

xk7llhaa4

June 6, 2024

- 1 import the necessary libraries.
- 2 Importing the dataset and doing usual exploratory analysis steps like checking the structure & characteristics of the data

```
[1]: import os
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers
import matplotlib.pyplot as plt
import pandas as pd
import random
import glob
import sklearn.metrics as metrics
from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping, ReduceLROnPlateau
```

```
[2]: !wget 1c1ZX-1V_MLxKHSyeyTheX50CQtNCUcqT
```

Downloading...

From (original): https://drive.google.com/uc?id=1c1ZX-1V_MLxKHSyeyTheX50CQtNCUcqT

From (redirected): https://drive.google.com/uc?id=1c1ZX-1V_MLxKHSyeyTheX50CQtNCUcqT&confirm=t&uuid=c3e8bb18-a590-4b52-b4d0-950536e7be28

To: C:\Users\criss\ninjacart_data.zip

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```

```

[3]: import zipfile
import os

def unzip_file(zip_file, extract_to):
    """
    Unzips a zip file to a specified directory.

    Parameters:
        zip_file (str): Path to the zip file.
        extract_to (str): Directory to extract the contents to.
    """
    # Create the extraction directory if it doesn't exist
    os.makedirs(extract_to, exist_ok=True)

    # Open the zip file
    with zipfile.ZipFile(zip_file, 'r') as zip_ref:
        # Extract all contents to the specified directory
        zip_ref.extractall(extract_to)

    print("Extraction complete.")

# Example usage:
zip_file = "C:\\Users\\criss\\ninjacart_data.zip"
extract_to = "C:\\Users\\criss\\extracted_data"
unzip_file(zip_file, extract_to)

```

Extraction complete.

```

[4]: import os
import glob
import random
import matplotlib.pyplot as plt
import zipfile
import tensorflow as tf

# Path to the zip file
zip_file = r"C:\Users\criss\ninjacart_data.zip"

# Directory where the data will be extracted
extracted_dir = r"C:\Users\criss\ninjacart_data"

# Extract the zip file
with zipfile.ZipFile(zip_file, 'r') as zip_ref:
    zip_ref.extractall(extracted_dir)

# Paths to train and test directories
train_dir = os.path.join(extracted_dir, "ninjacart_data", "train")
test_dir = os.path.join(extracted_dir, "ninjacart_data", "test")

# Helper function to get directory information
def get_directory_info(directory):
    dir_info = {}
    for dir_name in os.listdir(directory):
        dir_path = os.path.join(directory, dir_name)
        if os.path.isdir(dir_path):
            file_list = glob.glob(os.path.join(dir_path, '*'))
            dir_info[dir_name] = {
                'path': dir_path,
                'file_count': len(file_list),
                'file_paths': file_list,
                'sample_file': random.choice(file_list) if file_list else None
            }
    return dir_info

# Get information about training and test directories
train_info = get_directory_info(train_dir)
test_info = get_directory_info(test_dir)

# Display the information
print("Training Directory Information:")
for cls, info in train_info.items():
    print(f"Class: {cls}, Path: {info['path']}, File Count: {info['file_count']}")

print("\nTest Directory Information:")

```

```

for cls, info in test_info.items():
    print(f"Class: {cls}, Path: {info['path']}, File Count: {info['file_count']}")

# Dictionary to store image array (key) for every class (value)
image_dict = {}

# Load and visualize sample images from the training set
plt.figure(figsize=(15, 8))
for i, (cls, info) in enumerate(train_info.items()):
    if info['sample_file']:
        img = tf.keras.utils.load_img(info['sample_file'])
        image_dict[cls] = img
        plt.subplot(3, 2, i + 1)
        plt.imshow(img)
        plt.axis('off')
        plt.title(f'{cls}, {img.size}')

plt.show()

```

Training Directory Information:

Class: indian market, Path:

C:\Users\criss\ninjacart_data\ninjacart_data\train\indian market, File Count: 599

Class: onion, Path: C:\Users\criss\ninjacart_data\ninjacart_data\train\onion, File Count: 849

Class: potato, Path: C:\Users\criss\ninjacart_data\ninjacart_data\train\potato, File Count: 898

Class: tomato, Path: C:\Users\criss\ninjacart_data\ninjacart_data\train\tomato, File Count: 789

Test Directory Information:

Class: indian market, Path:

C:\Users\criss\ninjacart_data\ninjacart_data\test\indian market, File Count: 81

Class: onion, Path: C:\Users\criss\ninjacart_data\ninjacart_data\test\onion, File Count: 83

Class: potato, Path: C:\Users\criss\ninjacart_data\ninjacart_data\test\potato, File Count: 81

Class: tomato, Path: C:\Users\criss\ninjacart_data\ninjacart_data\test\tomato, File Count: 106

indian market, (600, 1066)



onion, (259, 194)



potato, (268, 188)



tomato, (500, 400)



3 Exploratory Data Analysis

Plotting class distribution & Visualizing Image dimensions with their plots

Splitting the dataset into train, validation, and test

4 Split the dataset to a train and validation set.

The provided data does not contain separate training and validation folders. For us to do hyperparameter tuning of our models, it is important to divide the dataset into an 80-20 split for training and validation respectively.

```
[5]: import tensorflow as tf

# Paths to train and test directories
train_dir = r"C:\Users\criss\ninjacart_data\ninjacart_data\train"
test_dir = r"C:\Users\criss\ninjacart_data\ninjacart_data\test"

# Image size
image_size = (128, 128)

# Create training and validation datasets from the training directory
train_ds = tf.keras.utils.image_dataset_from_directory(
    train_dir,
    label_mode='categorical',
    image_size=image_size,
    validation_split=0.2,
    subset='training',
    seed=42,
```

```

        shuffle=True
    )

val_ds = tf.keras.utils.image_dataset_from_directory(
    train_dir,
    label_mode='categorical',
    image_size=image_size,
    validation_split=0.2,
    subset='validation',
    seed=42,
    shuffle=True
)

# Create test dataset from the test directory
test_ds = tf.keras.utils.image_dataset_from_directory(
    test_dir,
    label_mode='categorical',
    image_size=image_size
)

# Define the CNN model
model = tf.keras.Sequential([
    tf.keras.layers.Conv2D(32, (3, 3), activation='relu', input_shape=(128, 128, 3)),
    tf.keras.layers.MaxPooling2D((2, 2)),
    tf.keras.layers.Conv2D(64, (3, 3), activation='relu'),
    tf.keras.layers.MaxPooling2D((2, 2)),
    tf.keras.layers.Conv2D(128, (3, 3), activation='relu'),
    tf.keras.layers.MaxPooling2D((2, 2)),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.layers.Dense(4, activation='softmax') # Assuming 4 classes
])

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

# Train the model
history = model.fit(
    train_ds,
    epochs=10,
    validation_data=val_ds
)

# Evaluate the model on the test dataset

```



```

test_loss, test_acc = model.evaluate(test_ds)
print(f'Test accuracy: {test_acc:.2f}')

# Plot training & validation accuracy values
plt.figure(figsize=(12, 4))
plt.subplot(1, 2, 1)
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend(['Train', 'Validation'], loc='upper left')

# Plot training & validation loss values
plt.subplot(1, 2, 2)
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend(['Train', 'Validation'], loc='upper left')

plt.show()

```

Found 3135 files belonging to 4 classes.

Using 2508 files for training.

Found 3135 files belonging to 4 classes.

Using 627 files for validation.

Found 351 files belonging to 4 classes.

Epoch 1/10

C:\Users\criss\anaconda3\lib\site-

packages\keras\src\layers\convolutional\base_conv.py:99: 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__(
```

79/79 16s 180ms/step -

accuracy: 0.3552 - loss: 70.0240 - val_accuracy: 0.5758 - val_loss: 1.1860

Epoch 2/10

79/79 13s 162ms/step -

accuracy: 0.5929 - loss: 1.0607 - val_accuracy: 0.6300 - val_loss: 0.9990

Epoch 3/10

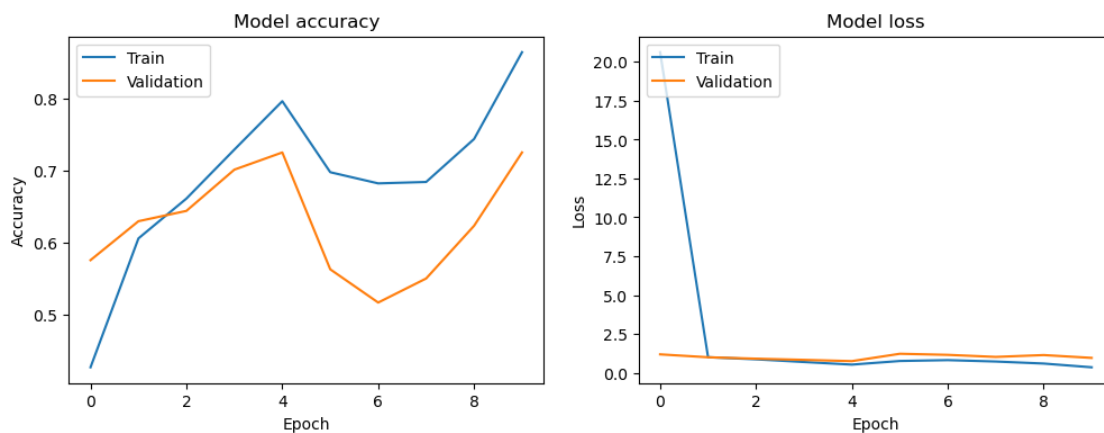
79/79 13s 164ms/step -

accuracy: 0.6612 - loss: 0.8434 - val_accuracy: 0.6443 - val_loss: 0.9071

Epoch 4/10

79/79 13s 163ms/step -

accuracy: 0.7165 - loss: 0.7448 - val_accuracy: 0.7018 - val_loss: 0.8320
 Epoch 5/10
 79/79 13s 164ms/step -
 accuracy: 0.7741 - loss: 0.5862 - val_accuracy: 0.7257 - val_loss: 0.7492
 Epoch 6/10
 79/79 13s 164ms/step -
 accuracy: 0.7399 - loss: 0.6918 - val_accuracy: 0.5630 - val_loss: 1.2238
 Epoch 7/10
 79/79 13s 167ms/step -
 accuracy: 0.6559 - loss: 0.8718 - val_accuracy: 0.5167 - val_loss: 1.1540
 Epoch 8/10
 79/79 13s 168ms/step -
 accuracy: 0.6387 - loss: 0.8182 - val_accuracy: 0.5502 - val_loss: 1.0209
 Epoch 9/10
 79/79 13s 166ms/step -
 accuracy: 0.7118 - loss: 0.6546 - val_accuracy: 0.6236 - val_loss: 1.1406
 Epoch 10/10
 79/79 13s 164ms/step -
 accuracy: 0.8340 - loss: 0.4399 - val_accuracy: 0.7257 - val_loss: 0.9584
 11/11 1s 44ms/step -
 accuracy: 0.5854 - loss: 1.4965
 Test accuracy: 0.64



5 Defining the CNN Classifier model from scratch

```

[6]: import tensorflow as tf
    from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense, Dropout
    from tensorflow.keras.models import Sequential
    import matplotlib.pyplot as plt
  
```

