ 137s 246ms/step - accuracy: 0.7599 -
loss: 0.6557 - val_accuracy: 0.7308 - val_loss: 0.7404 -
learning_rate: 0.0010
Epoch 9/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 0s 232ms/step - accuracy: 0.7609 - loss:
0.6630
Epoch 9: val_accuracy did not improve from 0.73084
535/535 ━━━━━━━━━━━━━━━━━━━━ 140s 251ms/step - accuracy: 0.7609 -
loss: 0.6630 - val_accuracy: 0.2318 - val_loss: 1.9677 -
learning_rate: 0.0010
Epoch 10/10
535/535 ━━━━━━━━━━━━━━━━━━━━ 0s 230ms/step - accuracy: 0.7354 - loss:
0.7071
Epoch 10: val_accuracy did not improve from 0.73084
535/535 ━━━━━━━━━━━━━━━━━━━━ 135s 241ms/step - accuracy: 0.7354 -
loss: 0.7071 - val_accuracy: 0.6563 - val_loss: 0.9383 -
learning_rate: 0.0010
Restoring model weights from the end of the best epoch: 8.

# Step 14: Evaluate the Model
val_loss, val_accuracy = model.evaluate(val_ds)
print(f"\nValidation Loss: {val_loss:.4f}")
print(f"Validation Accuracy: {val_accuracy:.4f}")
```

```
134/134 ━━━━━━━━━━━━━━━━━━━━ 6s 46ms/step - accuracy: 0.7293 - loss: 0.7448

Validation Loss: 0.7404
Validation Accuracy: 0.7308
```

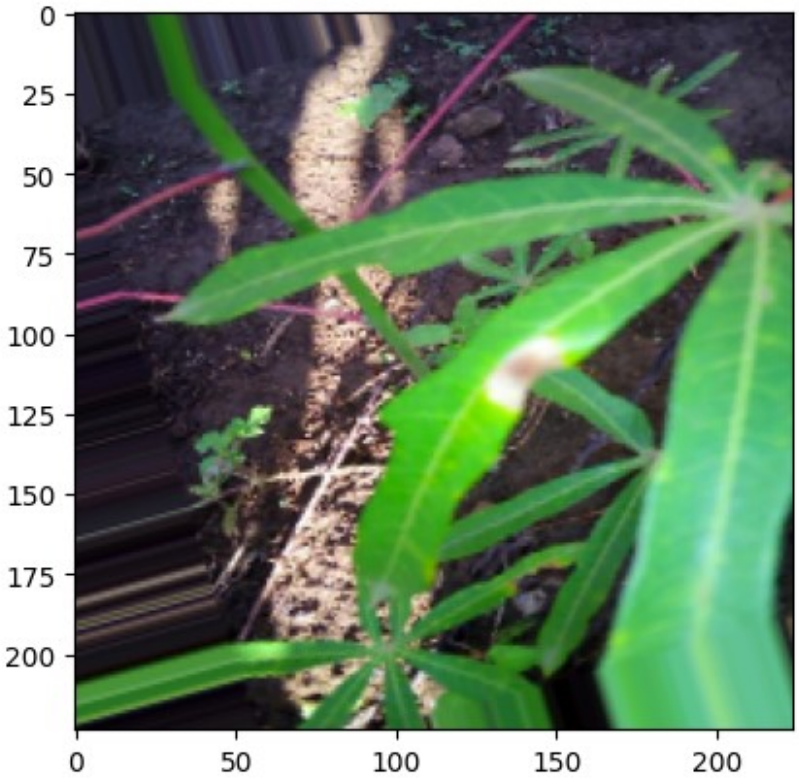
```python
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']
epochs_range = range(len(acc))

# Plot Accuracy
plt.figure(figsize=(14, 6))
plt.subplot(1, 2, 1)
plt.plot(epochs_range, acc, label='Training Accuracy')
plt.plot(epochs_range, val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

# Plot Loss
plt.subplot(1, 2, 2)
plt.plot(epochs_range, loss, label='Training Loss')
plt.plot(epochs_range, val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')

plt.show()
```

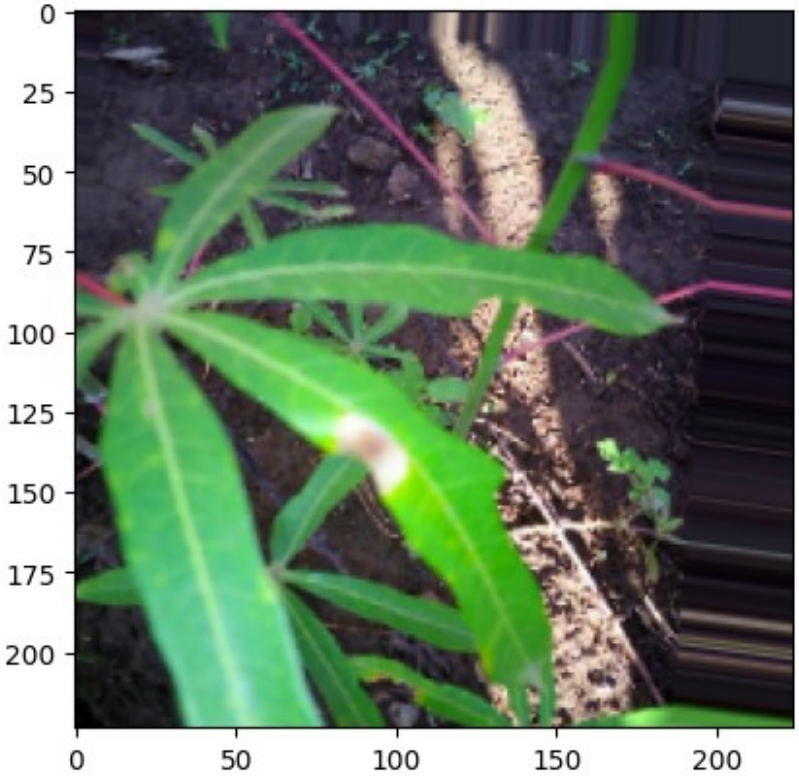


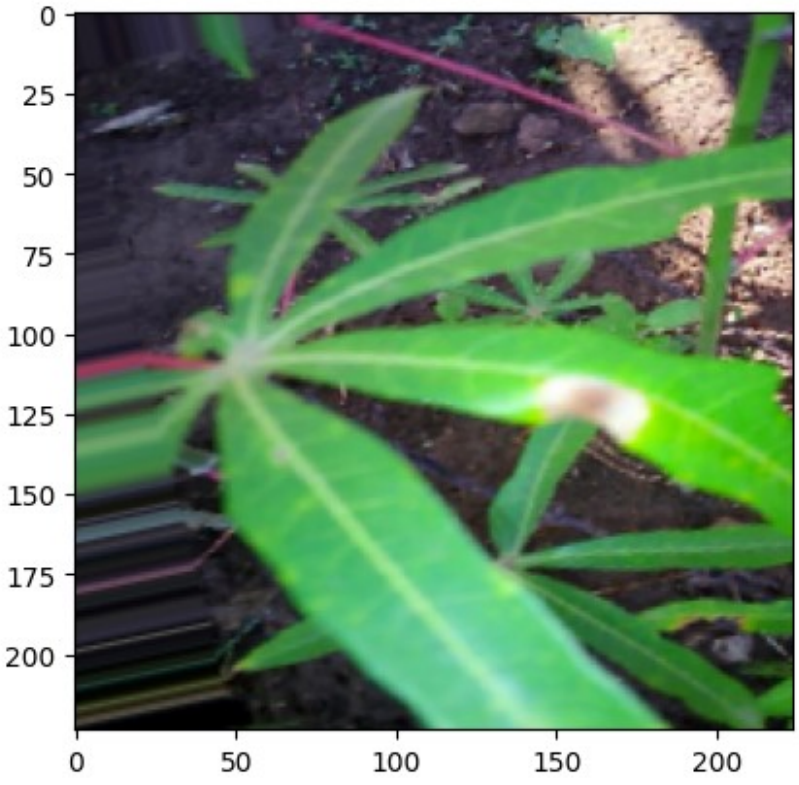


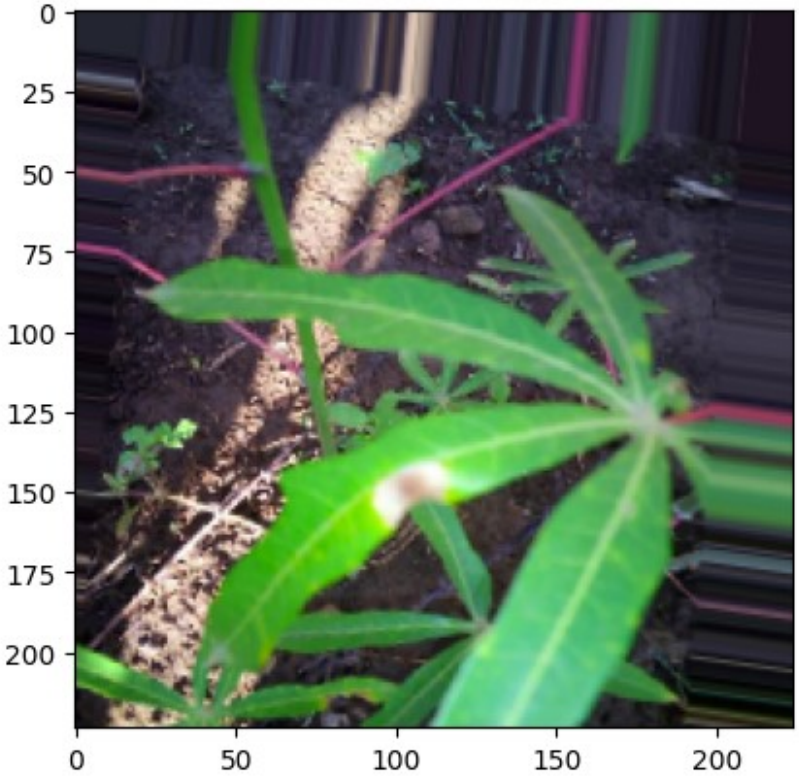
Visualising the augmentations

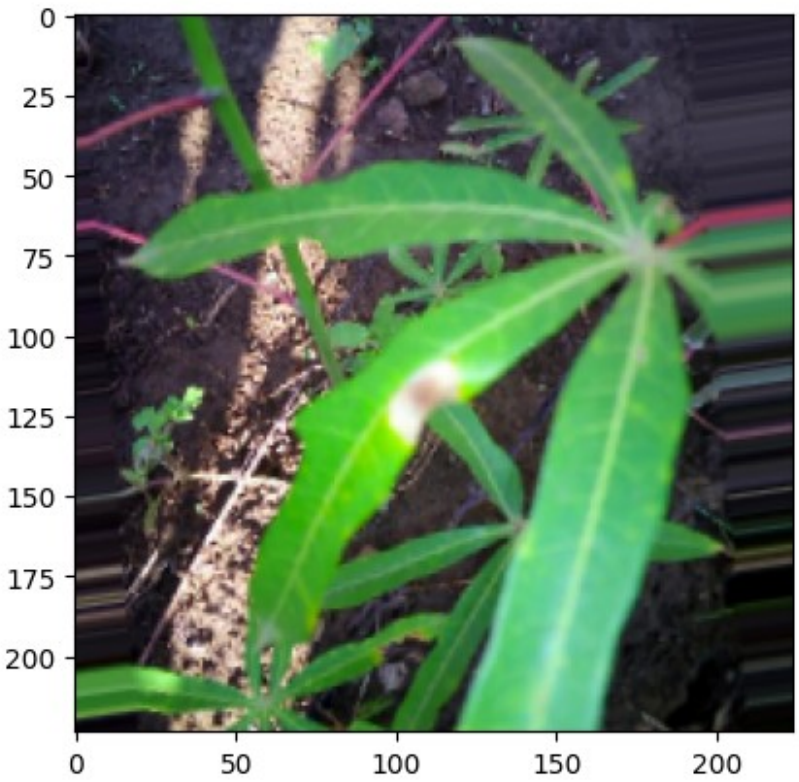
```
from tensorflow.keras.preprocessing.image import ImageDataGenerator

# Define your data augmentation generator
datagen = ImageDataGenerator(
    rotation_range=20,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True,
    fill_mode='nearest'
)

# Example usage on one image
from tensorflow.keras.preprocessing import image

img = image.load_img('/kaggle/input/cassava-leaf-disease-
classification/train_images/1001320321.jpg',
                     target_size=(224, 224))
x = image.img_to_array(img)
x = x.reshape((1,) + x.shape)

# Generate 5 augmented images
i = 0
for batch in datagen.flow(x, batch_size=1):
    plt.figure(i)
    imgplot = plt.imshow(image.array_to_img(batch[0]))
    i += 1
    if i % 5 == 0:
        break
plt.show()
```


0
25
50
75
100
125
150
175
200
0
50
100
150
200


0
25
50
75
100
125
150
175
200
0
50
100
150
200


0
25
50
75
100
125
150
175
200
0
50
100
150
200


0
25
50
75
100
125
150
175
200
0
50
100
150
200



Understanding class weights

```
# Compute class weights
from sklearn.utils import class_weight
import numpy as np

class_weights = class_weight.compute_class_weight(
    'balanced',
    classes=np.unique(df_train['label']),
    y=df_train['label']
)
class_weights = dict(enumerate(class_weights))
class_weights
```

```
{0: 3.9368905243790246,
 1: 1.954956601187757,
 2: 1.7935456831517183,
 3: 0.3252317981456148,
 4: 1.6606131160263873}
```

```
model.fit(class_weights = class_weights )
```

Implementing Focal Loss

```
focal_loss = tfa.losses.SparseCategoricalFocalCrossentropy(
    from_logits=False,  # Since the model outputs probabilities with
softmax
    alpha=class_weights,  # Class weights computed earlier
    gamma=2.0  # Focusing parameter
)
```

```
---------------------------------------------------------------------
-----
NameError                                 Traceback (most recent call
last)
Cell In[72], line 1
----> 1 focal_loss = tfa.losses.SparseCategoricalFocalCrossentropy(
      2     from_logits=False,  # Since the model outputs
probabilities with softmax
      3     alpha=class_weights,  # Class weights computed earlier
      4     gamma=2.0  # Focusing parameter
      5 )

NameError: name 'tfa' is not defined
```

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

history = model.fit(
                    train_ds,
                    validation_data=val_ds,
                    epochs=10,
                    callbacks=callbacks
                   )

# Step 14: Evaluate the Model
val_loss, val_accuracy = model.evaluate(val_ds)
print(f"\nValidation Loss: {val_loss:.4f}")
print(f"Validation Accuracy: {val_accuracy:.4f}")

# Step 15: Save the Model
model.save('cnn_cassava_leaf_disease_focal_loss.keras')
print("\nModel saved successfully!")

acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']
epochs_range = range(len(acc))
```

```
# Plot Accuracy
plt.figure(figsize=(14, 6))
plt.subplot(1, 2, 1)
plt.plot(epochs_range, acc, label='Training Accuracy')
plt.plot(epochs_range, val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

# Plot Loss
plt.subplot(1, 2, 2)
plt.plot(epochs_range, loss, label='Training Loss')
plt.plot(epochs_range, val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')

plt.show()
```

Implementing Transfer Learning RESNET

Home work fine tuning.

Model training, plotting, evalution, confusion matirix.

```


from tensorflow.keras.applications import ResNet50

# Effecient net

# Load the ResNet50 model without the top classification layers
base_model = ResNet50(
    weights='imagenet',
    include_top=False,
    input_shape=(224, 224, 3)
)

# Freeze the base model
base_model.trainable = False

# Create a new model on top
model = models.Sequential([
    base_model,
```

```
    layers.GlobalAveragePooling2D(),
    layers.Dense(256, activation='relu'),
    layers.BatchNormalization(),
    layers.Dense(512, activation='relu'),
    layers.BatchNormalization(),
    layers.Dropout(0.5),
    layers.Dense(5, activation='softmax')
])

# Compile with Focal Loss
model.compile(
    optimizer='adam',
    loss='categorial_cross_entropy',
    metrics=['accuracy']
)

# Model summary
model.summary()
```

Transfer Leanring Effecient Net

```
!pip uninstall tensorflow_addons
```

```
Found existing installation: tensorflow-addons 0.23.0
Uninstalling tensorflow-addons-0.23.0:
  Would remove:
    /opt/conda/lib/python3.10/site-packages/_foo.cpython-310-x86_64-
linux-gnu.so
    /opt/conda/lib/python3.10/site-packages/tensorflow_addons-
0.23.0.dist-info/*
    /opt/conda/lib/python3.10/site-packages/tensorflow_addons/*
Proceed (Y/n)?
```

```
# Step 1: Import Necessary Libraries
import os
import json
from collections import Counter

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

import tensorflow as tf
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras import layers, models, regularizers
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import EarlyStopping, ModelCheckpoint,
ReduceLROnPlateau
```

```
# import tensorflow_addons as tfa

from sklearn.model_selection import train_test_split
from sklearn.utils import class_weight


import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import GlobalAveragePooling2D, Flatten,
Dense, Dropout, BatchNormalization
from tensorflow.keras.optimizers import RMSprop, Adam
from tensorflow.keras.callbacks import EarlyStopping, ModelCheckpoint,
ReduceLROnPlateau
from tensorflow.keras.applications import EfficientNetB3

# Step 2: Define Paths
work_dir = '../input/cassava-leaf-disease-classification/'  # Update
if necessary
train_path = os.path.join(work_dir, 'train_images')  # Path to
training images
train_csv_path = os.path.join(work_dir, 'train.csv')  # Path to
train.csv
label_map_path = os.path.join(work_dir,
'label_num_to_disease_map.json')  # Path to label mapping JSON

# a. Load Train Data
data = pd.read_csv(train_csv_path)
print("Initial DataFrame:")
print(data.head())

# Check label frequencies
print("\nLabel Frequencies:")
print(Counter(data['label']))
```

```
Initial DataFrame:
         image_id  label
0  1000015157.jpg      0
1  1000201771.jpg      3
2   100042118.jpg      1
3  1000723321.jpg      1
4  1000812911.jpg      3

Label Frequencies:
Counter({3: 13158, 4: 2577, 2: 2386, 1: 2189, 0: 1087})
```

```
# b. Load Label Mapping
with open(label_map_path, 'r') as f:
    real_labels = json.load(f)

# Convert string keys to integers
real_labels = {int(k): v for k, v in real_labels.items()}
```

```
# Map label numbers to class names
data['class_name'] = data['label'].map(real_labels)
print("\nDataFrame with 'class_name':")
print(data.head())
```

```
DataFrame with 'class_name':
          image_id  label                              class_name
0  1000015157.jpg      0       Cassava Bacterial Blight (CBB)
1  1000201771.jpg      3         Cassava Mosaic Disease (CMD)
2   100042118.jpg      1  Cassava Brown Streak Disease (CBSD)
3  1000723321.jpg      1  Cassava Brown Streak Disease (CBSD)
4  1000812911.jpg      3         Cassava Mosaic Disease (CMD)
```

```
# Step 4: Compute Class Weights
labels = data['label'].values  # Integer-encoded labels

# Compute class weights
class_weights_array = class_weight.compute_class_weight(
    class_weight='balanced',
    classes=np.unique(labels),
    y=labels
)

# Create a dictionary mapping class indices to weights
class_weights_dict = {i: weight for i, weight in
enumerate(class_weights_array)}
print("\nClass Weights:")
print(class_weights_dict)
```

```
Class Weights:
{0: 3.9368905243790246, 1: 1.954956601187757, 2: 1.7935456831517183,
3: 0.3252317981456148, 4: 1.6606131160263873}
```

```
# Step 5: Define ImageDataGenerators
IMG_SIZE = 224
TARGET_SIZE = (IMG_SIZE, IMG_SIZE)
NUM_CLASSES = 5  # Update based on actual number of classes
BATCH_SIZE = 15

datagen_train = ImageDataGenerator(

preprocessing_function=tf.keras.applications.efficientnet.preprocess_i
nput,  # EfficientNet preprocessing
    rotation_range=40,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.2,
```

```
    zoom_range=0.2,
    horizontal_flip=True,
    vertical_flip=True,
    fill_mode='nearest'
)

# ImageDataGenerator for validation (only normalization)
datagen_val = ImageDataGenerator(

preprocessing_function=tf.keras.applications.efficientnet.preprocess_i
nput  # EfficientNet preprocessing
)
```

Effecient net uses upscaling metod. 512 * 512

```
train_df, val_df = train_test_split(
    data,
    test_size=0.05,  # 5% for validation
    random_state=42,
    stratify=data['class_name']
)
print(f"\nNumber of training samples: {len(train_df)}")
print(f"Number of validation samples: {len(val_df)}")


Number of training samples: 20327
Number of validation samples: 1070

train_set = datagen_train.flow_from_dataframe(train_df,
                              directory = train_path,
                              seed=42,
                              x_col = 'image_id',
                              y_col = 'class_name',
                              target_size = TARGET_SIZE,
                              #color_mode="rgb",
                              class_mode = 'categorical',
                              interpolation = 'nearest',
                              shuffle = True,
                              batch_size = BATCH_SIZE)

val_set = datagen_val.flow_from_dataframe(val_df,
                              directory = train_path,
                              seed=42,
                              x_col = 'image_id',
                              y_col = 'class_name',
                              target_size = TARGET_SIZE,
                              #color_mode="rgb",
                              class_mode = 'categorical',
```

```
                                interpolation = 'nearest',
                                shuffle = True,
                                batch_size = BATCH_SIZE)

Found 20327 validated image filenames belonging to 5 classes.
Found 1070 validated image filenames belonging to 5 classes.

base_model = EfficientNetB3(input_shape=(224, 224, 3),
include_top=False,
                                    weights='imagenet',
drop_connect_rate=0.6)

base_model.summary()

Model: "efficientnetb3"
```