```

# Define the baseline CNN model
def create_cnn_model():
    model = Sequential([
        Conv2D(32, (3, 3), activation='relu', input_shape=(128, 128, 3)),
        MaxPooling2D((2, 2)),
        Conv2D(64, (3, 3), activation='relu'),
        MaxPooling2D((2, 2)),
        Conv2D(128, (3, 3), activation='relu'),
        MaxPooling2D((2, 2)),
        Flatten(),
        Dense(128, activation='relu'),
        Dense(4, activation='softmax') # Assuming 4 classes
    ])
    return model

# Compile the baseline model
baseline_model = create_cnn_model()
baseline_model.compile(optimizer='adam', loss='categorical_crossentropy',
    metrics=['accuracy'])

```

6 Improving Baseline CNN to reduce overfitting

```

[7]: from tensorflow.keras.preprocessing.image import ImageDataGenerator

# Create a more complex model with dropout layers to reduce overfitting
def create_improved_cnn_model():
    model = Sequential([
        Conv2D(32, (3, 3), activation='relu', input_shape=(128, 128, 3)),
        MaxPooling2D((2, 2)),
        Dropout(0.25),
        Conv2D(64, (3, 3), activation='relu'),
        MaxPooling2D((2, 2)),
        Dropout(0.25),
        Conv2D(128, (3, 3), activation='relu'),
        MaxPooling2D((2, 2)),
        Dropout(0.5),
        Flatten(),
        Dense(128, activation='relu'),
        Dropout(0.5),
        Dense(4, activation='softmax')
    ])
    return model

# Compile the improved model
improved_model = create_improved_cnn_model()

```

```

improved_model.compile(optimizer='adam', loss='categorical_crossentropy',
    metrics=['accuracy'])

# Data augmentation
train_datagen = ImageDataGenerator(
    rescale=1./255,
    rotation_range=20,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True,
    validation_split=0.2
)

val_datagen = ImageDataGenerator(rescale=1./255, validation_split=0.2)

train_ds = train_datagen.flow_from_directory(
    train_dir,
    target_size=(128, 128),
    batch_size=32,
    class_mode='categorical',
    subset='training',
    seed=42
)

val_ds = val_datagen.flow_from_directory(
    train_dir,
    target_size=(128, 128),
    batch_size=32,
    class_mode='categorical',
    subset='validation',
    seed=42
)

```

Found 2511 images belonging to 4 classes.
 Found 624 images belonging to 4 classes.

7 Implementing Callbacks while training the model

```

[8]: from tensorflow.keras.callbacks import EarlyStopping, ModelCheckpoint

# Callbacks
callbacks = [
    EarlyStopping(monitor='val_loss', patience=5, restore_best_weights=True),

```

```

    ModelCheckpoint('best_model.keras', monitor='val_loss',
↪save_best_only=True) # Corrected file extension
]

```

```

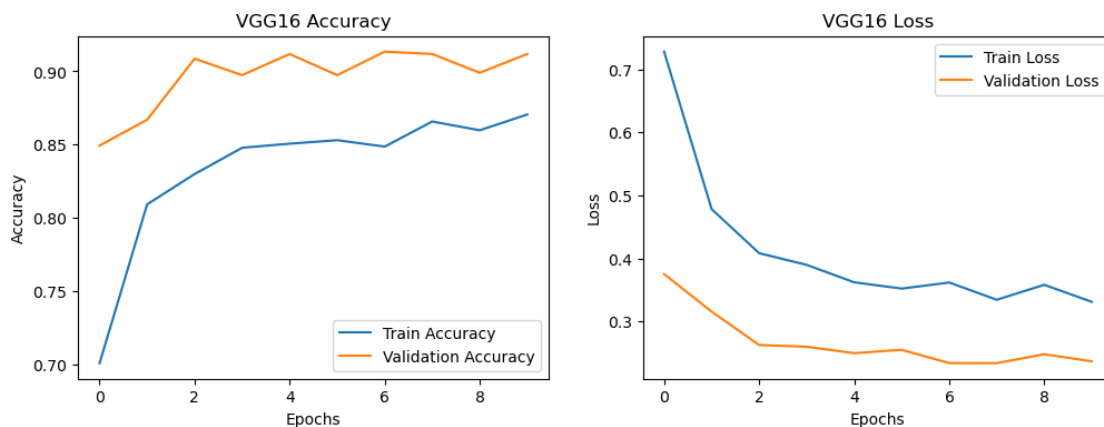
[53]: # Plotting function
def plot_history(history, model_name):
    plt.figure(figsize=(12, 4))
    plt.subplot(1, 2, 1)
    plt.plot(history.history['accuracy'], label='Train Accuracy')
    plt.plot(history.history['val_accuracy'], label='Validation Accuracy')
    plt.title(f'{model_name} Accuracy')
    plt.xlabel('Epochs')
    plt.ylabel('Accuracy')
    plt.legend()

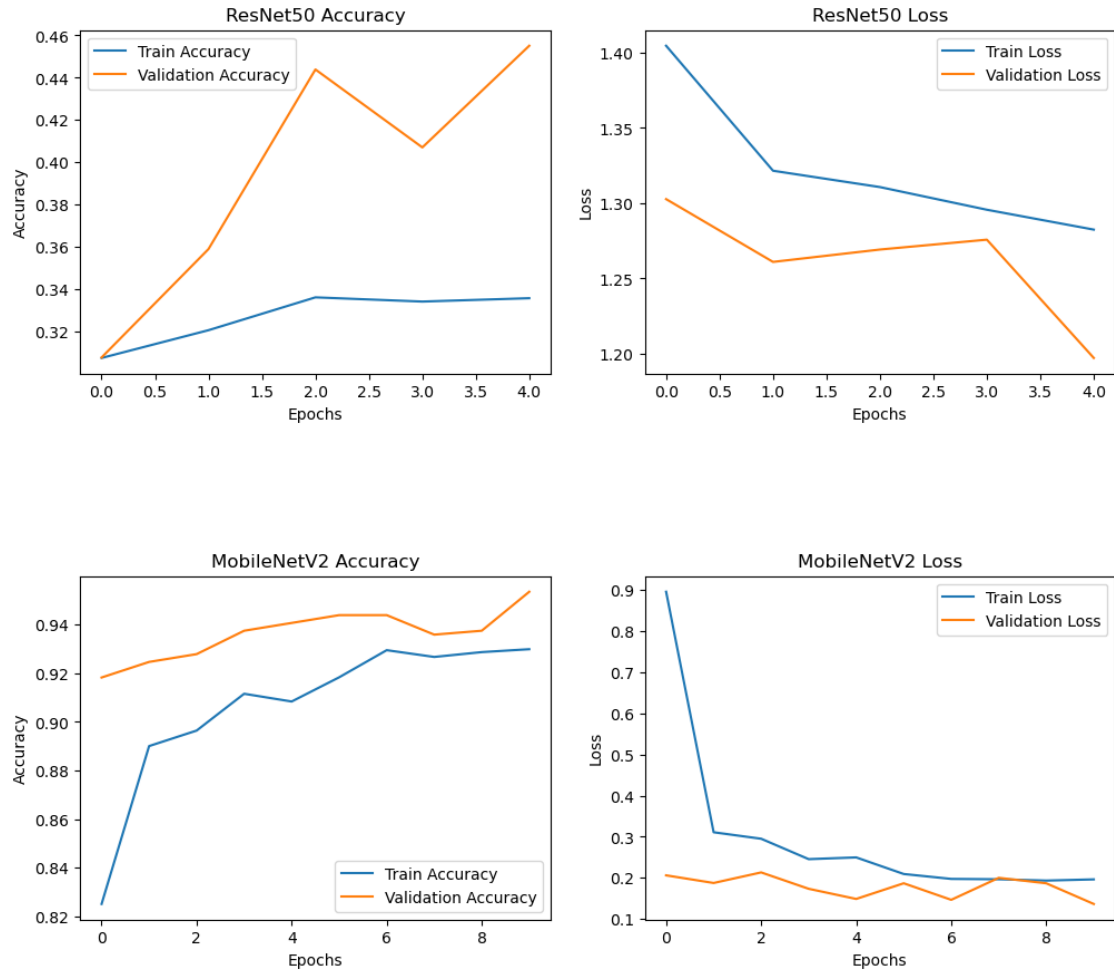
    plt.subplot(1, 2, 2)
    plt.plot(history.history['loss'], label='Train Loss')
    plt.plot(history.history['val_loss'], label='Validation Loss')
    plt.title(f'{model_name} Loss')
    plt.xlabel('Epochs')
    plt.ylabel('Loss')
    plt.legend()

    plt.show()

# Plot histories
plot_history(vgg_history, "VGG16")
plot_history(resnet_history, "ResNet50")
plot_history(mobilenet_history, "MobileNetV2")

```





8 Setting Up the Data Loaders

We'll use ImageDataGenerator to load and augment the data.

```
[11]: from tensorflow.keras.preprocessing.image import ImageDataGenerator

train_dir = r'C:\Users\criss\ninjacart_data\ninjacart_data\train'
test_dir = r'C:\Users\criss\ninjacart_data\ninjacart_data\test'

# Data augmentation for training data
train_datagen = ImageDataGenerator(
    rescale=1./255,
    rotation_range=20,
    width_shift_range=0.2,
    height_shift_range=0.2,
    horizontal_flip=True
```

```

)

# Only rescaling for validation and test data
test_datagen = ImageDataGenerator(rescale=1./255)

train_generator = train_datagen.flow_from_directory(
    train_dir,
    target_size=(64, 64),
    batch_size=32,
    class_mode='sparse'
)

test_generator = test_datagen.flow_from_directory(
    test_dir,
    target_size=(64, 64),
    batch_size=32,
    class_mode='sparse',
    shuffle=False
)

```

Found 3135 images belonging to 4 classes.

Found 351 images belonging to 4 classes.

9 Defining the Model

We will define an improved CNN model to handle potential overfitting issues.

```

[12]: def create_improved_cnn_model(input_shape, num_classes):
    model = Sequential([
        Conv2D(32, (3, 3), activation='relu', input_shape=input_shape,
        ↪kernel_regularizer=tf.keras.regularizers.l2(0.001)),
        MaxPooling2D((2, 2)),
        Dropout(0.25),
        Conv2D(64, (3, 3), activation='relu', kernel_regularizer=tf.keras.
        ↪regularizers.l2(0.001)),
        MaxPooling2D((2, 2)),
        Dropout(0.25),
        Conv2D(128, (3, 3), activation='relu', kernel_regularizer=tf.keras.
        ↪regularizers.l2(0.001)),
        MaxPooling2D((2, 2)),
        Dropout(0.25),
        Flatten(),
        Dense(128, activation='relu', kernel_regularizer=tf.keras.regularizers.
        ↪l2(0.001)),
        Dropout(0.5),
        Dense(num_classes, activation='softmax')
    ])

```

```

    return model

input_shape = (64, 64, 3)
num_classes = 4 # Number of classes: indian market, onion, potato, tomato
model = create_improved_cnn_model(input_shape, num_classes)
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy',
    ↪metrics=['accuracy'])
model.summary()

```

Model: "sequential_7"

Layer (type)	Output Shape	
↪Param #		
conv2d_12 (Conv2D)	(None, 62, 62, 32)	
↪896		
max_pooling2d_12 (MaxPooling2D)	(None, 31, 31, 32)	
↪ 0		
dropout_11 (Dropout)	(None, 31, 31, 32)	
↪ 0		
conv2d_13 (Conv2D)	(None, 29, 29, 64)	
↪18,496		
max_pooling2d_13 (MaxPooling2D)	(None, 14, 14, 64)	
↪ 0		
dropout_12 (Dropout)	(None, 14, 14, 64)	
↪ 0		
conv2d_14 (Conv2D)	(None, 12, 12, 128)	
↪73,856		
max_pooling2d_14 (MaxPooling2D)	(None, 6, 6, 128)	
↪ 0		
dropout_13 (Dropout)	(None, 6, 6, 128)	
↪ 0		
flatten_7 (Flatten)	(None, 4608)	
↪ 0		


```

dense_14 (Dense)                                     (None, 128)
↳589,952

dropout_14 (Dropout)                                 (None, 128)
↳ 0

dense_15 (Dense)                                     (None, 4)
↳516

Total params: 683,716 (2.61 MB)

Trainable params: 683,716 (2.61 MB)

Non-trainable params: 0 (0.00 B)

```

10 Implementing Callbacks

We will add callbacks to save the best model, early stopping, and reduce learning rate on plateau.

```

[13]: callbacks = [
        ModelCheckpoint('best_model.keras', save_best_only=True,
        ↳monitor='val_loss'),
        EarlyStopping(monitor='val_loss', patience=10, restore_best_weights=True),
        ReduceLROnPlateau(monitor='val_loss', factor=0.1, patience=5)
    ]

```

11 Training the Model

We will train the model using the training and validation generators.

```

[14]: history = model.fit(
        train_generator,
        epochs=10,
        validation_data=test_generator,
        callbacks=callbacks
    )

```

```

Epoch 1/10
98/98          14s 129ms/step -
accuracy: 0.4105 - loss: 1.5367 - val_accuracy: 0.6467 - val_loss: 0.9447 -
learning_rate: 0.0010
Epoch 2/10
98/98          13s 127ms/step -

```

```

accuracy: 0.6995 - loss: 0.9452 - val_accuracy: 0.7721 - val_loss: 0.6814 -
learning_rate: 0.0010
Epoch 3/10
98/98          13s 127ms/step -
accuracy: 0.7695 - loss: 0.7466 - val_accuracy: 0.7835 - val_loss: 0.6593 -
learning_rate: 0.0010
Epoch 4/10
98/98          13s 125ms/step -
accuracy: 0.7808 - loss: 0.6978 - val_accuracy: 0.7607 - val_loss: 0.7302 -
learning_rate: 0.0010
Epoch 5/10
98/98          13s 128ms/step -
accuracy: 0.8141 - loss: 0.6108 - val_accuracy: 0.8034 - val_loss: 0.6798 -
learning_rate: 0.0010
Epoch 6/10
98/98          13s 127ms/step -
accuracy: 0.8166 - loss: 0.5822 - val_accuracy: 0.8063 - val_loss: 0.5931 -
learning_rate: 0.0010
Epoch 7/10
98/98          13s 128ms/step -
accuracy: 0.8333 - loss: 0.5461 - val_accuracy: 0.7265 - val_loss: 1.0396 -
learning_rate: 0.0010
Epoch 8/10
98/98          13s 125ms/step -
accuracy: 0.8275 - loss: 0.5696 - val_accuracy: 0.7949 - val_loss: 0.7152 -
learning_rate: 0.0010
Epoch 9/10
98/98          13s 127ms/step -
accuracy: 0.8367 - loss: 0.5368 - val_accuracy: 0.7578 - val_loss: 0.7945 -
learning_rate: 0.0010
Epoch 10/10
98/98          13s 126ms/step -
accuracy: 0.8331 - loss: 0.5232 - val_accuracy: 0.8034 - val_loss: 0.5468 -
learning_rate: 0.0010

```

```

[15]: import matplotlib.pyplot as plt

def plot_training_history(history):
    plt.figure(figsize=(12, 4))

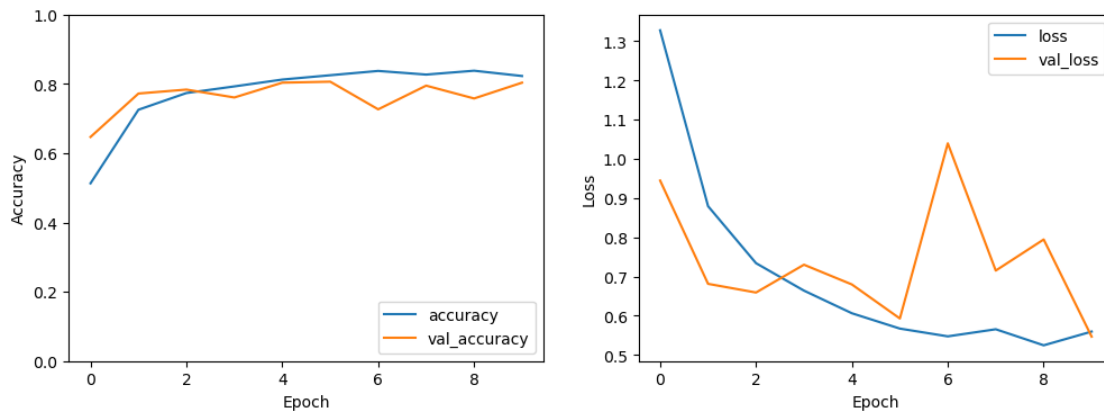
    plt.subplot(1, 2, 1)
    plt.plot(history.history['accuracy'], label='accuracy')
    plt.plot(history.history['val_accuracy'], label='val_accuracy')
    plt.xlabel('Epoch')
    plt.ylabel('Accuracy')
    plt.ylim([0, 1])
    plt.legend(loc='lower right')

```

```
plt.subplot(1, 2, 2)
plt.plot(history.history['loss'], label='loss')
plt.plot(history.history['val_loss'], label='val_loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend(loc='upper right')

plt.show()

plot_training_history(history)
```



12 Plotting Confusion Matrix

```
[16]: from sklearn.metrics import confusion_matrix
import seaborn as sns
import numpy as np

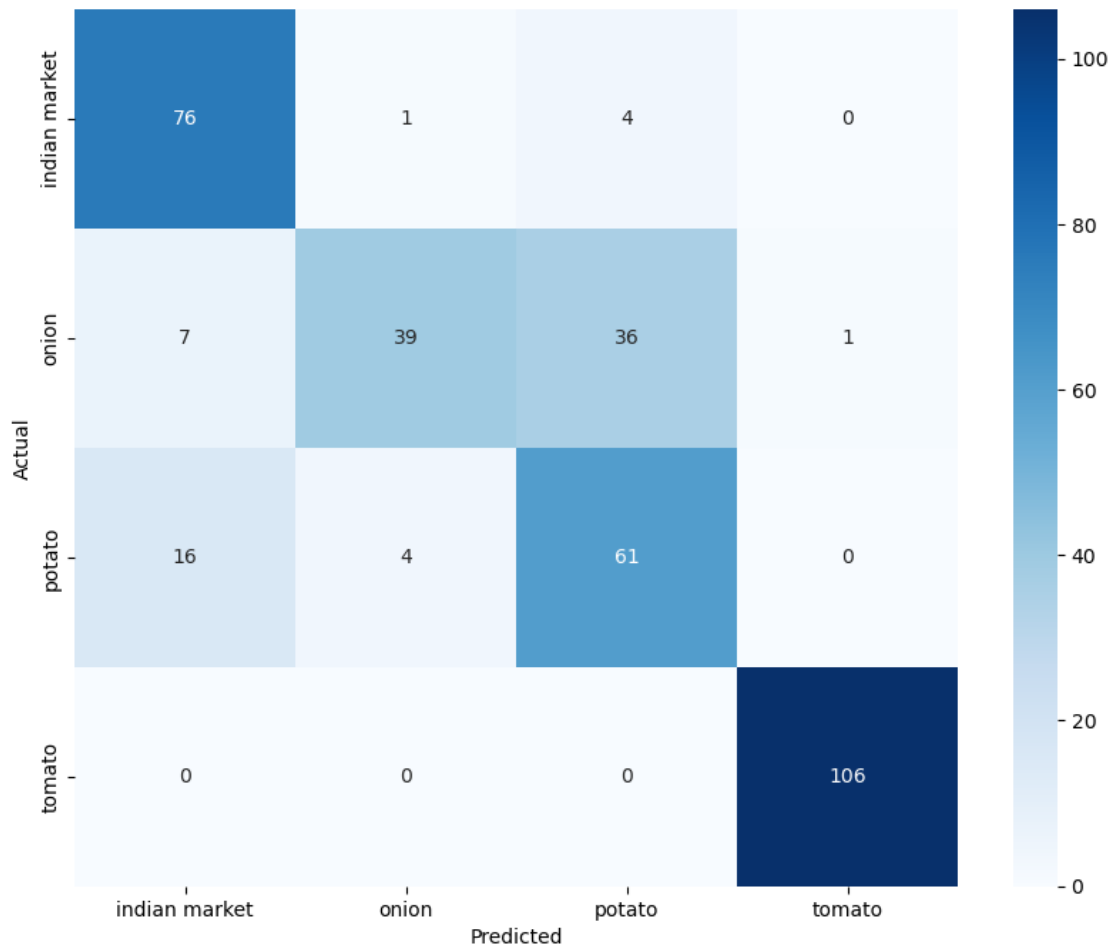
def plot_confusion_matrix(y_true, y_pred, class_names):
    cm = confusion_matrix(y_true, y_pred)
    plt.figure(figsize=(10, 8))
    sns.heatmap(cm, annot=True, fmt='d', cmap='Blues', xticklabels=class_names,
    yticklabels=class_names)
    plt.ylabel('Actual')
    plt.xlabel('Predicted')
    plt.show()

# Predicting on the test data
y_pred = model.predict(test_generator)
y_pred_classes = np.argmax(y_pred, axis=1)
y_true = test_generator.classes
```

```
class_names = list(test_generator.class_indices.keys())

plot_confusion_matrix(y_true, y_pred_classes, class_names)
```

11/11 1s 88ms/step



```
[17]: import os
import matplotlib.pyplot as plt

# Define paths to train and test directories
train_dir = r'C:\Users\criss\ninjacart_data\ninjacart_data\train'
test_dir = r'C:\Users\criss\ninjacart_data\ninjacart_data\test'