Layer (type)	Output Shape	Param #	Connected to
input_layer_10 (InputLayer)	(None, 224, 224, 3)	0	-
rescaling_18 (Rescaling)	(None, 224, 224, 3)	0	input_layer_10[0…
normalization_9 (Normalization)	(None, 224, 224, 3)	7	rescaling_18[0][…
rescaling_19 (Rescaling)	(None, 224, 224, 3)	0	normalization_9[…
stem_conv_pad (ZeroPadding2D)	(None, 225, 225, 3)	0	rescaling_19[0][…

```
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ stem_conv (Conv2D)   │ (None, 112, 112,   │       1,080 │
stem_conv_pad[0][0… │
│                      │ 40)                  │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ stem_bn              │ (None, 112, 112,   │         160 │ stem_conv[0]
[0]   │
│ (BatchNormalizatio… │ 40)                  │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ stem_activation      │ (None, 112, 112,   │           0 │ stem_bn[0][0]
│
│ (Activation)         │ 40)                  │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block1a_dwconv       │ (None, 112, 112,   │         360 │
stem_activation[… │
│ (DepthwiseConv2D)    │ 40)                  │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block1a_bn           │ (None, 112, 112,   │         160 │
block1a_dwconv[0… │
│ (BatchNormalizatio… │ 40)                  │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block1a_activation   │ (None, 112, 112,   │           0 │ block1a_bn[0]
[0]   │
│ (Activation)         │ 40)                  │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block1a_se_squeeze   │ (None, 40)           │           0 │
block1a_activati… │
│ (GlobalAveragePool… │                      │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block1a_se_reshape   │ (None, 1, 1, 40)     │           0 │
block1a_se_squee… │
│ (Reshape)            │                      │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
```

```
──────┤
| block1a_se_reduce   | (None, 1, 1, 10)  |        410 |
block1a_se_resha… |
| (Conv2D)            |                   |            |
|
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
| block1a_se_expand   | (None, 1, 1, 40)  |        440 |
block1a_se_reduc… |
| (Conv2D)            |                   |            |
|
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
| block1a_se_excite   | (None, 112, 112,  |          0 |
block1a_activati… |
| (Multiply)          | 40)               |            |
block1a_se_expan… |
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
| block1a_project_co… | (None, 112, 112,  |        960 |
block1a_se_excit… |
| (Conv2D)            | 24)               |            |
|
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
| block1a_project_bn  | (None, 112, 112,  |         96 |
block1a_project_… |
| (BatchNormalizatio… | 24)               |            |
|
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
| block1b_dwconv      | (None, 112, 112,  |        216 |
block1a_project_… |
| (DepthwiseConv2D)   | 24)               |            |
|
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
| block1b_bn          | (None, 112, 112,  |         96 |
block1b_dwconv[0… |
| (BatchNormalizatio… | 24)               |            |
|
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
| block1b_activation  | (None, 112, 112,  |          0 | block1b_bn[0]
[0]  |
| (Activation)        | 24)               |            |
|
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
```

```
| block1b_se_squeeze  | (None, 24)         |           0 |
block1b_activati… |
| (GlobalAveragePool… |                    |             |
|
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block1b_se_reshape  | (None, 1, 1, 24)   |           0 |
block1b_se_squee… |
| (Reshape)           |                    |             |
|
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block1b_se_reduce   | (None, 1, 1, 6)    |         150 |
block1b_se_resha… |
| (Conv2D)            |                    |             |
|
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block1b_se_expand   | (None, 1, 1, 24)   |         168 |
block1b_se_reduc… |
| (Conv2D)            |                    |             |
|
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block1b_se_excite   | (None, 112, 112,   |           0 |
block1b_activati… |
| (Multiply)          | 24)                |             |
block1b_se_expan… |
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block1b_project_co… | (None, 112, 112,   |         576 |
block1b_se_excit… |
| (Conv2D)            | 24)                |             |
|
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block1b_project_bn  | (None, 112, 112,   |          96 |
block1b_project_… |
| (BatchNormalizatio… | 24)                |             |
|
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block1b_drop        | (None, 112, 112,   |           0 |
block1b_project_… |
| (Dropout)           | 24)                |             |
|
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block1b_add (Add)   | (None, 112, 112,   |           0 |
```

```
block1b_drop[0][… │
│                     │ 24)                 │             │
block1a_project_… │
├─────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block2a_expand_conv │ (None, 112, 112,    │       3,456 │
block1b_add[0][0] │
│ (Conv2D)            │ 144)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block2a_expand_bn   │ (None, 112, 112,    │         576 │
block2a_expand_c… │
│ (BatchNormalizatio… │ 144)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block2a_expand_act… │ (None, 112, 112,    │           0 │
block2a_expand_b… │
│ (Activation)        │ 144)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block2a_dwconv_pad  │ (None, 113, 113,    │           0 │
block2a_expand_a… │
│ (ZeroPadding2D)     │ 144)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block2a_dwconv      │ (None, 56, 56,      │       1,296 │
block2a_dwconv_p… │
│ (DepthwiseConv2D)   │ 144)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block2a_bn          │ (None, 56, 56,      │         576 │
block2a_dwconv[0… │
│ (BatchNormalizatio… │ 144)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block2a_activation  │ (None, 56, 56,      │           0 │ block2a_bn[0]
[0]  │
│ (Activation)        │ 144)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block2a_se_squeeze  │ (None, 144)         │           0 │
block2a_activati… │
```

(GlobalAveragePool…			
block2a_se_reshape (Reshape)	(None, 1, 1, 144)	0	block2a_se_squee…
block2a_se_reduce (Conv2D)	(None, 1, 1, 6)	870	block2a_se_resha…
block2a_se_expand (Conv2D)	(None, 1, 1, 144)	1,008	block2a_se_reduc…
block2a_se_excite (Multiply)	(None, 56, 56, 144)	0	block2a_activati… block2a_se_expan…
block2a_project_co… (Conv2D)	(None, 56, 56, 32)	4,608	block2a_se_excit…
block2a_project_bn (BatchNormalizatio…	(None, 56, 56, 32)	128	block2a_project_…
block2b_expand_conv (Conv2D)	(None, 56, 56, 192)	6,144	block2a_project_…
block2b_expand_bn (BatchNormalizatio…	(None, 56, 56, 192)	768	block2b_expand_c…

```
│
├───────────────────────┼────────────────────┼─────────────┼───────────────
───────┤
│ block2b_expand_act… │ (None, 56, 56,     │           0 │
block2b_expand_b… │
│ (Activation)        │ 192)               │             │
│
├───────────────────────┼────────────────────┼─────────────┼───────────────
───────┤
│ block2b_dwconv      │ (None, 56, 56,     │       1,728 │
block2b_expand_a… │
│ (DepthwiseConv2D)   │ 192)               │             │
│
├───────────────────────┼────────────────────┼─────────────┼───────────────
───────┤
│ block2b_bn          │ (None, 56, 56,     │         768 │
block2b_dwconv[0… │
│ (BatchNormalizatio… │ 192)               │             │
│
├───────────────────────┼────────────────────┼─────────────┼───────────────
───────┤
│ block2b_activation  │ (None, 56, 56,     │           0 │ block2b_bn[0]
[0]  │
│ (Activation)        │ 192)               │             │
│
├───────────────────────┼────────────────────┼─────────────┼───────────────
───────┤
│ block2b_se_squeeze  │ (None, 192)        │           0 │
block2b_activati… │
│ (GlobalAveragePool… │                    │             │
│
├───────────────────────┼────────────────────┼─────────────┼───────────────
───────┤
│ block2b_se_reshape  │ (None, 1, 1, 192)  │           0 │
block2b_se_squee… │
│ (Reshape)           │                    │             │
│
├───────────────────────┼────────────────────┼─────────────┼───────────────
───────┤
│ block2b_se_reduce   │ (None, 1, 1, 8)    │       1,544 │
block2b_se_resha… │
│ (Conv2D)            │                    │             │
│
├───────────────────────┼────────────────────┼─────────────┼───────────────
───────┤
│ block2b_se_expand   │ (None, 1, 1, 192)  │       1,728 │
block2b_se_reduc… │
│ (Conv2D)            │                    │             │
│
```

```
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────
──────┤
│ block2b_se_excite    │ (None, 56, 56,       │            0 │
block2b_activati… │
│ (Multiply)           │ 192)                 │              │
block2b_se_expan… │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────
──────┤
│ block2b_project_co… │ (None, 56, 56,       │        6,144 │
block2b_se_excit… │
│ (Conv2D)             │ 32)                  │              │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────
──────┤
│ block2b_project_bn   │ (None, 56, 56,       │          128 │
block2b_project_… │
│ (BatchNormalizatio… │ 32)                  │              │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────
──────┤
│ block2b_drop         │ (None, 56, 56,       │            0 │
block2b_project_… │
│ (Dropout)            │ 32)                  │              │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────
──────┤
│ block2b_add (Add)    │ (None, 56, 56,       │            0 │
block2b_drop[0][… │
│                      │ 32)                  │              │
block2a_project_… │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────
──────┤
│ block2c_expand_conv │ (None, 56, 56,       │        6,144 │
block2b_add[0][0] │
│ (Conv2D)             │ 192)                 │              │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────
──────┤
│ block2c_expand_bn    │ (None, 56, 56,       │          768 │
block2c_expand_c… │
│ (BatchNormalizatio… │ 192)                 │              │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────
──────┤
│ block2c_expand_act… │ (None, 56, 56,       │            0 │
block2c_expand_b… │
│ (Activation)         │ 192)                 │              │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────
```

```
──────┤
│ block2c_dwconv       │ (None, 56, 56,     │       1,728 │
block2c_expand_a… │
│ (DepthwiseConv2D)    │ 192)               │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block2c_bn           │ (None, 56, 56,     │         768 │
block2c_dwconv[0… │
│ (BatchNormalizatio… │ 192)               │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block2c_activation   │ (None, 56, 56,     │           0 │ block2c_bn[0]
[0]  │
│ (Activation)         │ 192)               │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block2c_se_squeeze   │ (None, 192)        │           0 │
block2c_activati… │
│ (GlobalAveragePool… │                    │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block2c_se_reshape   │ (None, 1, 1, 192)  │           0 │
block2c_se_squee… │
│ (Reshape)            │                    │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block2c_se_reduce    │ (None, 1, 1, 8)    │       1,544 │
block2c_se_resha… │
│ (Conv2D)             │                    │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block2c_se_expand    │ (None, 1, 1, 192)  │       1,728 │
block2c_se_reduc… │
│ (Conv2D)             │                    │             │
│
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block2c_se_excite    │ (None, 56, 56,     │           0 │
block2c_activati… │
│ (Multiply)           │ 192)               │             │
block2c_se_expan… │
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
```

```
| block2c_project_co… | (None, 56, 56,     |       6,144 |
block2c_se_excit… |
| (Conv2D)            | 32)                |             |
|
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block2c_project_bn  | (None, 56, 56,     |         128 |
block2c_project_… |
| (BatchNormalizatio… | 32)                |             |
|
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block2c_drop        | (None, 56, 56,     |           0 |
block2c_project_… |
| (Dropout)           | 32)                |             |
|
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block2c_add (Add)   | (None, 56, 56,     |           0 |
block2c_drop[0][… |
|                     | 32)                |             |
block2b_add[0][0] |
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block3a_expand_conv | (None, 56, 56,     |       6,144 |
block2c_add[0][0] |
| (Conv2D)            | 192)               |             |
|
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block3a_expand_bn   | (None, 56, 56,     |         768 |
block3a_expand_c… |
| (BatchNormalizatio… | 192)               |             |
|
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block3a_expand_act… | (None, 56, 56,     |           0 |
block3a_expand_b… |
| (Activation)        | 192)               |             |
|
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block3a_dwconv_pad  | (None, 59, 59,     |           0 |
block3a_expand_a… |
| (ZeroPadding2D)     | 192)               |             |
|
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block3a_dwconv      | (None, 28, 28,     |       4,800 |
```

```
block3a_dwconv_p… │
│ (DepthwiseConv2D)   │ 192)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block3a_bn          │ (None, 28, 28,     │         768 │
block3a_dwconv[0… │
│ (BatchNormalizatio… │ 192)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block3a_activation  │ (None, 28, 28,     │           0 │ block3a_bn[0]
[0]  │
│ (Activation)        │ 192)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block3a_se_squeeze  │ (None, 192)        │           0 │
block3a_activati… │
│ (GlobalAveragePool… │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block3a_se_reshape  │ (None, 1, 1, 192)  │           0 │
block3a_se_squee… │
│ (Reshape)           │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block3a_se_reduce   │ (None, 1, 1, 8)    │       1,544 │
block3a_se_resha… │
│ (Conv2D)            │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block3a_se_expand   │ (None, 1, 1, 192)  │       1,728 │
block3a_se_reduc… │
│ (Conv2D)            │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block3a_se_excite   │ (None, 28, 28,     │           0 │
block3a_activati… │
│ (Multiply)          │ 192)               │             │
block3a_se_expan… │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block3a_project_co… │ (None, 28, 28,     │       9,216 │
block3a_se_excit… │
│ (Conv2D)            │ 48)                │             │
```

```
│
├─────────────────────┼───────────────────┼────────────┼───────────
──────┤
│ block3a_project_bn  │ (None, 28, 28,    │        192 │
block3a_project_… │
│ (BatchNormalizatio… │ 48)               │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────
──────┤
│ block3b_expand_conv │ (None, 28, 28,    │     13,824 │
block3a_project_… │
│ (Conv2D)            │ 288)              │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────
──────┤
│ block3b_expand_bn   │ (None, 28, 28,    │      1,152 │
block3b_expand_c… │
│ (BatchNormalizatio… │ 288)              │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────
──────┤
│ block3b_expand_act… │ (None, 28, 28,    │          0 │
block3b_expand_b… │
│ (Activation)        │ 288)              │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────
──────┤
│ block3b_dwconv      │ (None, 28, 28,    │      7,200 │
block3b_expand_a… │
│ (DepthwiseConv2D)   │ 288)              │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────
──────┤
│ block3b_bn          │ (None, 28, 28,    │      1,152 │
block3b_dwconv[0… │
│ (BatchNormalizatio… │ 288)              │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────
──────┤
│ block3b_activation  │ (None, 28, 28,    │          0 │ block3b_bn[0]
[0]  │
│ (Activation)        │ 288)              │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────
──────┤
│ block3b_se_squeeze  │ (None, 288)       │          0 │
block3b_activati… │
│ (GlobalAveragePool… │                   │            │
│
```

```
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┼──────┤
│ block3b_se_reshape   │ (None, 1, 1, 288)    │            0 │ block3b_se_squee…    │
│ (Reshape)            │                      │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┼──────┤
│ block3b_se_reduce    │ (None, 1, 1, 12)     │        3,468 │ block3b_se_resha…    │
│ (Conv2D)             │                      │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┼──────┤
│ block3b_se_expand    │ (None, 1, 1, 288)    │        3,744 │ block3b_se_reduc…    │
│ (Conv2D)             │                      │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┼──────┤
│ block3b_se_excite    │ (None, 28, 28,       │            0 │ block3b_activati…    │
│ (Multiply)           │ 288)                 │              │ block3b_se_expan…    │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┼──────┤
│ block3b_project_co…  │ (None, 28, 28,       │       13,824 │ block3b_se_excit…    │
│ (Conv2D)             │ 48)                  │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┼──────┤
│ block3b_project_bn   │ (None, 28, 28,       │          192 │ block3b_project_…    │
│ (BatchNormalizatio…  │ 48)                  │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┼──────┤
│ block3b_drop         │ (None, 28, 28,       │            0 │ block3b_project_…    │
│ (Dropout)            │ 48)                  │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┼──────┤
│ block3b_add (Add)    │ (None, 28, 28,       │            0 │ block3b_drop[0][…    │
│                      │ 48)                  │              │ block3a_project_…    │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┼──────┤
```