# Function to count images in a directory
def count_images_in_directory(directory):
    counts = {}
    for root, dirs, files in os.walk(directory):
```

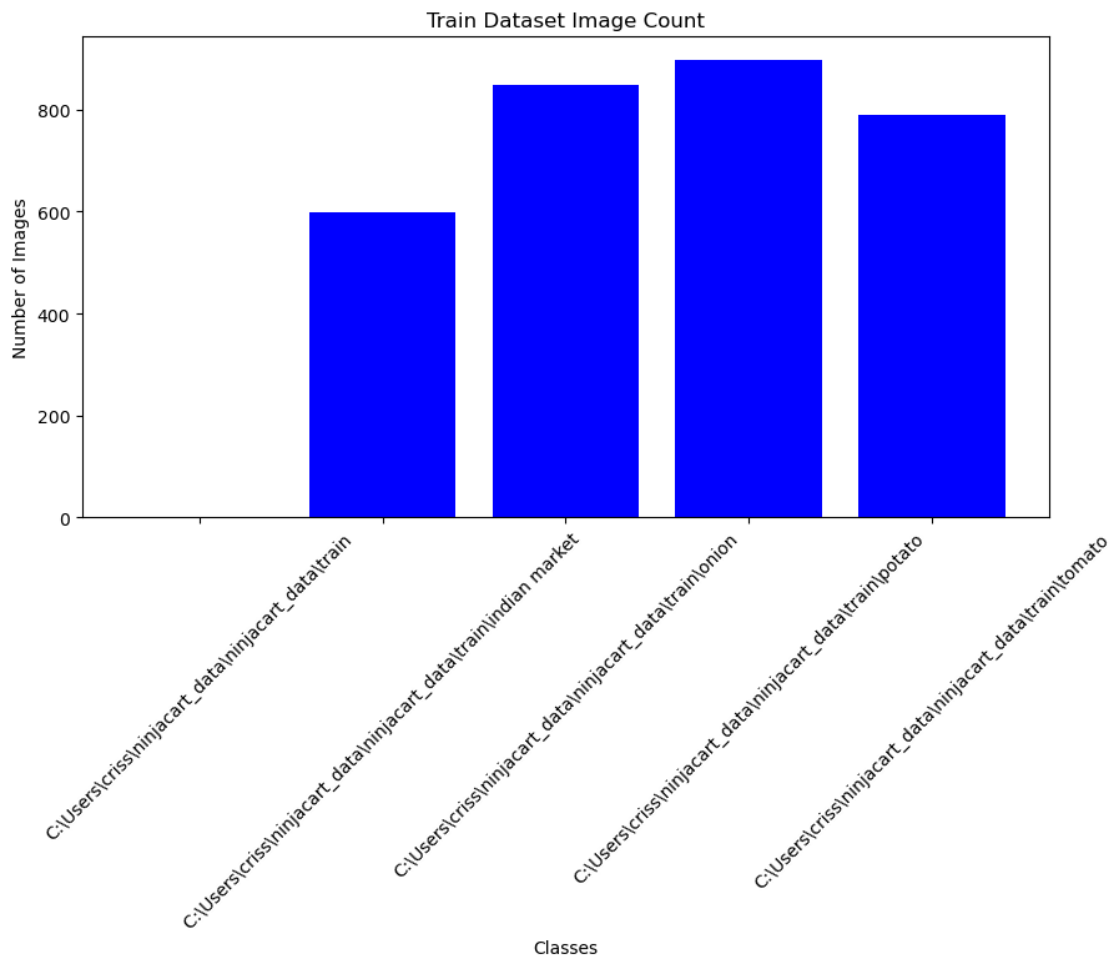
```

        counts[root] = len(files)
    return counts

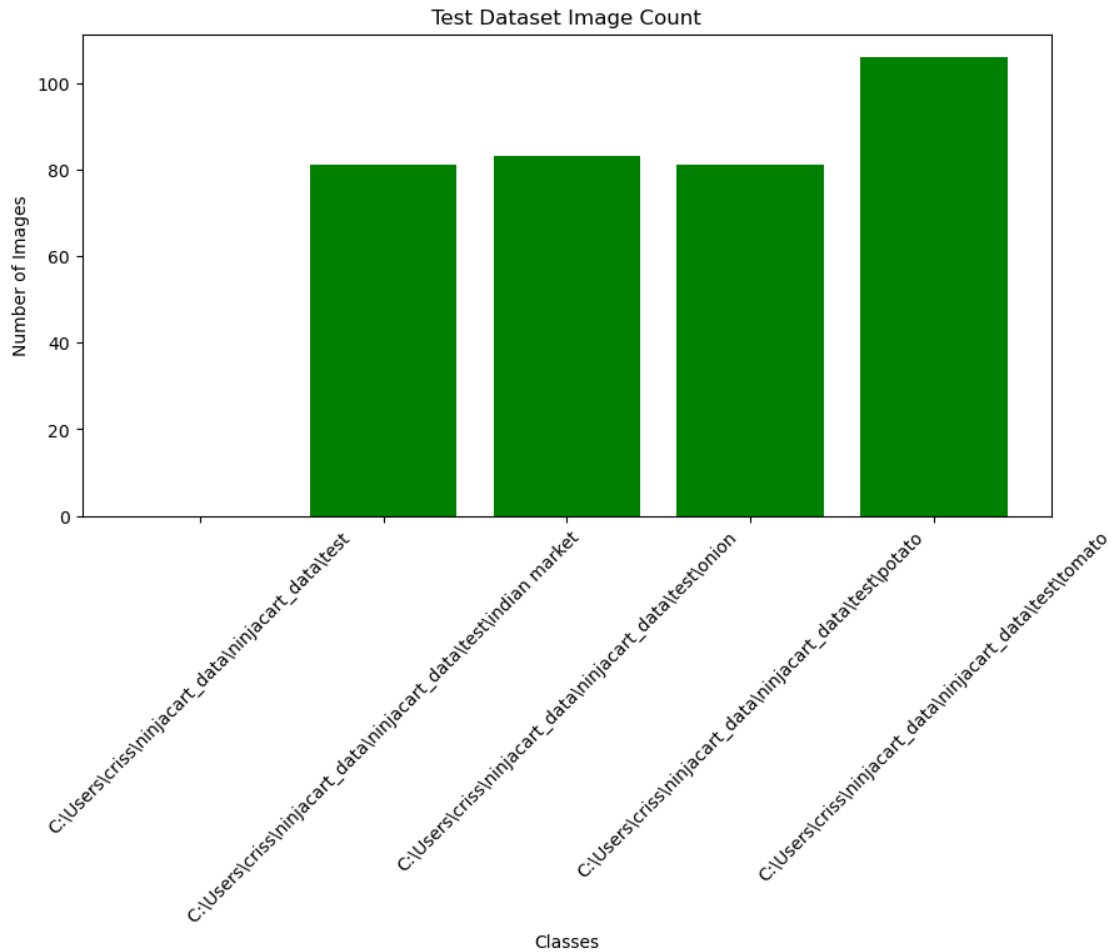
# Count images in train and test directories
train_counts = count_images_in_directory(train_dir)
test_counts = count_images_in_directory(test_dir)

# Plot histogram for train directory
plt.figure(figsize=(10, 5))
plt.bar(train_counts.keys(), train_counts.values(), color='blue')
plt.xlabel('Classes')
plt.ylabel('Number of Images')
plt.title('Train Dataset Image Count')
plt.xticks(rotation=45)
plt.show()

```



```
[18]: # Plot histogram for test directory
plt.figure(figsize=(10, 5))
plt.bar(test_counts.keys(), test_counts.values(), color='green')
plt.xlabel('Classes')
plt.ylabel('Number of Images')
plt.title('Test Dataset Image Count')
plt.xticks(rotation=45)
plt.show()
```



```
[19]: # Compare reported counts with actual counts
print("Reported Train Counts:")
for cls, count in train_info.items():
    print(f"{cls}: Reported - {count}, Actual - {train_counts.get(os.path.
    ↪join(train_dir, cls), 0)}")

print("\nReported Test Counts:")
for cls, count in test_info.items():
```

```
print(f"{cls}: Reported - {count}, Actual - {test_counts.get(os.path.  
↪join(test_dir, cls), 0)}")
```

Reported Train Counts:

indian market: Reported - {'path':

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market',

'file_count': 599, 'file_paths':

['C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\ionn2.jpeg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\ionn84.jpeg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\ionnionn (2).jpeg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\ionnionn.jpeg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\ionnionnionnionn.jpeg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\ionnjsbh.jpeg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\ionnvj.jpeg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\ioob.jpeg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\istockphoto-1145439264-612x612.jpg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\istockphoto-1150886692-612x612.jpg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\istockphoto-1157310203-612x612.jpg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\istockphoto-1159759369-612x612.jpg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\istockphoto-1186670497-612x612.jpg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\istockphoto-1194425307-612x612.jpg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\istockphoto-1212679579-612x612.jpg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\istockphoto-1213508609-612x612.jpg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\istockphoto-1213544046-612x612.jpg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\istockphoto-1250028757-612x612.jpg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\istockphoto-1313476705-612x612.jpg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian
market\\istockphoto-491960782-612x612.jpg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\istockphoto-495698527-612x612.jpg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\istockphoto-497147639-612x612.jpg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\istockphoto-509316626-612x612.jpg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\istockphoto-533453030-612x612.jpg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\istockphoto-953512502-612x612.jpg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\j.hvx.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\khckktycrd.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\kohub.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market-3967502__340.jpg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market-51313__340.jpg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market-6282658__340.jpg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market-6372159__340.jpg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market-6372161__340.jpg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market-7156488__340.jpg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11001.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11002.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11003.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11004.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11005.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11006.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11007.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11008.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11009.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11010.jpeg',

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11395.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11396.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11397.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11398.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11399.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11400.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11401.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11402.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\market11403.png',
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arti-agarwal-2158999.jpg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\pexels-
photo-11118207.jpeg',
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'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\pexels-photo-974252.jpg',
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'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\photo-1460058418905-d61a1b4a55fe.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\photo-1482304651556-cb27a6fb596a.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\photo-1485846299386-f367c81034d8.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\photo-1486486704382-8ee6f7754a45.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\photo-1487646709898-58d3c6e8d886.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\photo-1488459716781-31db52582fe9.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\photo-1496938498205-cfb8381042c3.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\photo-1501523460185-2aa5d2a0f981.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\photo-1504244648668-89000185ea9b.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\photo-1508589066756-c5dfb2cb7587.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\indian market\\photo-1510247548804-1a5c6f550b2d.jpeg',
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'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato11.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato110.png'
, 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato111.pn
g', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato112.
png', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato11
3.png', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato
114.png', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\toma
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to\\tomato119.png',
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'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato120.png'
, 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato121.pn

```


[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

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[illegible]

[illegible]

[illegible]


```
g', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato892.
png', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato89
3.png', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato
894.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato9.png',
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'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato93.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato94.png',
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'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato96.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato97.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato98.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomato\\tomato99.png']
, 'sample_file': 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\train\\tomat
o\\tomato119.png'}, Actual - 789
```

Reported Test Counts:

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indian market: Reported - {'path':
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian market',
'file_count': 81, 'file_paths':
['C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\bhl.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\bhv.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\bn.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\hxx.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\igis.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\in.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\india-4898453_340.jpg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian market\\indian-
women-232500_340.jpg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket10.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket12.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket13.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket14.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket15.jpeg'],
```

[illegible]

[illegible]

```

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket72.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket74.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket75.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket77.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket79.jpeg',
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market\\indianmarket88.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket89.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket9.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket90.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket91.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket92.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket95.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket96.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket97.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket98.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\indianmarket99.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\inia.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian market\\ionn
(2).jpeg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\indian
market\\ionn.jpeg'], 'sample_file':
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market\\indianmarket63.jpeg'}}, Actual - 81
onion: Reported - {'path':
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion', 'file_count':
83, 'file_paths': ['C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onio
n\\0920GHDV72AQ.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\o
nion\\11L7YSL0WRPJ.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test
\\onion\\128HMGKA3VT7.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\t
est\\onion\\13L6HU3AN4PG.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data

```

\\test\\onion\\14T8M955CTOF.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\17F4ATB13F07.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\20FHZ4SJOP5N.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\25PZO5RHZYMU.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\2825PUL9ICYN.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\28W1CL9LAL32.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\329IDTVD7K55.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\32Q0C4319KES.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\40Z966TV39WQ.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\42Z9KW2V2PKZ.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\43X1NN131FPS.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\46892NJ3406I.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\47KTCPTYC7D5.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\51HQV10I82Z1.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\53HKW60YG000.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\611M01HI4A73.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\63NUVT3V10U4.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\6486L1RXU3QT.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\64UR96S9B1R9.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\64WF5EZR XM03.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\64XX8 GOXE BRI.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\662IEHOWNSN8.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\66SLRFOD76K1.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\6J7YLDCAEC5.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\6LAHM1SFNF3Y.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\6SHZSE31GR9K.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\6U9FY0CKTOLW.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\6Y1QYL44X8F1.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\6ZS377G3UTKC.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\70LUMOQDZ6DQ.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\710J7JY2JBHD.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\71UDPV1JEQ92.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\74E9E7D5UP2G.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\7633MT10WIVI.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\7B9X0B00JGAQ.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\7DU804PMK05Y.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\7EB1VUQCRUWB.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\7F9BKNT7IUJO.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\7J4N4ISOT9X7.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\7MUZPJ6MOWMR.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\705TLOQP1KPJ.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\7Q9RLVPLQ4CA.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\7QUVP1R42QBE.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\7RC2P3QT5D5N.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\7TOB5AFUJXDR.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\7U58YJPKGRAU.jpg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\onion\\7UTZLLF

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potato: Reported - {'path':

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato', 'file_count':

81, 'file_paths':

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'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1102

(1).jpeg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1102.jpeg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1103

(1).jpeg', 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1103.jpeg',

'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1104