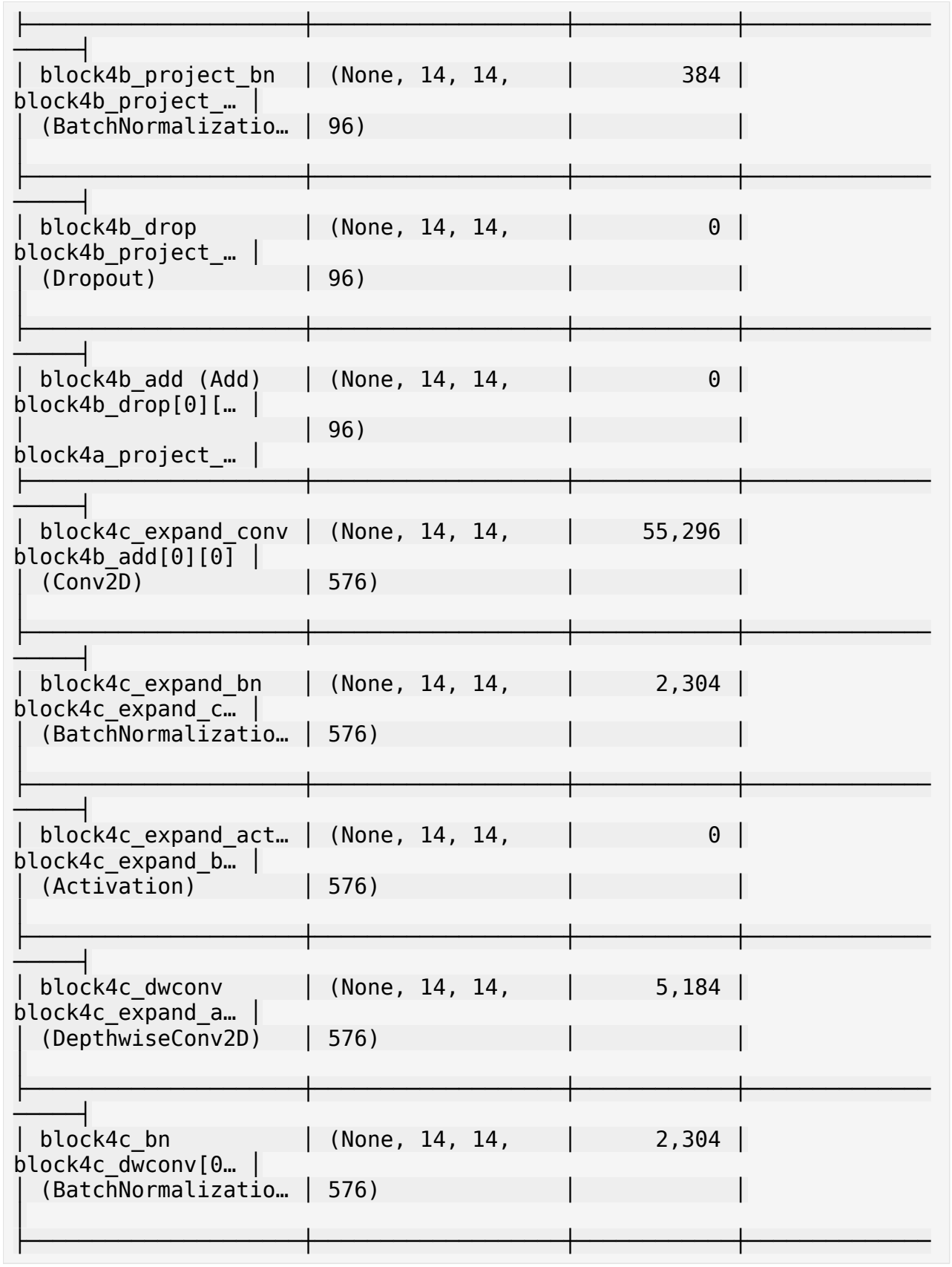
```
──────┤
│ block3c_expand_conv │ (None, 28, 28,     │     13,824 │
block3b_add[0][0] │
│ (Conv2D)            │ 288)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block3c_expand_bn   │ (None, 28, 28,     │      1,152 │
block3c_expand_c… │
│ (BatchNormalizatio… │ 288)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block3c_expand_act… │ (None, 28, 28,     │          0 │
block3c_expand_b… │
│ (Activation)        │ 288)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block3c_dwconv      │ (None, 28, 28,     │      7,200 │
block3c_expand_a… │
│ (DepthwiseConv2D)   │ 288)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block3c_bn          │ (None, 28, 28,     │      1,152 │
block3c_dwconv[0… │
│ (BatchNormalizatio… │ 288)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block3c_activation  │ (None, 28, 28,     │          0 │ block3c_bn[0]
[0]  │
│ (Activation)        │ 288)               │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block3c_se_squeeze  │ (None, 288)        │          0 │
block3c_activati… │
│ (GlobalAveragePool… │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block3c_se_reshape  │ (None, 1, 1, 288)  │          0 │
block3c_se_squee… │
│ (Reshape)           │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
```

block3c_se_reduce (Conv2D)	(None, 1, 1, 12)	3,468	block3c_se_resha…
block3c_se_expand (Conv2D)	(None, 1, 1, 288)	3,744	block3c_se_reduc…
block3c_se_excite (Multiply)	(None, 28, 28, 288)	0	block3c_activati… block3c_se_expan…
block3c_project_co… (Conv2D)	(None, 28, 28, 48)	13,824	block3c_se_excit…
block3c_project_bn (BatchNormalizatio…	(None, 28, 28, 48)	192	block3c_project_…
block3c_drop (Dropout)	(None, 28, 28, 48)	0	block3c_project_…
block3c_add (Add)	(None, 28, 28, 48)	0	block3c_drop[0][… block3b_add[0][0]
block4a_expand_conv (Conv2D)	(None, 28, 28, 288)	13,824	block3c_add[0][0]
block4a_expand_bn	(None, 28, 28,	1,152	

```
block4a_expand_c… │
│ (BatchNormalizatio… │ 288)               │            │
│                     │                    │            │
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block4a_expand_act… │ (None, 28, 28,     │          0 │
block4a_expand_b… │
│ (Activation)        │ 288)               │            │
│                     │                    │            │
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block4a_dwconv_pad  │ (None, 29, 29,     │          0 │
block4a_expand_a… │
│ (ZeroPadding2D)     │ 288)               │            │
│                     │                    │            │
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block4a_dwconv      │ (None, 14, 14,     │      2,592 │
block4a_dwconv_p… │
│ (DepthwiseConv2D)   │ 288)               │            │
│                     │                    │            │
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block4a_bn          │ (None, 14, 14,     │      1,152 │
block4a_dwconv[0… │
│ (BatchNormalizatio… │ 288)               │            │
│                     │                    │            │
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block4a_activation  │ (None, 14, 14,     │          0 │ block4a_bn[0]
[0]  │
│ (Activation)        │ 288)               │            │
│                     │                    │            │
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block4a_se_squeeze  │ (None, 288)        │          0 │
block4a_activati… │
│ (GlobalAveragePool… │                    │            │
│                     │                    │            │
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block4a_se_reshape  │ (None, 1, 1, 288)  │          0 │
block4a_se_squee… │
│ (Reshape)           │                    │            │
│                     │                    │            │
├─────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block4a_se_reduce   │ (None, 1, 1, 12)   │      3,468 │
block4a_se_resha… │
```