```
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1104.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1105.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1106.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1107.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1108.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1109.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1110.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1111.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1112.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1113.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1114.jpeg',
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'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1116.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1117.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1118.jpeg',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\potato\\potato1119.jpeg',
```

[illegible]

[illegible]

```
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato219.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato220.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato221.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato222.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato223.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato224.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato225.png',
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'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato230.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato231.png',
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'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato242.png',
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'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato244.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato245.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato246.png',
'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato247.png']
, 'sample_file': 'C:\\Users\\criss\\ninjacart_data\\ninjacart_data\\test\\tomato\\tomato218.png'}, Actual - 106
```

```
[20]: import os

# Define the path to the "indian market" train folder
train_indian_market_dir = r'C:
↳\Users\criss\ninjacart_data\ninjacart_data\train\indian market'

# Count the number of images in the "indian market" train folder
num_images_train = len(os.listdir(train_indian_market_dir))

# Compare the reported count with the actual count
reported_count = 599 # Replace with the reported count
if num_images_train == reported_count:
    print("The reported count matches the actual count.")
else:
    print("The reported count does not match the actual count.")
```

```
print(f"Reported Count: {reported_count}")
print(f"Actual Count: {num_images_train}")
```

The reported count matches the actual count.

```
[21]: import os
import shutil
from sklearn.model_selection import train_test_split

# Define the root directory of the original dataset
root_dir = r'C:\Users\criss\ninjacart_data\ninjacart_data'

# Define the directory containing all the images
image_dir = os.path.join(root_dir, 'train')

# Get the list of all image file paths
image_files = []
for class_name in os.listdir(image_dir):
    class_dir = os.path.join(image_dir, class_name)
    if os.path.isdir(class_dir):
        image_files.extend([os.path.join(class_dir, f) for f in os.
↪listdir(class_dir)])

# Define the labels for each image based on the folder name
labels = [os.path.basename(os.path.dirname(f)) for f in image_files]

# Split the dataset into training and validation sets (80-20 split)
train_files, val_files, train_labels, val_labels = ↵
↪train_test_split(image_files, labels, test_size=0.2, random_state=42)

# Define the directory paths for the training and validation sets
train_dir = os.path.join(root_dir, 'train_split', 'train')
val_dir = os.path.join(root_dir, 'train_split', 'validation')

# Create directories for the training and validation sets
os.makedirs(train_dir, exist_ok=True)
os.makedirs(val_dir, exist_ok=True)

# Move training images to the train directory
for src, label in zip(train_files, train_labels):
    dst = os.path.join(train_dir, label)
    os.makedirs(dst, exist_ok=True)
    shutil.copy(src, dst)

# Move validation images to the validation directory
for src, label in zip(val_files, val_labels):
    dst = os.path.join(val_dir, label)
```

```

os.makedirs(dst, exist_ok=True)
shutil.copy(src, dst)

print("Dataset split into train and validation sets successfully.")
print(f"Number of training images: {len(train_files)}")
print(f"Number of validation images: {len(val_files)}")

```

Dataset split into train and validation sets successfully.
Number of training images: 2508
Number of validation images: 627

```

[22]: import os
from tensorflow.keras.preprocessing.image import ImageDataGenerator
import tensorflow as tf

# Define paths to the training and validation directories
train_dir = r'C:\Users\criss\ninjacart_data\ninjacart_data\train_split\train'
val_dir = r'C:\Users\criss\ninjacart_data\ninjacart_data\train_split\validation'

# Define the target size for resizing images
target_size = (128, 128) # Adjust as needed for your model

# Create ImageDataGenerator instances for training and validation sets
train_datagen = ImageDataGenerator(
    rescale=1.0/255.0,
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True
)

val_datagen = ImageDataGenerator(rescale=1.0/255.0)

# Create generators
train_generator = train_datagen.flow_from_directory(
    train_dir,
    target_size=target_size,
    batch_size=32,
    class_mode='categorical'
)

val_generator = val_datagen.flow_from_directory(
    val_dir,
    target_size=target_size,
    batch_size=32,
    class_mode='categorical'
)

```

```
# Verify the generator output shapes
for data_batch, labels_batch in train_generator:
    print("Data batch shape:", data_batch.shape)
    print("Labels batch shape:", labels_batch.shape)
    break
```

Found 2508 images belonging to 4 classes.

Found 627 images belonging to 4 classes.

Data batch shape: (32, 128, 128, 3)

Labels batch shape: (32, 4)

13 Import Libraries and Setup Data Generators

First, we'll set up our data generators as we did before, ensuring the images are preprocessed correctly.

```
[23]: import tensorflow as tf
from tensorflow.keras.applications import VGG16
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Dense, Flatten, Dropout
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping, ReduceLROnPlateau
from tensorflow.keras.preprocessing.image import ImageDataGenerator

# Define paths to the training and validation directories
train_dir = r'C:\Users\criss\ninjacart_data\ninjacart_data\train_split\train'
val_dir = r'C:\Users\criss\ninjacart_data\ninjacart_data\train_split\validation'

# Define the target size for resizing images
target_size = (224, 224) # VGG16 expects 224x224 images

# Create ImageDataGenerator instances for training and validation sets
train_datagen = ImageDataGenerator(
    rescale=1.0/255.0,
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True
)

val_datagen = ImageDataGenerator(rescale=1.0/255.0)

# Create generators
train_generator = train_datagen.flow_from_directory(
    train_dir,
    target_size=target_size,
    batch_size=32,
```



```

        class_mode='categorical'
    )

    val_generator = val_datagen.flow_from_directory(
        val_dir,
        target_size=target_size,
        batch_size=32,
        class_mode='categorical'
    )

```

Found 2508 images belonging to 4 classes.

Found 627 images belonging to 4 classes.

14 Load the VGG16 Model with Pretrained Weights

We'll load the VGG16 model with pretrained weights from ImageNet and freeze the convolutional base.

```

[24]: # Load the VGG16 model with pretrained weights from ImageNet, excluding the top
      ↪(fully connected layers)
      base_model = VGG16(weights='imagenet', include_top=False, input_shape=(224,
      ↪224, 3))

      # Freeze the convolutional base
      for layer in base_model.layers:
          layer.trainable = False

```

15 Add a Custom Classification Head

We need to add a custom classification head on top of the convolutional base.

```

[25]: # Add custom layers on top of the base model
      x = base_model.output
      x = Flatten()(x)
      x = Dense(512, activation='relu')(x)
      x = Dropout(0.5)(x)
      x = Dense(128, activation='relu')(x)
      x = Dropout(0.5)(x)
      predictions = Dense(4, activation='softmax')(x) # Assuming 4 classes

      # Define the model
      model = Model(inputs=base_model.input, outputs=predictions)

```

16 Compile and Train the Model

We'll compile the model and train it using appropriate callbacks to save the best model and avoid overfitting.

```
[27]: # Compile the model
model.compile(optimizer=Adam(learning_rate=1e-4),
              ↪loss='categorical_crossentropy', metrics=['accuracy'])

# Define callbacks
callbacks = [
    ModelCheckpoint('best_model.keras', save_best_only=True,
    ↪monitor='val_loss'),
    EarlyStopping(monitor='val_loss', patience=10, restore_best_weights=True),
    ReduceLROnPlateau(monitor='val_loss', factor=0.1, patience=5)
]

# Train the model
history = model.fit(
    train_generator,
    epochs=10,
    validation_data=val_generator,
    callbacks=callbacks
)
```

Epoch 1/10

79/79 165s 2s/step -

accuracy: 0.5545 - loss: 1.0681 - val_accuracy: 0.7959 - val_loss: 0.4696 -

learning_rate: 1.0000e-04

Epoch 2/10

79/79 164s 2s/step -

accuracy: 0.7574 - loss: 0.5605 - val_accuracy: 0.8612 - val_loss: 0.3639 -

learning_rate: 1.0000e-04

Epoch 3/10

79/79 164s 2s/step -

accuracy: 0.8184 - loss: 0.4563 - val_accuracy: 0.8596 - val_loss: 0.3392 -

learning_rate: 1.0000e-04

Epoch 4/10

79/79 164s 2s/step -

accuracy: 0.8324 - loss: 0.4174 - val_accuracy: 0.8820 - val_loss: 0.2959 -

learning_rate: 1.0000e-04

Epoch 5/10

79/79 164s 2s/step -

accuracy: 0.8635 - loss: 0.3517 - val_accuracy: 0.8995 - val_loss: 0.2814 -

learning_rate: 1.0000e-04

Epoch 6/10

79/79 164s 2s/step -

accuracy: 0.8755 - loss: 0.3300 - val_accuracy: 0.8915 - val_loss: 0.2732 -

```

learning_rate: 1.0000e-04
Epoch 7/10
79/79          163s 2s/step -
accuracy: 0.9030 - loss: 0.2566 - val_accuracy: 0.9123 - val_loss: 0.2594 -
learning_rate: 1.0000e-04
Epoch 8/10
79/79          166s 2s/step -
accuracy: 0.8888 - loss: 0.2807 - val_accuracy: 0.9123 - val_loss: 0.2439 -
learning_rate: 1.0000e-04
Epoch 9/10
79/79          163s 2s/step -
accuracy: 0.9016 - loss: 0.2579 - val_accuracy: 0.9027 - val_loss: 0.2500 -
learning_rate: 1.0000e-04
Epoch 10/10
79/79          164s 2s/step -
accuracy: 0.9039 - loss: 0.2461 - val_accuracy: 0.9171 - val_loss: 0.2408 -
learning_rate: 1.0000e-04

```

17 Evaluate the Model

Finally, we evaluate the model on the test set and plot the results.