(Conv2D)			
block4a_se_expand (Conv2D)	(None, 1, 1, 288)	3,744	block4a_se_reduc…
block4a_se_excite (Multiply)	(None, 14, 14, 288)	0	block4a_activati… block4a_se_expan…
block4a_project_co… (Conv2D)	(None, 14, 14, 96)	27,648	block4a_se_excit…
block4a_project_bn (BatchNormalizatio…	(None, 14, 14, 96)	384	block4a_project_…
block4b_expand_conv (Conv2D)	(None, 14, 14, 576)	55,296	block4a_project_…
block4b_expand_bn (BatchNormalizatio…	(None, 14, 14, 576)	2,304	block4b_expand_c…
block4b_expand_act… (Activation)	(None, 14, 14, 576)	0	block4b_expand_b…
block4b_dwconv (DepthwiseConv2D)	(None, 14, 14, 576)	5,184	block4b_expand_a…

```
│
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ block4b_bn          │ (None, 14, 14,    │      2,304 │
block4b_dwconv[0… │
│ (BatchNormalizatio… │ 576)              │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ block4b_activation  │ (None, 14, 14,    │          0 │ block4b_bn[0]
[0]  │
│ (Activation)        │ 576)              │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ block4b_se_squeeze  │ (None, 576)       │          0 │
block4b_activati… │
│ (GlobalAveragePool… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ block4b_se_reshape  │ (None, 1, 1, 576) │          0 │
block4b_se_squee… │
│ (Reshape)           │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ block4b_se_reduce   │ (None, 1, 1, 24)  │     13,848 │
block4b_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ block4b_se_expand   │ (None, 1, 1, 576) │     14,400 │
block4b_se_reduc… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ block4b_se_excite   │ (None, 14, 14,    │          0 │
block4b_activati… │
│ (Multiply)          │ 576)              │            │
block4b_se_expan… │
├─────────────────────┼───────────────────┼────────────┼───────────────
──────┤
│ block4b_project_co… │ (None, 14, 14,    │     55,296 │
block4b_se_excit… │
│ (Conv2D)            │ 96)               │            │
│
```



```
──────┤
│ block4c_activation  │ (None, 14, 14,     │           0 │ block4c_bn[0]
[0]  │
│ (Activation)        │ 576)               │             │
│                     │                    │             │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block4c_se_squeeze  │ (None, 576)        │           0 │
block4c_activati… │
│ (GlobalAveragePool… │                    │             │
│                     │                    │             │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block4c_se_reshape  │ (None, 1, 1, 576)  │           0 │
block4c_se_squee… │
│ (Reshape)           │                    │             │
│                     │                    │             │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block4c_se_reduce   │ (None, 1, 1, 24)   │      13,848 │
block4c_se_resha… │
│ (Conv2D)            │                    │             │
│                     │                    │             │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block4c_se_expand   │ (None, 1, 1, 576)  │      14,400 │
block4c_se_reduc… │
│ (Conv2D)            │                    │             │
│                     │                    │             │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block4c_se_excite   │ (None, 14, 14,     │           0 │
block4c_activati… │
│ (Multiply)          │ 576)               │             │
block4c_se_expan… │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block4c_project_co… │ (None, 14, 14,     │      55,296 │
block4c_se_excit… │
│ (Conv2D)            │ 96)                │             │
│                     │                    │             │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block4c_project_bn  │ (None, 14, 14,     │         384 │
block4c_project_… │
│ (BatchNormalizatio… │ 96)                │             │
│                     │                    │             │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
```

```
| block4c_drop         | (None, 14, 14,     |           0 |
block4c_project_… |
| (Dropout)            | 96)                |             |
|
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block4c_add (Add)    | (None, 14, 14,     |           0 |
block4c_drop[0][… |
|                      | 96)                |             |
block4b_add[0][0] |
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block4d_expand_conv | (None, 14, 14,     |      55,296 |
block4c_add[0][0] |
| (Conv2D)             | 576)               |             |
|
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block4d_expand_bn    | (None, 14, 14,     |       2,304 |
block4d_expand_c… |
| (BatchNormalizatio… | 576)               |             |
|
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block4d_expand_act… | (None, 14, 14,     |           0 |
block4d_expand_b… |
| (Activation)         | 576)               |             |
|
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block4d_dwconv       | (None, 14, 14,     |       5,184 |
block4d_expand_a… |
| (DepthwiseConv2D)    | 576)               |             |
|
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block4d_bn           | (None, 14, 14,     |       2,304 |
block4d_dwconv[0… |
| (BatchNormalizatio… | 576)               |             |
|
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block4d_activation   | (None, 14, 14,     |           0 | block4d_bn[0]
[0]   |
| (Activation)         | 576)               |             |
|
├──────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
| block4d_se_squeeze   | (None, 576)        |           0 |
```

```
block4d_activati… │
│ (GlobalAveragePool… │                      │             │
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4d_se_reshape   │ (None, 1, 1, 576)    │           0 │
block4d_se_squee… │
│ (Reshape)            │                      │             │
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4d_se_reduce    │ (None, 1, 1, 24)     │      13,848 │
block4d_se_resha… │
│ (Conv2D)             │                      │             │
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4d_se_expand    │ (None, 1, 1, 576)    │      14,400 │
block4d_se_reduc… │
│ (Conv2D)             │                      │             │
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4d_se_excite    │ (None, 14, 14,       │           0 │
block4d_activati… │
│ (Multiply)           │ 576)                 │             │
block4d_se_expan… │
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4d_project_co… │ (None, 14, 14,       │      55,296 │
block4d_se_excit… │
│ (Conv2D)             │ 96)                  │             │
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4d_project_bn   │ (None, 14, 14,       │         384 │
block4d_project_… │
│ (BatchNormalizatio… │ 96)                  │             │
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4d_drop         │ (None, 14, 14,       │           0 │
block4d_project_… │
│ (Dropout)            │ 96)                  │             │
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4d_add (Add)    │ (None, 14, 14,       │           0 │
block4d_drop[0][… │
│                      │ 96)                  │             │
```

```
block4c_add[0][0] │
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4e_expand_conv │ (None, 14, 14,     │     55,296 │
block4d_add[0][0] │
│ (Conv2D)             │ 576)                 │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4e_expand_bn    │ (None, 14, 14,     │      2,304 │
block4e_expand_c… │
│ (BatchNormalizatio… │ 576)                 │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4e_expand_act… │ (None, 14, 14,     │           0 │
block4e_expand_b… │
│ (Activation)         │ 576)                 │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4e_dwconv       │ (None, 14, 14,     │      5,184 │
block4e_expand_a… │
│ (DepthwiseConv2D)    │ 576)                 │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4e_bn           │ (None, 14, 14,     │      2,304 │
block4e_dwconv[0… │
│ (BatchNormalizatio… │ 576)                 │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4e_activation   │ (None, 14, 14,     │           0 │ block4e_bn[0]
[0]  │
│ (Activation)         │ 576)                 │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4e_se_squeeze   │ (None, 576)          │           0 │
block4e_activati… │
│ (GlobalAveragePool… │                      │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block4e_se_reshape   │ (None, 1, 1, 576)  │           0 │
block4e_se_squee… │
│ (Reshape)            │                      │             │
│
```

```
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block4e_se_reduce    │ (None, 1, 1, 24)     │       13,848 │ block4e_se_resha… │
│ (Conv2D)             │                      │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block4e_se_expand    │ (None, 1, 1, 576)    │       14,400 │ block4e_se_reduc… │
│ (Conv2D)             │                      │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block4e_se_excite    │ (None, 14, 14,       │            0 │ block4e_activati… │
│ (Multiply)           │ 576)                 │              │ block4e_se_expan… │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block4e_project_co… │ (None, 14, 14,       │       55,296 │ block4e_se_excit… │
│ (Conv2D)             │ 96)                  │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block4e_project_bn   │ (None, 14, 14,       │          384 │ block4e_project_… │
│ (BatchNormalizatio… │ 96)                  │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block4e_drop         │ (None, 14, 14,       │            0 │ block4e_project_… │
│ (Dropout)            │ 96)                  │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block4e_add (Add)    │ (None, 14, 14,       │            0 │ block4e_drop[0][… │
│                      │ 96)                  │              │ block4d_add[0][0] │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block5a_expand_conv  │ (None, 14, 14,       │       55,296 │ block4e_add[0][0] │
│ (Conv2D)             │ 576)                 │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
```

```
──────┤
│ block5a_expand_bn   │ (None, 14, 14,     │       2,304 │
block5a_expand_c… │
│ (BatchNormalizatio… │ 576)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5a_expand_act… │ (None, 14, 14,     │           0 │
block5a_expand_b… │
│ (Activation)        │ 576)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5a_dwconv      │ (None, 14, 14,     │      14,400 │
block5a_expand_a… │
│ (DepthwiseConv2D)   │ 576)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5a_bn          │ (None, 14, 14,     │       2,304 │
block5a_dwconv[0… │
│ (BatchNormalizatio… │ 576)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5a_activation  │ (None, 14, 14,     │           0 │ block5a_bn[0]
[0]  │
│ (Activation)        │ 576)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5a_se_squeeze  │ (None, 576)        │           0 │
block5a_activati… │
│ (GlobalAveragePool… │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5a_se_reshape  │ (None, 1, 1, 576)  │           0 │
block5a_se_squee… │
│ (Reshape)           │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5a_se_reduce   │ (None, 1, 1, 24)   │      13,848 │
block5a_se_resha… │
│ (Conv2D)            │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
```

```
| block5a_se_expand   | (None, 1, 1, 576) |     14,400 |
block5a_se_reduc… |
| (Conv2D)            |                   |            |
|
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
| block5a_se_excite   | (None, 14, 14,    |          0 |
block5a_activati… |
| (Multiply)          | 576)              |            |
block5a_se_expan… |
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
| block5a_project_co… | (None, 14, 14,    |     78,336 |
block5a_se_excit… |
| (Conv2D)            | 136)              |            |
|
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
| block5a_project_bn  | (None, 14, 14,    |        544 |
block5a_project_… |
| (BatchNormalizatio… | 136)              |            |
|
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
| block5b_expand_conv | (None, 14, 14,    |    110,976 |
block5a_project_… |
| (Conv2D)            | 816)              |            |
|
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
| block5b_expand_bn   | (None, 14, 14,    |      3,264 |
block5b_expand_c… |
| (BatchNormalizatio… | 816)              |            |
|
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
| block5b_expand_act… | (None, 14, 14,    |          0 |
block5b_expand_b… |
| (Activation)        | 816)              |            |
|
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
| block5b_dwconv      | (None, 14, 14,    |     20,400 |
block5b_expand_a… |
| (DepthwiseConv2D)   | 816)              |            |
|
├─────────────────────┼───────────────────┼────────────┼──────────────
──────┤
| block5b_bn          | (None, 14, 14,    |      3,264 |
```

```
block5b_dwconv[0… │
│ (BatchNormalizatio… │ 816)               │             │
│                     │                    │             │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block5b_activation  │ (None, 14, 14,     │           0 │ block5b_bn[0]
[0]   │
│ (Activation)        │ 816)               │             │
│                     │                    │             │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block5b_se_squeeze  │ (None, 816)        │           0 │
block5b_activati… │
│ (GlobalAveragePool… │                    │             │
│                     │                    │             │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block5b_se_reshape  │ (None, 1, 1, 816)  │           0 │
block5b_se_squee… │
│ (Reshape)           │                    │             │
│                     │                    │             │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block5b_se_reduce   │ (None, 1, 1, 34)   │      27,778 │
block5b_se_resha… │
│ (Conv2D)            │                    │             │
│                     │                    │             │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block5b_se_expand   │ (None, 1, 1, 816)  │      28,560 │
block5b_se_reduc… │
│ (Conv2D)            │                    │             │
│                     │                    │             │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block5b_se_excite   │ (None, 14, 14,     │           0 │
block5b_activati… │
│ (Multiply)          │ 816)               │             │
block5b_se_expan… │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block5b_project_co… │ (None, 14, 14,     │     110,976 │
block5b_se_excit… │
│ (Conv2D)            │ 136)               │             │
│                     │                    │             │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block5b_project_bn  │ (None, 14, 14,     │         544 │
block5b_project_… │
```

```
| (BatchNormalizatio… | 136)                |             |
|                     |                     |             |
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block5b_drop        | (None, 14, 14,      |           0 |
block5b_project_… |
| (Dropout)           | 136)                |             |
|                     |                     |             |
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block5b_add (Add)   | (None, 14, 14,      |           0 |
block5b_drop[0][… |
|                     | 136)                |             |
block5a_project_… |
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block5c_expand_conv | (None, 14, 14,      |     110,976 |
block5b_add[0][0] |
| (Conv2D)            | 816)                |             |
|                     |                     |             |
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block5c_expand_bn   | (None, 14, 14,      |       3,264 |
block5c_expand_c… |
| (BatchNormalizatio… | 816)                |             |
|                     |                     |             |
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block5c_expand_act… | (None, 14, 14,      |           0 |
block5c_expand_b… |
| (Activation)        | 816)                |             |
|                     |                     |             |
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block5c_dwconv      | (None, 14, 14,      |      20,400 |
block5c_expand_a… |
| (DepthwiseConv2D)   | 816)                |             |
|                     |                     |             |
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block5c_bn          | (None, 14, 14,      |       3,264 |
block5c_dwconv[0… |
| (BatchNormalizatio… | 816)                |             |
|                     |                     |             |
├─────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block5c_activation  | (None, 14, 14,      |           0 | block5c_bn[0]
[0]  |
| (Activation)        | 816)                |             |
```

```
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5c_se_squeeze  │ (None, 816)        │           0 │
block5c_activati… │
│ (GlobalAveragePool… │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5c_se_reshape  │ (None, 1, 1, 816)  │           0 │
block5c_se_squee… │
│ (Reshape)           │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5c_se_reduce   │ (None, 1, 1, 34)   │      27,778 │
block5c_se_resha… │
│ (Conv2D)            │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5c_se_expand   │ (None, 1, 1, 816)  │      28,560 │
block5c_se_reduc… │
│ (Conv2D)            │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5c_se_excite   │ (None, 14, 14,     │           0 │
block5c_activati… │
│ (Multiply)          │ 816)               │             │
block5c_se_expan… │
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5c_project_co… │ (None, 14, 14,     │     110,976 │
block5c_se_excit… │
│ (Conv2D)            │ 136)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5c_project_bn  │ (None, 14, 14,     │         544 │
block5c_project_… │
│ (BatchNormalizatio… │ 136)               │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────
──────┤
│ block5c_drop        │ (None, 14, 14,     │           0 │
block5c_project_… │
│ (Dropout)           │ 136)               │             │
│
```

```