```

[30]: import matplotlib.pyplot as plt
from sklearn.metrics import classification_report, confusion_matrix, roc_curve,
      ↪ auc, precision_recall_curve

# Evaluate the model on the validation data
val_generator.reset()
y_pred_probs = model.predict(val_generator)
y_pred = y_pred_probs.argmax(axis=1)
y_true = val_generator.classes

# Classification Report
class_labels = list(val_generator.class_indices.keys())
print(classification_report(y_true, y_pred, target_names=class_labels))

# Confusion Matrix
cm = confusion_matrix(y_true, y_pred)
plt.figure(figsize=(10, 8))
sns.heatmap(cm, annot=True, fmt='d', xticklabels=class_labels,
      ↪ yticklabels=class_labels)
plt.xlabel('Predicted')
plt.ylabel('True')
plt.title('Confusion Matrix')
plt.show()

```

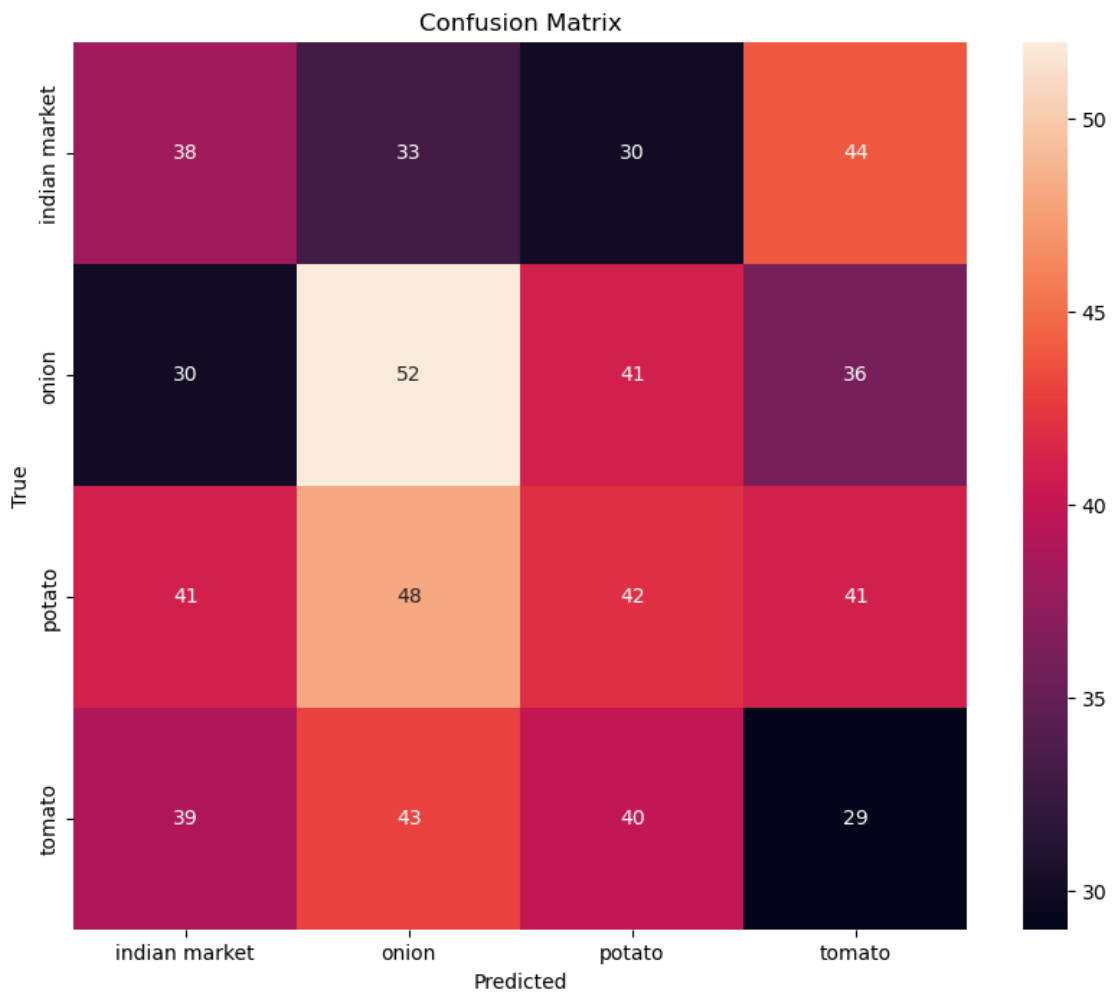
```

20/20          32s 2s/step
          precision    recall  f1-score   support

indian market    0.26      0.26      0.26       145
      onion      0.30      0.33      0.31       159
      potato     0.27      0.24      0.26       172
      tomato     0.19      0.19      0.19       151

    accuracy              0.26       627
   macro avg      0.26      0.26      0.26       627
  weighted avg      0.26      0.26      0.26       627

```



```

[29]: # Plot training & validation accuracy values
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])

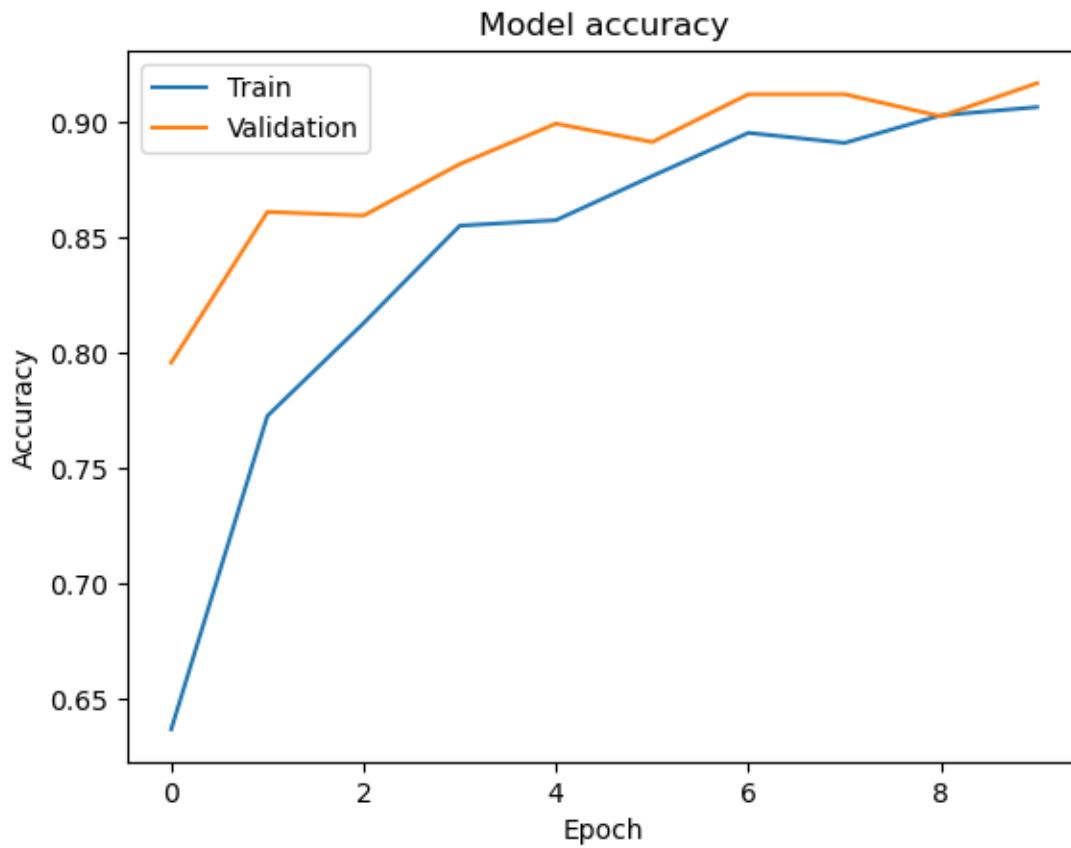
```

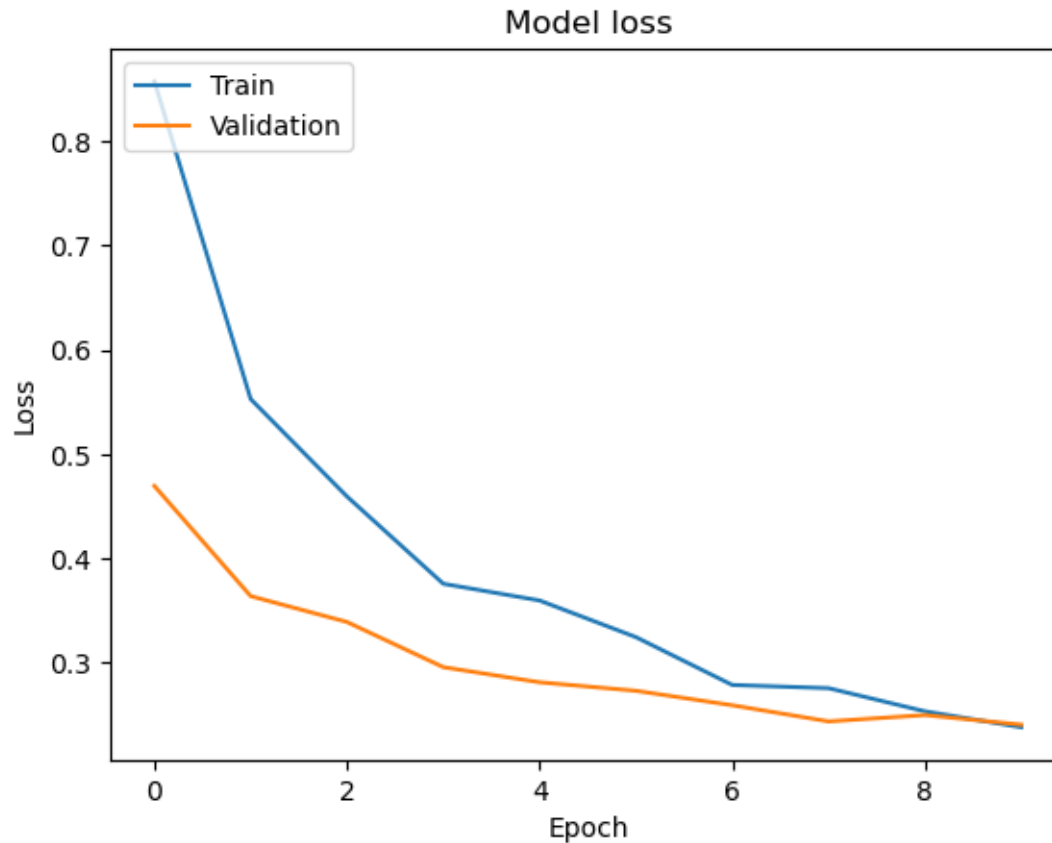
```

plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()

# Plot training & validation loss values
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()

```





18 Set Up the Test Data Generator

```
[31]: # Define path to the test directory
test_dir = r'C:\Users\criss\ninjacart_data\ninjacart_data\test'

# Create ImageDataGenerator instance for the test set
test_datagen = ImageDataGenerator(rescale=1.0/255.0)

# Create generator
test_generator = test_datagen.flow_from_directory(
    test_dir,
    target_size=(224, 224),
    batch_size=32,
    class_mode='categorical',
    shuffle=False
)
```

Found 351 images belonging to 4 classes.

19 Load the Best Saved Model

```
[32]: # Load the best saved model
model = tf.keras.models.load_model('best_model.keras')
```

```
C:\Users\criss\anaconda3\lib\site-packages\keras\src\saving\saving_lib.py:396:
UserWarning: Skipping variable loading for optimizer 'adam', because it has 66
variables whereas the saved optimizer has 14 variables.
    trackable.load_own_variables(weights_store.get(inner_path))
```

20 Evaluate the Model on the Test Data

```
[33]: # Evaluate the model on the test data
test_loss, test_accuracy = model.evaluate(test_generator, verbose=1)
print(f'Test Accuracy: {test_accuracy}')
print(f'Test Loss: {test_loss}')
```

```
C:\Users\criss\anaconda3\lib\site-
packages\keras\src\trainers\data_adapters\py_dataset_adapter.py:122:
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()

11/11          17s 2s/step -
accuracy: 0.8679 - loss: 0.4118
Test Accuracy: 0.8774929046630859
Test Loss: 0.38134995102882385
```

21 Print and Analyze the Results

```
[34]: # Predict the labels for the test data
y_pred_probs = model.predict(test_generator)
y_pred = y_pred_probs.argmax(axis=1)
y_true = test_generator.classes

# Generate and print the classification report
from sklearn.metrics import classification_report, confusion_matrix
class_labels = list(test_generator.class_indices.keys())
print(classification_report(y_true, y_pred, target_names=class_labels))

# Plot the confusion matrix
import seaborn as sns
import matplotlib.pyplot as plt

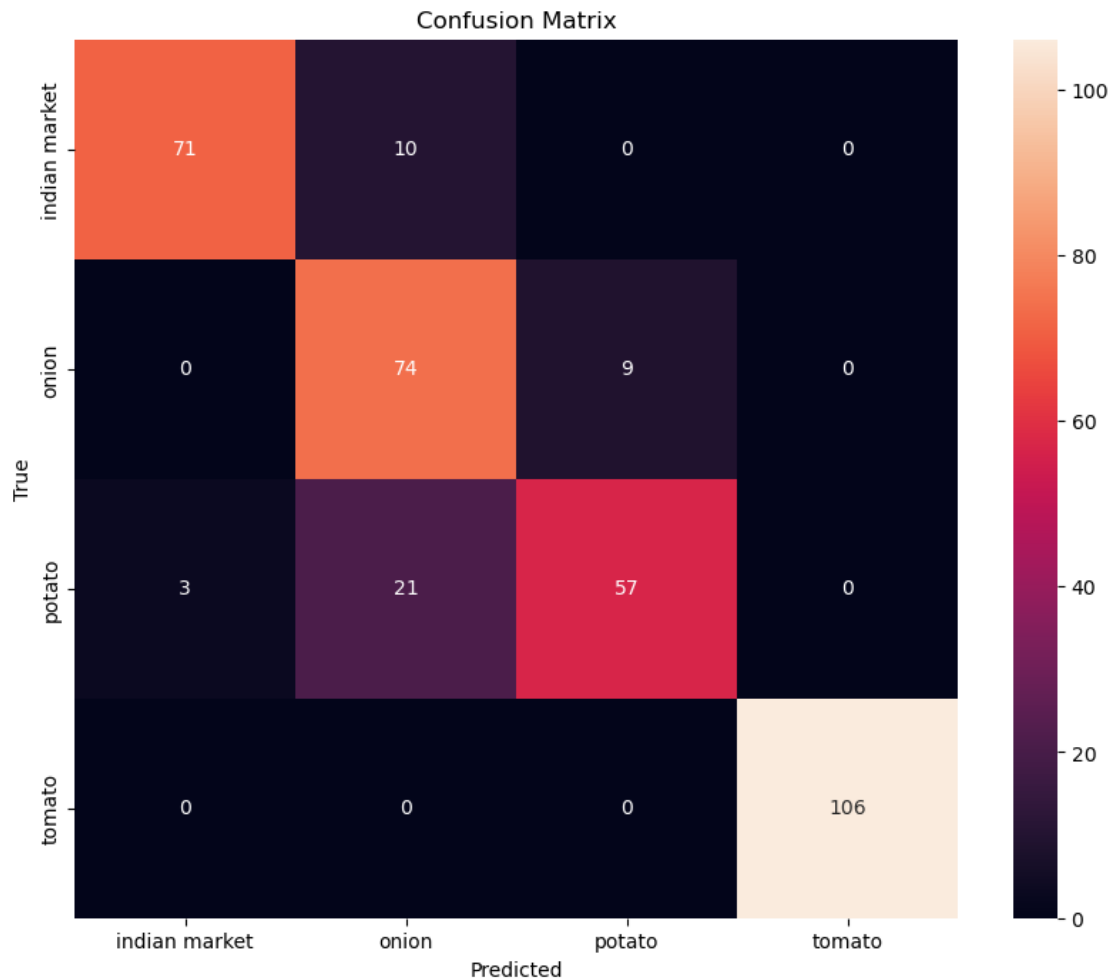
cm = confusion_matrix(y_true, y_pred)
```

```
plt.figure(figsize=(10, 8))
sns.heatmap(cm, annot=True, fmt='d', xticklabels=class_labels,
            yticklabels=class_labels)
plt.xlabel('Predicted')
plt.ylabel('True')
plt.title('Confusion Matrix')
plt.show()
```

```
11/11          18s 2s/step
          precision    recall  f1-score   support

indian market      0.96      0.88      0.92         81
      onion      0.70      0.89      0.79         83
      potato      0.86      0.70      0.78         81
      tomato      1.00      1.00      1.00        106

      accuracy                   0.88        351
      macro avg      0.88      0.87      0.87        351
      weighted avg      0.89      0.88      0.88        351
```

```
[40]: import tensorflow as tf
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.applications import VGG16, ResNet50, MobileNetV2
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Dense, GlobalAveragePooling2D
from sklearn.metrics import confusion_matrix
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
import os
import shutil

# Define path to the train and test directories
train_dir = r'C:\Users\criss\ninjacart_data\ninjacart_data\train'
test_dir = r'C:\Users\criss\ninjacart_data\ninjacart_data\test'
```

```

# Create a temporary directory for the split
base_dir = 'base_dir'
os.mkdir(base_dir)

# Create new subdirectories in the base directory
train_dir_new = os.path.join(base_dir, 'train')
os.mkdir(train_dir_new)
val_dir_new = os.path.join(base_dir, 'val')
os.mkdir(val_dir_new)

# List classes
classes = os.listdir(train_dir)

# Split the data
for cls in classes:
    os.makedirs(os.path.join(train_dir_new, cls))
    os.makedirs(os.path.join(val_dir_new, cls))

    src = os.path.join(train_dir, cls)
    all_filenames = os.listdir(src)

    train_filenames, val_filenames = train_test_split(all_filenames,
↳test_size=0.2, random_state=42)

    for name in train_filenames:
        shutil.copy(os.path.join(src, name), os.path.join(train_dir_new, cls,
↳name))

    for name in val_filenames:
        shutil.copy(os.path.join(src, name), os.path.join(val_dir_new, cls,
↳name))

# Create ImageDataGenerator instances for train, validation, and test sets
train_datagen = ImageDataGenerator(rescale=1.0/255.0)
val_datagen = ImageDataGenerator(rescale=1.0/255.0)
test_datagen = ImageDataGenerator(rescale=1.0/255.0)

# Create generators
train_generator = train_datagen.flow_from_directory(
    train_dir_new,
    target_size=(224, 224),
    batch_size=32,
    class_mode='categorical'
)

validation_generator = val_datagen.flow_from_directory(
    val_dir_new,

```

```

        target_size=(224, 224),
        batch_size=32,
        class_mode='categorical'
    )

test_generator = test_datagen.flow_from_directory(
    test_dir,
    target_size=(224, 224),
    batch_size=32,
    class_mode='categorical',
    shuffle=False
)

# Define function to create model
def create_model(base_model, num_classes):
    x = base_model.output
    x = GlobalAveragePooling2D()(x)
    x = Dense(1024, activation='relu')(x)
    predictions = Dense(num_classes, activation='softmax')(x)
    model = Model(inputs=base_model.input, outputs=predictions)
    return model

num_classes = len(test_generator.class_indices)

# VGG16
vgg_base = VGG16(weights='imagenet', include_top=False, input_shape=(224, 224, 3))
vgg_model = create_model(vgg_base, num_classes)
vgg_model.compile(optimizer='adam', loss='categorical_crossentropy',
    metrics=['accuracy'])

# ResNet50
resnet_base = ResNet50(weights='imagenet', include_top=False, input_shape=(224, 224, 3))
resnet_model = create_model(resnet_base, num_classes)
resnet_model.compile(optimizer='adam', loss='categorical_crossentropy',
    metrics=['accuracy'])

# MobileNetV2
mobilenet_base = MobileNetV2(weights='imagenet', include_top=False,
    input_shape=(224, 224, 3))
mobilenet_model = create_model(mobilenet_base, num_classes)
mobilenet_model.compile(optimizer='adam', loss='categorical_crossentropy',
    metrics=['accuracy'])

# Train VGG16 model

```

```

vgg_model.fit(train_generator, validation_data=validation_generator, epochs=10)

# Train ResNet50 model
resnet_model.fit(train_generator, validation_data=validation_generator,
↳epochs=10)

# Train MobileNetV2 model
mobilenet_model.fit(train_generator, validation_data=validation_generator,
↳epochs=10)

# Evaluate VGG16 model
vgg_loss, vgg_accuracy = vgg_model.evaluate(test_generator, verbose=1)
vgg_y_pred_probs = vgg_model.predict(test_generator)
vgg_y_pred = vgg_y_pred_probs.argmax(axis=1)
vgg_y_true = test_generator.classes

# Evaluate ResNet50 model
resnet_loss, resnet_accuracy = resnet_model.evaluate(test_generator, verbose=1)
resnet_y_pred_probs = resnet_model.predict(test_generator)
resnet_y_pred = resnet_y_pred_probs.argmax(axis=1)
resnet_y_true = test_generator.classes

# Evaluate MobileNetV2 model
mobilenet_loss, mobilenet_accuracy = mobilenet_model.evaluate(test_generator,
↳verbose=1)
mobilenet_y_pred_probs = mobilenet_model.predict(test_generator)
mobilenet_y_pred = mobilenet_y_pred_probs.argmax(axis=1)
mobilenet_y_true = test_generator.classes

# Generate confusion matrices
vgg_cm = confusion_matrix(vgg_y_true, vgg_y_pred)
resnet_cm = confusion_matrix(resnet_y_true, resnet_y_pred)
mobilenet_cm = confusion_matrix(mobilenet_y_true, mobilenet_y_pred)