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block5c_add (Add)    │ (None, 14, 14,       │            0 │ block5c_drop[0][…    │
│                      │ 136)                 │              │ block5b_add[0][0]    │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block5d_expand_conv  │ (None, 14, 14,       │      110,976 │ block5c_add[0][0]    │
│ (Conv2D)             │ 816)                 │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block5d_expand_bn    │ (None, 14, 14,       │        3,264 │ block5d_expand_c…    │
│ (BatchNormalizatio…  │ 816)                 │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block5d_expand_act…  │ (None, 14, 14,       │            0 │ block5d_expand_b…    │
│ (Activation)         │ 816)                 │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block5d_dwconv       │ (None, 14, 14,       │       20,400 │ block5d_expand_a…    │
│ (DepthwiseConv2D)    │ 816)                 │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block5d_bn           │ (None, 14, 14,       │        3,264 │ block5d_dwconv[0…    │
│ (BatchNormalizatio…  │ 816)                 │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block5d_activation   │ (None, 14, 14,       │            0 │ block5d_bn[0][0]     │
│ (Activation)         │ 816)                 │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
│ block5d_se_squeeze   │ (None, 816)          │            0 │ block5d_activati…    │
│ (GlobalAveragePool…  │                      │              │                      │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────────┤
```

```
──────┤
│ block5d_se_reshape  │ (None, 1, 1, 816) │          0 │
block5d_se_squee… │
│ (Reshape)           │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
│ block5d_se_reduce   │ (None, 1, 1, 34)  │     27,778 │
block5d_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
│ block5d_se_expand   │ (None, 1, 1, 816) │     28,560 │
block5d_se_reduc… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
│ block5d_se_excite   │ (None, 14, 14,    │          0 │
block5d_activati… │
│ (Multiply)          │ 816)              │            │
block5d_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
│ block5d_project_co… │ (None, 14, 14,    │    110,976 │
block5d_se_excit… │
│ (Conv2D)            │ 136)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
│ block5d_project_bn  │ (None, 14, 14,    │        544 │
block5d_project_… │
│ (BatchNormalizatio… │ 136)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
│ block5d_drop        │ (None, 14, 14,    │          0 │
block5d_project_… │
│ (Dropout)           │ 136)              │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
│ block5d_add (Add)   │ (None, 14, 14,    │          0 │
block5d_drop[0][… │
│                     │ 136)              │            │
block5c_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
```

```
| block5e_expand_conv | (None, 14, 14,     |    110,976 |
block5d_add[0][0] |
| (Conv2D)            | 816)               |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block5e_expand_bn   | (None, 14, 14,     |      3,264 |
block5e_expand_c… |
| (BatchNormalizatio… | 816)               |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block5e_expand_act… | (None, 14, 14,     |          0 |
block5e_expand_b… |
| (Activation)        | 816)               |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block5e_dwconv      | (None, 14, 14,     |     20,400 |
block5e_expand_a… |
| (DepthwiseConv2D)   | 816)               |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block5e_bn          | (None, 14, 14,     |      3,264 |
block5e_dwconv[0… |
| (BatchNormalizatio… | 816)               |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block5e_activation  | (None, 14, 14,     |          0 | block5e_bn[0]
[0]  |
| (Activation)        | 816)               |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block5e_se_squeeze  | (None, 816)        |          0 |
block5e_activati… |
| (GlobalAveragePool… |                    |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block5e_se_reshape  | (None, 1, 1, 816)  |          0 |
block5e_se_squee… |
| (Reshape)           |                    |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block5e_se_reduce   | (None, 1, 1, 34)   |     27,778 |
```

```
block5e_se_resha… │
│ (Conv2D)              │                      │              │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block5e_se_expand    │ (None, 1, 1, 816) │      28,560 │
block5e_se_reduc… │
│ (Conv2D)              │                      │              │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block5e_se_excite    │ (None, 14, 14,     │           0 │
block5e_activati… │
│ (Multiply)            │ 816)                 │              │
block5e_se_expan… │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block5e_project_co… │ (None, 14, 14,     │    110,976 │
block5e_se_excit… │
│ (Conv2D)              │ 136)                 │              │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block5e_project_bn   │ (None, 14, 14,     │         544 │
block5e_project_… │
│ (BatchNormalizatio… │ 136)                 │              │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block5e_drop         │ (None, 14, 14,     │           0 │
block5e_project_… │
│ (Dropout)             │ 136)                 │              │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block5e_add (Add)    │ (None, 14, 14,     │           0 │
block5e_drop[0][… │
│                       │ 136)                 │              │
block5d_add[0][0] │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block6a_expand_conv │ (None, 14, 14,     │    110,976 │
block5e_add[0][0] │
│ (Conv2D)              │ 816)                 │              │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block6a_expand_bn    │ (None, 14, 14,     │       3,264 │
block6a_expand_c… │
│ (BatchNormalizatio… │ 816)                 │              │
```

```
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
───────┤
│ block6a_expand_act… │ (None, 14, 14,      │           0 │
block6a_expand_b… │
│ (Activation)        │ 816)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
───────┤
│ block6a_dwconv_pad  │ (None, 17, 17,      │           0 │
block6a_expand_a… │
│ (ZeroPadding2D)     │ 816)                │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
───────┤
│ block6a_dwconv      │ (None, 7, 7, 816)   │      20,400 │
block6a_dwconv_p… │
│ (DepthwiseConv2D)   │                     │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
───────┤
│ block6a_bn          │ (None, 7, 7, 816)   │       3,264 │
block6a_dwconv[0… │
│ (BatchNormalizatio… │                     │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
───────┤
│ block6a_activation  │ (None, 7, 7, 816)   │           0 │ block6a_bn[0]
[0]   │
│ (Activation)        │                     │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
───────┤
│ block6a_se_squeeze  │ (None, 816)         │           0 │
block6a_activati… │
│ (GlobalAveragePool… │                     │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
───────┤
│ block6a_se_reshape  │ (None, 1, 1, 816)   │           0 │
block6a_se_squee… │
│ (Reshape)           │                     │             │
│
├─────────────────────┼─────────────────────┼─────────────┼──────────────
───────┤
│ block6a_se_reduce   │ (None, 1, 1, 34)    │      27,778 │
block6a_se_resha… │
│ (Conv2D)            │                     │             │
│
```

```
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block6a_se_expand    │ (None, 1, 1, 816)    │      28,560 │
block6a_se_reduc… │
│ (Conv2D)             │                      │             │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block6a_se_excite    │ (None, 7, 7, 816)    │           0 │
block6a_activati… │
│ (Multiply)           │                      │             │
block6a_se_expan… │
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block6a_project_co… │ (None, 7, 7, 232)    │     189,312 │
block6a_se_excit… │
│ (Conv2D)             │                      │             │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block6a_project_bn   │ (None, 7, 7, 232)    │         928 │
block6a_project_… │
│ (BatchNormalizatio… │                      │             │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block6b_expand_conv │ (None, 7, 7,         │     322,944 │
block6a_project_… │
│ (Conv2D)             │ 1392)                │             │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block6b_expand_bn    │ (None, 7, 7,         │       5,568 │
block6b_expand_c… │
│ (BatchNormalizatio… │ 1392)                │             │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block6b_expand_act… │ (None, 7, 7,         │           0 │
block6b_expand_b… │
│ (Activation)         │ 1392)                │             │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block6b_dwconv       │ (None, 7, 7,         │      34,800 │
block6b_expand_a… │
│ (DepthwiseConv2D)    │ 1392)                │             │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
```

```
──────┤
│ block6b_bn           │ (None, 7, 7,       │      5,568 │
block6b_dwconv[0… │
│ (BatchNormalizatio… │ 1392)              │            │
│
├──────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block6b_activation   │ (None, 7, 7,       │          0 │ block6b_bn[0]
[0]   │
│ (Activation)         │ 1392)              │            │
│
├──────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block6b_se_squeeze   │ (None, 1392)       │          0 │
block6b_activati… │
│ (GlobalAveragePool… │                    │            │
│
├──────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block6b_se_reshape   │ (None, 1, 1,       │          0 │
block6b_se_squee… │
│ (Reshape)            │ 1392)              │            │
│
├──────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block6b_se_reduce    │ (None, 1, 1, 58)   │     80,794 │
block6b_se_resha… │
│ (Conv2D)             │                    │            │
│
├──────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block6b_se_expand    │ (None, 1, 1,       │     82,128 │
block6b_se_reduc… │
│ (Conv2D)             │ 1392)              │            │
│
├──────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block6b_se_excite    │ (None, 7, 7,       │          0 │
block6b_activati… │
│ (Multiply)           │ 1392)              │            │
block6b_se_expan… │
├──────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
│ block6b_project_co… │ (None, 7, 7, 232)  │    322,944 │
block6b_se_excit… │
│ (Conv2D)             │                    │            │
│
├──────────────────────┼────────────────────┼────────────┼──────────────────
──────┤
```

```
| block6b_project_bn  | (None, 7, 7, 232) |         928 |
block6b_project_… |
| (BatchNormalizatio… |                   |             |
|
├─────────────────────┼───────────────────┼─────────────┼──────────────────
──────┤
| block6b_drop        | (None, 7, 7, 232) |           0 |
block6b_project_… |
| (Dropout)           |                   |             |
|
├─────────────────────┼───────────────────┼─────────────┼──────────────────
──────┤
| block6b_add (Add)   | (None, 7, 7, 232) |           0 |
block6b_drop[0][… |
|                     |                   |             |
block6a_project_… |
├─────────────────────┼───────────────────┼─────────────┼──────────────────
──────┤
| block6c_expand_conv | (None, 7, 7,      |     322,944 |
block6b_add[0][0] |
| (Conv2D)            | 1392)             |             |
|
├─────────────────────┼───────────────────┼─────────────┼──────────────────
──────┤
| block6c_expand_bn   | (None, 7, 7,      |       5,568 |
block6c_expand_c… |
| (BatchNormalizatio… | 1392)             |             |
|
├─────────────────────┼───────────────────┼─────────────┼──────────────────
──────┤
| block6c_expand_act… | (None, 7, 7,      |           0 |
block6c_expand_b… |
| (Activation)        | 1392)             |             |
|
├─────────────────────┼───────────────────┼─────────────┼──────────────────
──────┤
| block6c_dwconv      | (None, 7, 7,      |      34,800 |
block6c_expand_a… |
| (DepthwiseConv2D)   | 1392)             |             |
|
├─────────────────────┼───────────────────┼─────────────┼──────────────────
──────┤
| block6c_bn          | (None, 7, 7,      |       5,568 |
block6c_dwconv[0… |
| (BatchNormalizatio… | 1392)             |             |
|
├─────────────────────┼───────────────────┼─────────────┼──────────────────
──────┤
| block6c_activation  | (None, 7, 7,      |           0 | block6c_bn[0]
```

```
[0]  │
│ (Activation)         │ 1392)               │             │
│                      │                     │             │
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block6c_se_squeeze   │ (None, 1392)        │           0 │
block6c_activati… │
│ (GlobalAveragePool… │                     │             │
│                      │                     │             │
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block6c_se_reshape   │ (None, 1, 1,        │           0 │
block6c_se_squee… │
│ (Reshape)            │ 1392)               │             │
│                      │                     │             │
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block6c_se_reduce    │ (None, 1, 1, 58)    │      80,794 │
block6c_se_resha… │
│ (Conv2D)             │                     │             │
│                      │                     │             │
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block6c_se_expand    │ (None, 1, 1,        │      82,128 │
block6c_se_reduc… │
│ (Conv2D)             │ 1392)               │             │
│                      │                     │             │
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block6c_se_excite    │ (None, 7, 7,        │           0 │
block6c_activati… │
│ (Multiply)           │ 1392)               │             │
block6c_se_expan… │
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block6c_project_co… │ (None, 7, 7, 232) │     322,944 │
block6c_se_excit… │
│ (Conv2D)             │                     │             │
│                      │                     │             │
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block6c_project_bn   │ (None, 7, 7, 232) │         928 │
block6c_project_… │
│ (BatchNormalizatio… │                     │             │
│                      │                     │             │
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
│ block6c_drop         │ (None, 7, 7, 232) │           0 │
block6c_project_… │
```

```
| (Dropout)             |                     |             |
|                       |                     |             |
├───────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block6c_add (Add)     | (None, 7, 7, 232)   |           0 |
block6c_drop[0][… |
|                       |                     |             |
block6b_add[0][0] |
├───────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block6d_expand_conv | (None, 7, 7,        |     322,944 |
block6c_add[0][0] |
| (Conv2D)              | 1392)               |             |
|                       |                     |             |
├───────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block6d_expand_bn     | (None, 7, 7,        |       5,568 |
block6d_expand_c… |
| (BatchNormalizatio… | 1392)               |             |
|                       |                     |             |
├───────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block6d_expand_act… | (None, 7, 7,        |           0 |
block6d_expand_b… |
| (Activation)          | 1392)               |             |
|                       |                     |             |
├───────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block6d_dwconv        | (None, 7, 7,        |      34,800 |
block6d_expand_a… |
| (DepthwiseConv2D)     | 1392)               |             |
|                       |                     |             |
├───────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block6d_bn            | (None, 7, 7,        |       5,568 |
block6d_dwconv[0… |
| (BatchNormalizatio… | 1392)               |             |
|                       |                     |             |
├───────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block6d_activation    | (None, 7, 7,        |           0 | block6d_bn[0]
[0]  |
| (Activation)          | 1392)               |             |
|                       |                     |             |
├───────────────────────┼─────────────────────┼─────────────┼──────────────
──────┤
| block6d_se_squeeze    | (None, 1392)        |           0 |
block6d_activati… |
| (GlobalAveragePool… |                     |             |
```

```
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block6d_se_reshape   │ (None, 1, 1,         │           0 │
block6d_se_squee… │
│ (Reshape)            │ 1392)                │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block6d_se_reduce    │ (None, 1, 1, 58)     │      80,794 │
block6d_se_resha… │
│ (Conv2D)             │                      │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block6d_se_expand    │ (None, 1, 1,         │      82,128 │
block6d_se_reduc… │
│ (Conv2D)             │ 1392)                │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block6d_se_excite    │ (None, 7, 7,         │           0 │
block6d_activati… │
│ (Multiply)           │ 1392)                │             │
block6d_se_expan… │
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block6d_project_co… │ (None, 7, 7, 232)    │     322,944 │
block6d_se_excit… │
│ (Conv2D)             │                      │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block6d_project_bn   │ (None, 7, 7, 232)    │         928 │
block6d_project_… │
│ (BatchNormalizatio… │                      │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block6d_drop         │ (None, 7, 7, 232)    │           0 │
block6d_project_… │
│ (Dropout)            │                      │             │
│
├──────────────────────┼──────────────────────┼─────────────┼──────────────────
──────┤
│ block6d_add (Add)    │ (None, 7, 7, 232)    │           0 │
block6d_drop[0][… │
│                      │                      │             │
block6c_add[0][0] │
```

block6e_expand_conv (Conv2D)	(None, 7, 7, 1392)	322,944	block6d_add[0][0]
block6e_expand_bn (BatchNormalizatio…	(None, 7, 7, 1392)	5,568	block6e_expand_c…
block6e_expand_act… (Activation)	(None, 7, 7, 1392)	0	block6e_expand_b…
block6e_dwconv (DepthwiseConv2D)	(None, 7, 7, 1392)	34,800	block6e_expand_a…
block6e_bn (BatchNormalizatio…	(None, 7, 7, 1392)	5,568	block6e_dwconv[0…
block6e_activation (Activation)	(None, 7, 7, 1392)	0	block6e_bn[0][0]
block6e_se_squeeze (GlobalAveragePool…	(None, 1392)	0	block6e_activati…
block6e_se_reshape (Reshape)	(None, 1, 1, 1392)	0	block6e_se_squee…

```
──────┤
│ block6e_se_reduce   │ (None, 1, 1, 58)  │     80,794 │
block6e_se_resha… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
│ block6e_se_expand   │ (None, 1, 1,      │     82,128 │
block6e_se_reduc… │
│ (Conv2D)            │ 1392)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
│ block6e_se_excite   │ (None, 7, 7,      │          0 │
block6e_activati… │
│ (Multiply)          │ 1392)             │            │
block6e_se_expan… │
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
│ block6e_project_co… │ (None, 7, 7, 232) │    322,944 │
block6e_se_excit… │
│ (Conv2D)            │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
│ block6e_project_bn  │ (None, 7, 7, 232) │        928 │
block6e_project_… │
│ (BatchNormalizatio… │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
│ block6e_drop        │ (None, 7, 7, 232) │          0 │
block6e_project_… │
│ (Dropout)           │                   │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
│ block6e_add (Add)   │ (None, 7, 7, 232) │          0 │
block6e_drop[0][… │
│                     │                   │            │
block6d_add[0][0] │
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
│ block6f_expand_conv │ (None, 7, 7,      │    322,944 │
block6e_add[0][0] │
│ (Conv2D)            │ 1392)             │            │
│
├─────────────────────┼───────────────────┼────────────┼──────────────────
──────┤
```

```
| block6f_expand_bn   | (None, 7, 7,       |      5,568 |
block6f_expand_c… |
| (BatchNormalizatio… | 1392)              |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block6f_expand_act… | (None, 7, 7,       |          0 |
block6f_expand_b… |
| (Activation)        | 1392)              |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block6f_dwconv      | (None, 7, 7,       |     34,800 |
block6f_expand_a… |
| (DepthwiseConv2D)   | 1392)              |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block6f_bn          | (None, 7, 7,       |      5,568 |
block6f_dwconv[0… |
| (BatchNormalizatio… | 1392)              |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block6f_activation  | (None, 7, 7,       |          0 | block6f_bn[0]
[0]  |
| (Activation)        | 1392)              |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block6f_se_squeeze  | (None, 1392)       |          0 |
block6f_activati… |
| (GlobalAveragePool… |                    |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block6f_se_reshape  | (None, 1, 1,       |          0 |
block6f_se_squee… |
| (Reshape)           | 1392)              |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block6f_se_reduce   | (None, 1, 1, 58)   |     80,794 |
block6f_se_resha… |
| (Conv2D)            |                    |            |
|
├─────────────────────┼────────────────────┼────────────┼──────────────
──────┤
| block6f_se_expand   | (None, 1, 1,       |     82,128 |
```

```
block6f_se_reduc… |
| (Conv2D)             | 1392)               |             |
|
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
| block6f_se_excite    | (None, 7, 7,        |           0 |
block6f_activati… |
| (Multiply)           | 1392)               |             |
block6f_se_expan… |
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
| block6f_project_co… | (None, 7, 7, 232) |     322,944 |
block6f_se_excit… |
| (Conv2D)             |                     |             |
|
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
| block6f_project_bn   | (None, 7, 7, 232) |         928 |
block6f_project_… |
| (BatchNormalizatio… |                     |             |
|
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
| block6f_drop         | (None, 7, 7, 232) |           0 |
block6f_project_… |
| (Dropout)            |                     |             |
|
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
| block6f_add (Add)    | (None, 7, 7, 232) |           0 |
block6f_drop[0][… |
|                      |                     |             |
block6e_add[0][0] |
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
| block7a_expand_conv | (None, 7, 7,        |     322,944 |
block6f_add[0][0] |
| (Conv2D)             | 1392)               |             |
|
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
| block7a_expand_bn    | (None, 7, 7,        |       5,568 |
block7a_expand_c… |
| (BatchNormalizatio… | 1392)               |             |
|
├──────────────────────┼─────────────────────┼─────────────┼──────────────────
──────┤
| block7a_expand_act… | (None, 7, 7,        |           0 |
block7a_expand_b… |
| (Activation)         | 1392)               |             |
```

```
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block7a_dwconv      │ (None, 7, 7,       │     12,528 │
block7a_expand_a… │
│ (DepthwiseConv2D)   │ 1392)              │            │
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block7a_bn          │ (None, 7, 7,       │      5,568 │
block7a_dwconv[0… │
│ (BatchNormalizatio… │ 1392)              │            │
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block7a_activation  │ (None, 7, 7,       │          0 │ block7a_bn[0]
[0]  │
│ (Activation)        │ 1392)              │            │
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block7a_se_squeeze  │ (None, 1392)       │          0 │
block7a_activati… │
│ (GlobalAveragePool… │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block7a_se_reshape  │ (None, 1, 1,       │          0 │
block7a_se_squee… │
│ (Reshape)           │ 1392)              │            │
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block7a_se_reduce   │ (None, 1, 1, 58)   │     80,794 │
block7a_se_resha… │
│ (Conv2D)            │                    │            │
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block7a_se_expand   │ (None, 1, 1,       │     82,128 │
block7a_se_reduc… │
│ (Conv2D)            │ 1392)              │            │
│
├─────────────────────┼────────────────────┼────────────┼─────────────
──────┤
│ block7a_se_excite   │ (None, 7, 7,       │          0 │
block7a_activati… │
│ (Multiply)          │ 1392)              │            │
block7a_se_expan… │
```

```
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block7a_project_co… │ (None, 7, 7, 384) │    534,528 │
block7a_se_excit… │
│ (Conv2D)             │                      │            │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block7a_project_bn   │ (None, 7, 7, 384) │      1,536 │
block7a_project_… │
│ (BatchNormalizatio… │                      │            │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block7b_expand_conv  │ (None, 7, 7,       │    884,736 │
block7a_project_… │
│ (Conv2D)             │ 2304)              │            │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block7b_expand_bn    │ (None, 7, 7,       │      9,216 │
block7b_expand_c… │
│ (BatchNormalizatio… │ 2304)              │            │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block7b_expand_act… │ (None, 7, 7,       │          0 │
block7b_expand_b… │
│ (Activation)         │ 2304)              │            │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block7b_dwconv       │ (None, 7, 7,       │     20,736 │
block7b_expand_a… │
│ (DepthwiseConv2D)    │ 2304)              │            │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block7b_bn           │ (None, 7, 7,       │      9,216 │
block7b_dwconv[0… │
│ (BatchNormalizatio… │ 2304)              │            │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
──────┤
│ block7b_activation   │ (None, 7, 7,       │          0 │ block7b_bn[0]
[0]  │
│ (Activation)         │ 2304)              │            │
│
├──────────────────────┼──────────────────────┼──────────────┼──────────────────
```

```
──────┤
│ block7b_se_squeeze  │ (None, 2304)       │           0 │
block7b_activati… │
│ (GlobalAveragePool… │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block7b_se_reshape  │ (None, 1, 1,       │           0 │
block7b_se_squee… │
│ (Reshape)           │ 2304)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block7b_se_reduce   │ (None, 1, 1, 96)   │     221,280 │
block7b_se_resha… │
│ (Conv2D)            │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block7b_se_expand   │ (None, 1, 1,       │     223,488 │
block7b_se_reduc… │
│ (Conv2D)            │ 2304)              │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block7b_se_excite   │ (None, 7, 7,       │           0 │
block7b_activati… │
│ (Multiply)          │ 2304)              │             │
block7b_se_expan… │
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block7b_project_co… │ (None, 7, 7, 384)  │     884,736 │
block7b_se_excit… │
│ (Conv2D)            │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block7b_project_bn  │ (None, 7, 7, 384)  │       1,536 │
block7b_project_… │
│ (BatchNormalizatio… │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
│ block7b_drop        │ (None, 7, 7, 384)  │           0 │
block7b_project_… │
│ (Dropout)           │                    │             │
│
├─────────────────────┼────────────────────┼─────────────┼──────────────────
──────┤
```

```
| block7b_add (Add)    | (None, 7, 7, 384) |          0 |
block7b_drop[0][… |
|                      |                   |            |
block7a_project_… |
├──────────────────────┼───────────────────┼────────────┼──────────────
──────┤
| top_conv (Conv2D)    | (None, 7, 7,      |    589,824 |
block7b_add[0][0] |
|                      | 1536)             |            |
|
├──────────────────────┼───────────────────┼────────────┼──────────────
──────┤
| top_bn               | (None, 7, 7,      |      6,144 | top_conv[0]
[0]    |
| (BatchNormalizatio… | 1536)             |            |
|
├──────────────────────┼───────────────────┼────────────┼──────────────
──────┤
| top_activation       | (None, 7, 7,      |          0 | top_bn[0][0]
|
| (Activation)         | 1536)             |            |
|
└──────────────────────┴───────────────────┴────────────┴──────────────
──────┘

 Total params: 10,783,535 (41.14 MB)

 Trainable params: 10,696,232 (40.80 MB)

 Non-trainable params: 87,303 (341.03 KB)
```

```python
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.applications import EfficientNetB3

# Set up the model
model = Sequential()

# Add an input layer
model.add(tf.keras.Input(shape=(224, 224, 3)))

# Add EfficientNetB3 base model
base_model = EfficientNetB3(include_top=False, weights='imagenet',
drop_connect_rate=0.6)
model.add(base_model)

# Now the model is built, you can call summary
model.summary()
```

```
Downloading data from https://storage.googleapis.com/keras-
applications/efficientnetb3_notop.h5
43941136/43941136 ━━━━━━━━━━━━━━━━━━━━ 0s 0us/step

Model: "sequential_4"
```

```
┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━┓
┃ Layer (type)                          ┃ Output Shape                ┃
Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━┩
│ efficientnetb3 (Functional)           │ (None, 7, 7, 1536)          │
10,783,535 │
└───────────────────────────────────────┴─────────────────────────────┴─────────────────┘
```

```
 Total params: 10,783,535 (41.14 MB)

 Trainable params: 10,696,232 (40.80 MB)

 Non-trainable params: 87,303 (341.03 KB)
```

```
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import GlobalAveragePooling2D, Dense,
Dropout
from tensorflow.keras.applications import EfficientNetB3

def create_model():

    model = Sequential()
    # Add an input layer
    model.add(tf.keras.Input(shape=(224, 224, 3)))

    # Initialize EfficientNetB3 with input_shape explicitly defined
    base_model = EfficientNetB3(input_shape=(224, 224, 3),
include_top=False,
                                weights='imagenet',
drop_connect_rate=0.6)

    # Freeze layers (except last 40 layers)
    for layer in base_model.layers[:-40]:
        layer.trainable = False

    # Add the base model
    model.add(base_model)

    # Add global average pooling layer
    model.add(GlobalAveragePooling2D())
```

```
    # Add Dense layer with regularization
    model.add(Dense(256, activation='relu',

bias_regularizer=tf.keras.regularizers.L1L2(l1=0.01, l2=0.001)))

    # Add Dropout layer
    model.add(Dropout(0.5))

    # Add output Dense layer for classification (5 classes)
    model.add(Dense(5, activation='softmax'))

    return model

# Create and summarize the model
leaf_model = create_model()
leaf_model.summary()
```

```
Model: "sequential_5"
```

```
┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━┓
┃ Layer (type)                         ┃ Output Shape                ┃
Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━┩
│ efficientnetb3 (Functional)          │ (None, 7, 7, 1536)          │
10,783,535 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ global_average_pooling2d             │ (None, 1536)                │
0 │
│ (GlobalAveragePooling2D)             │                             │
│
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ dense_6 (Dense)                      │ (None, 256)                 │
393,472 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ dropout_3 (Dropout)                  │ (None, 256)                 │
0 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ dense_7 (Dense)                      │ (None, 5)                   │
1,285 │
└──────────────────────────────────────┴─────────────────────────────┴─────────────────┘
```

```
 Total params: 11,178,292 (42.64 MB)

 Trainable params: 4,758,201 (18.15 MB)
```

```
 Non-trainable params: 6,420,091 (24.49 MB)

EPOCHS = 50
STEP_SIZE_TRAIN = train_set.n//train_set.batch_size
STEP_SIZE_VALID = val_set.n//val_set.batch_size

def Model_fit():

    #leaf_model = None

    leaf_model = create_model()

    '''Compiling the model'''

    loss = tf.keras.losses.CategoricalCrossentropy(from_logits =
False,

label_smoothing=0.0001,

name='categorical_crossentropy' )

    leaf_model.compile(optimizer = Adam(learning_rate = 1e-3),
                       loss = loss, #'categorical_crossentropy'
                       metrics = ['categorical_accuracy']) #'acc'

    # Stop training when the val_loss has stopped decreasing for 3
epochs.
    es = EarlyStopping(monitor='val_loss', mode='min', patience=3,
                       restore_best_weights=True, verbose=1)

    # Save the model with the minimum validation loss
    checkpoint_cb = ModelCheckpoint("Cassava_best_model.keras",
                                    save_best_only=True,
                                    monitor = 'val_loss',
                                    mode='min')
    # reduce learning rate
    reduce_lr = ReduceLROnPlateau(monitor = 'val_loss',
                                  factor = 0.2,
                                  patience = 2,
                                  min_lr = 1e-6,
                                  mode = 'min',
                                  verbose = 1)

    history = leaf_model.fit(train_set,
                             validation_data = val_set,
                             epochs= EPOCHS,
                             batch_size = BATCH_SIZE,
                             # class_weight = d_class_weights,
                             steps_per_epoch = STEP_SIZE_TRAIN,
                             validation_steps = STEP_SIZE_VALID,
                             callbacks=[es, checkpoint_cb, reduce_lr])
```

```
    leaf_model.save('Cassava_model'+'.keras')

    return history

results = Model_fit()
```

```
Epoch 1/50

/opt/conda/lib/python3.10/site-packages/keras/src/trainers/
data_adapters/py_dataset_adapter.py:121: UserWarning: Your `PyDataset`
class should call `super().__init__(**kwargs)` in its constructor.
`**kwargs` can include `workers`, `use_multiprocessing`,
`max_queue_size`. Do not pass these arguments to `fit()`, as they will
be ignored.
  self._warn_if_super_not_called()
WARNING: All log messages before absl::InitializeLog() is called are
written to STDERR
I0000 00:00:1726315338.916660     167 service.cc:145] XLA service
0x7e91c001d690 initialized for platform CUDA (this does not guarantee
that XLA will be used). Devices:
I0000 00:00:1726315338.916741     167 service.cc:153]   StreamExecutor
device (0): Tesla T4, Compute Capability 7.5
I0000 00:00:1726315338.916745     167 service.cc:153]   StreamExecutor
device (1): Tesla T4, Compute Capability 7.5

   2/1355 ━━━━━━━━━━━━━━━━━━━━ 1:32 68ms/step - categorical_accuracy:
0.1667 - loss: 1.7674

I0000 00:00:1726315384.574417     167 device_compiler.h:188] Compiled
cluster using XLA!  This line is logged at most once for the lifetime
of the process.

1355/1355 ━━━━━━━━━━━━━━━━━━━━ 624s 410ms/step - categorical_accuracy:
0.6583 - loss: 0.9676 - val_categorical_accuracy: 0.7690 - val_loss:
0.6937 - learning_rate: 0.0010
Epoch 2/50
   1/1355 ━━━━━━━━━━━━━━━━━━━━ 1:28 65ms/step - categorical_accuracy:
0.8000 - loss: 0.7827

/opt/conda/lib/python3.10/contextlib.py:153: UserWarning: Your input
ran out of data; interrupting training. Make sure that your dataset or
generator can generate at least `steps_per_epoch * epochs` batches.
You may need to use the `.repeat()` function when building your
dataset.
  self.gen.throw(typ, value, traceback)

1355/1355 ━━━━━━━━━━━━━━━━━━━━ 7s 5ms/step - categorical_accuracy:
0.8000 - loss: 0.7827 - val_categorical_accuracy: 1.0000 - val_loss:
0.0762 - learning_rate: 0.0010
Epoch 3/50
```

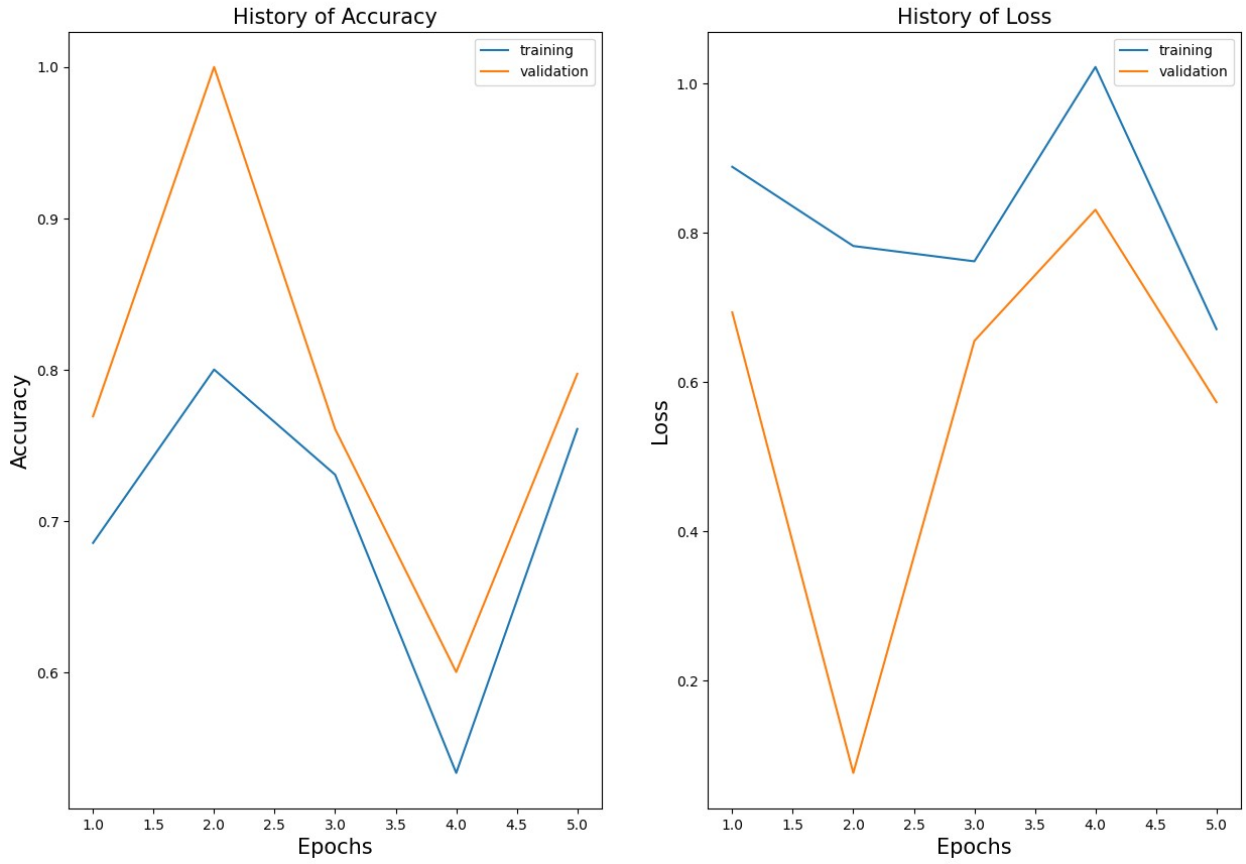
```
1355/1355 ━━━━━━━━━━━━━━━━━━━━ 351s 257ms/step - categorical_accuracy:
0.7274 - loss: 0.7747 - val_categorical_accuracy: 0.7606 - val_loss:
0.6555 - learning_rate: 0.0010
Epoch 4/50
   1/1355 ━━━━━━━━━━━━━━━━━━━━ 57s 43ms/step - categorical_accuracy:
0.5333 - loss: 1.0227
Epoch 4: ReduceLROnPlateau reducing learning rate to
0.00020000000949949026.
1355/1355 ━━━━━━━━━━━━━━━━━━━━ 0s 31us/step - categorical_accuracy:
0.5333 - loss: 1.0227 - val_categorical_accuracy: 0.6000 - val_loss:
0.8312 - learning_rate: 0.0010
Epoch 5/50
1355/1355 ━━━━━━━━━━━━━━━━━━━━ 345s 253ms/step - categorical_accuracy:
0.7538 - loss: 0.6843 - val_categorical_accuracy: 0.7972 - val_loss:
0.5733 - learning_rate: 2.0000e-04
Epoch 5: early stopping
Restoring model weights from the end of the best epoch: 2.
```

```
print('Train_Cat-Acc: ', max(results.history['categorical_accuracy']))
print('Val_Cat-Acc: ',
max(results.history['val_categorical_accuracy']))
```

```
Train_Cat-Acc:  0.800000011920929
Val_Cat-Acc:  1.0
```

```
def Train_Val_Plot(acc,val_acc,loss,val_loss):

    fig, (ax1, ax2) = plt.subplots(1,2, figsize= (15,10))
    fig.suptitle(" MODEL'S METRICS VISUALIZATION ", fontsize=20)

    ax1.plot(range(1, len(acc) + 1), acc)
    ax1.plot(range(1, len(val_acc) + 1), val_acc)
    ax1.set_title('History of Accuracy', fontsize=15)
    ax1.set_xlabel('Epochs', fontsize=15)
    ax1.set_ylabel('Accuracy', fontsize=15)
    ax1.legend(['training', 'validation'])


    ax2.plot(range(1, len(loss) + 1), loss)
    ax2.plot(range(1, len(val_loss) + 1), val_loss)
    ax2.set_title('History of Loss', fontsize=15)
    ax2.set_xlabel('Epochs', fontsize=15)
    ax2.set_ylabel('Loss', fontsize=15)
    ax2.legend(['training', 'validation'])
    plt.show()


Train_Val_Plot(results.history['categorical_accuracy'],results.history
['val_categorical_accuracy'],
               results.history['loss'],results.history['val_loss'])
```

MODEL'S METRICS VISUALIZATION




```
# EVALUATING THE MODEL

import keras

final_model = keras.models.load_model('Cassava_best_model.keras')
```

Test Time Augmentaiton

```
TEST_DIR = '../input/cassava-leaf-disease-classification/test_images/'
test_images = os.listdir(TEST_DIR)
datagen = ImageDataGenerator(horizontal_flip=True)


def pred(images):
    for image in test_images:
        img = Image.open(TEST_DIR + image)
        img = img.resize(size)
        samples = np.expand_dims(img, axis=0)
        it = datagen.flow(samples, batch_size=10)
```

```
        yhats = final_model.predict_generator(it, steps=10, verbose=0)
        summed = np.sum(yhats, axis=0)
    return np.argmax(summed)

predictions = pred(test_images)
```