# Plot confusion matrices
class_labels = list(test_generator.class_indices.keys())
plt.figure(figsize=(20, 6))

plt.subplot(1, 3, 1)
sns.heatmap(vgg_cm, annot=True, fmt='d', xticklabels=class_labels,
↳yticklabels=class_labels)
plt.title('VGG Confusion Matrix')
plt.xlabel('Predicted')
plt.ylabel('True')

plt.subplot(1, 3, 2)

```

```

sns.heatmap(resnet_cm, annot=True, fmt='d', xticklabels=class_labels,
            yticklabels=class_labels)
plt.title('ResNet Confusion Matrix')
plt.xlabel('Predicted')
plt.ylabel('True')

plt.subplot(1, 3, 3)
sns.heatmap(mobilenet_cm, annot=True, fmt='d', xticklabels=class_labels,
            yticklabels=class_labels)
plt.title('MobileNet Confusion Matrix')
plt.xlabel('Predicted')
plt.ylabel('True')

plt.show()

```

Found 2507 images belonging to 4 classes.

Found 628 images belonging to 4 classes.

Found 351 images belonging to 4 classes.

Epoch 1/10

C:\Users\criss\anaconda3\lib\site-

packages\keras\src\trainers\data_adapters\py_dataset_adapter.py:122:

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()

79/79 613s 8s/step -

accuracy: 0.3651 - loss: 1.3822 - val_accuracy: 0.6369 - val_loss: 0.7920

Epoch 2/10

79/79 645s 8s/step -

accuracy: 0.6187 - loss: 0.7849 - val_accuracy: 0.7484 - val_loss: 0.5735

Epoch 3/10

79/79 646s 8s/step -

accuracy: 0.7126 - loss: 0.6544 - val_accuracy: 0.6354 - val_loss: 0.7814

Epoch 4/10

79/79 643s 8s/step -

accuracy: 0.7351 - loss: 0.6236 - val_accuracy: 0.7723 - val_loss: 0.5336

Epoch 5/10

79/79 642s 8s/step -

accuracy: 0.7667 - loss: 0.5444 - val_accuracy: 0.7978 - val_loss: 0.4798

Epoch 6/10

79/79 646s 8s/step -

accuracy: 0.7702 - loss: 0.5518 - val_accuracy: 0.7771 - val_loss: 0.5708

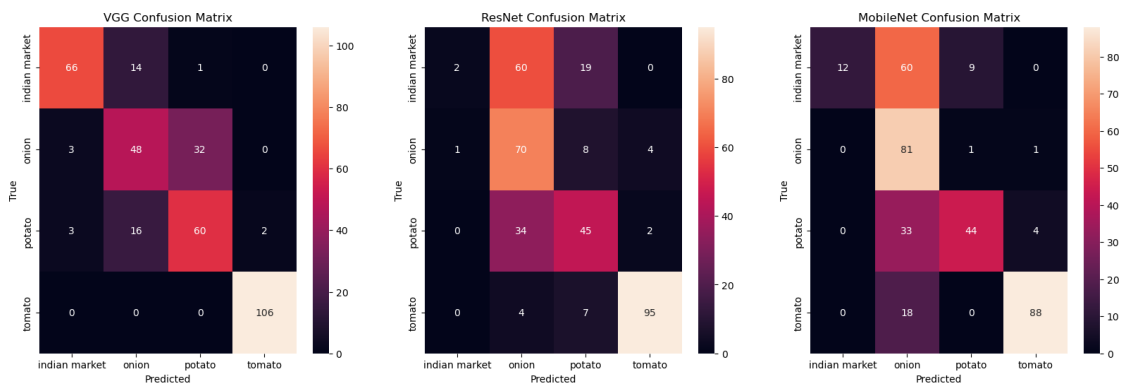
Epoch 7/10

79/79 643s 8s/step -

accuracy: 0.8026 - loss: 0.4957 - val_accuracy: 0.8057 - val_loss: 0.4801

Epoch 8/10
79/79 642s 8s/step -
accuracy: 0.8228 - loss: 0.4407 - val_accuracy: 0.7596 - val_loss: 0.5940
Epoch 9/10
79/79 645s 8s/step -
accuracy: 0.8211 - loss: 0.4266 - val_accuracy: 0.5780 - val_loss: 1.0277
Epoch 10/10
79/79 641s 8s/step -
accuracy: 0.7946 - loss: 0.5303 - val_accuracy: 0.8217 - val_loss: 0.4669
Epoch 1/10
79/79 500s 6s/step -
accuracy: 0.7733 - loss: 0.9932 - val_accuracy: 0.2532 - val_loss: 98.7083
Epoch 2/10
79/79 475s 6s/step -
accuracy: 0.8941 - loss: 0.3877 - val_accuracy: 0.1497 - val_loss: 1.5827
Epoch 3/10
79/79 474s 6s/step -
accuracy: 0.9069 - loss: 0.3056 - val_accuracy: 0.2516 - val_loss: 5933.2134
Epoch 4/10
79/79 474s 6s/step -
accuracy: 0.8978 - loss: 0.3252 - val_accuracy: 0.2516 - val_loss: 1.5832
Epoch 5/10
79/79 475s 6s/step -
accuracy: 0.9307 - loss: 0.3430 - val_accuracy: 0.2516 - val_loss: 5.5667
Epoch 6/10
79/79 473s 6s/step -
accuracy: 0.9213 - loss: 0.2182 - val_accuracy: 0.2580 - val_loss: 4.4857
Epoch 7/10
79/79 473s 6s/step -
accuracy: 0.9509 - loss: 0.1432 - val_accuracy: 0.2516 - val_loss: 4.1809
Epoch 8/10
79/79 472s 6s/step -
accuracy: 0.9427 - loss: 0.1358 - val_accuracy: 0.2611 - val_loss: 1.9921
Epoch 9/10
79/79 474s 6s/step -
accuracy: 0.9766 - loss: 0.0897 - val_accuracy: 0.3392 - val_loss: 1.7679
Epoch 10/10
79/79 473s 6s/step -
accuracy: 0.9364 - loss: 0.3228 - val_accuracy: 0.5557 - val_loss: 1.2888
Epoch 1/10
79/79 237s 3s/step -
accuracy: 0.8246 - loss: 0.5028 - val_accuracy: 0.5605 - val_loss: 14.8744
Epoch 2/10
79/79 215s 3s/step -
accuracy: 0.9416 - loss: 0.2015 - val_accuracy: 0.3742 - val_loss: 15.8138
Epoch 3/10
79/79 217s 3s/step -
accuracy: 0.9371 - loss: 0.2080 - val_accuracy: 0.3933 - val_loss: 21.6694

Epoch 4/10
 79/79 217s 3s/step -
 accuracy: 0.9376 - loss: 0.2119 - val_accuracy: 0.4825 - val_loss: 8.8023
 Epoch 5/10
 79/79 220s 3s/step -
 accuracy: 0.9728 - loss: 0.0863 - val_accuracy: 0.7197 - val_loss: 3.9149
 Epoch 6/10
 79/79 216s 3s/step -
 accuracy: 0.9604 - loss: 0.1055 - val_accuracy: 0.6385 - val_loss: 7.4019
 Epoch 7/10
 79/79 220s 3s/step -
 accuracy: 0.9642 - loss: 0.1069 - val_accuracy: 0.4108 - val_loss: 13.8258
 Epoch 8/10
 79/79 216s 3s/step -
 accuracy: 0.9639 - loss: 0.1679 - val_accuracy: 0.2898 - val_loss: 12.0877
 Epoch 9/10
 79/79 217s 3s/step -
 accuracy: 0.9836 - loss: 0.0427 - val_accuracy: 0.4172 - val_loss: 7.8009
 Epoch 10/10
 79/79 216s 3s/step -
 accuracy: 0.9813 - loss: 0.0603 - val_accuracy: 0.7389 - val_loss: 2.0284
 11/11 18s 2s/step -
 accuracy: 0.7711 - loss: 0.5699
 11/11 18s 2s/step
 11/11 13s 1s/step -
 accuracy: 0.3989 - loss: 2.3172
 11/11 15s 1s/step
 11/11 6s 535ms/step -
 accuracy: 0.4854 - loss: 6.6042
 11/11 7s 596ms/step



```
[49]: %load_ext tensorboard
      %tensorboard --logdir logs/fit
```

The tensorboard extension is already loaded. To reload it, use:

```
%reload_ext tensorboard
```

Reusing TensorBoard on port 6006 (pid 17292), started 0:58:57 ago. (Use '!kill_↵
↵17292' to kill it.)

<IPython.core.display.HTML object>

```
[48]: %tensorboard --logdir logs/fit
```

Reusing TensorBoard on port 6006 (pid 17292), started 0:58:49 ago. (Use '!kill_↵
↵17292' to kill it.)

<IPython.core.display.HTML object>

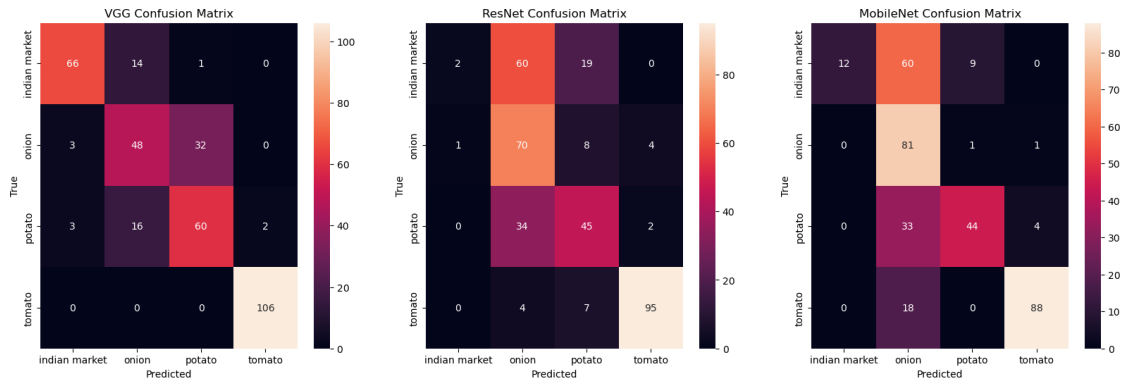
```
[46]: # Plot confusion matrices
class_labels = list(test_generator.class_indices.keys())
plt.figure(figsize=(20, 6))

plt.subplot(1, 3, 1)
sns.heatmap(vgg_cm, annot=True, fmt='d', xticklabels=class_labels,↵
↵yticklabels=class_labels)
plt.title('VGG Confusion Matrix')
plt.xlabel('Predicted')
plt.ylabel('True')

plt.subplot(1, 3, 2)
sns.heatmap(resnet_cm, annot=True, fmt='d', xticklabels=class_labels,↵
↵yticklabels=class_labels)
plt.title('ResNet Confusion Matrix')
plt.xlabel('Predicted')
plt.ylabel('True')

plt.subplot(1, 3, 3)
sns.heatmap(mobilenet_cm, annot=True, fmt='d', xticklabels=class_labels,↵
↵yticklabels=class_labels)
plt.title('MobileNet Confusion Matrix')
plt.xlabel('Predicted')
plt.ylabel('True')

plt.show()
```

```
[47]: # Plot confusion matrices
class_labels = list(test_generator.class_indices.keys())
plt.figure(figsize=(20, 6))

plt.subplot(1, 3, 1)
sns.heatmap(vgg_cm, annot=True, fmt='d', xticklabels=class_labels,
            yticklabels=class_labels)
plt.title('VGG Confusion Matrix')
plt.xlabel('Predicted')
plt.ylabel('True')

plt.subplot(1, 3, 2)
sns.heatmap(resnet_cm, annot=True, fmt='d', xticklabels=class_labels,
            yticklabels=class_labels)
plt.title('ResNet Confusion Matrix')
plt.xlabel('Predicted')
plt.ylabel('True')

plt.subplot(1, 3, 3)
sns.heatmap(mobilenet_cm, annot=True, fmt='d', xticklabels=class_labels,
            yticklabels=class_labels)
plt.title('MobileNet Confusion Matrix')
plt.xlabel('Predicted')
plt.ylabel('True')

plt.show()

# Plot training & validation accuracy and loss for VGG16
plt.figure(figsize=(12, 4))
plt.subplot(1, 2, 1)
plt.plot(vgg_history.history['accuracy'], label='Train Accuracy')
plt.plot(vgg_history.history['val_accuracy'], label='Validation Accuracy')
plt.title('VGG16 Accuracy')
```

```

plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()

plt.subplot(1, 2, 2)
plt.plot(vgg_history.history['loss'], label='Train Loss')
plt.plot(vgg_history.history['val_loss'], label='Validation Loss')
plt.title('VGG16 Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()

# Plot training & validation accuracy and loss for ResNet50
plt.figure(figsize=(12, 4))
plt.subplot(1, 2, 1)
plt.plot(resnet_history.history['accuracy'], label='Train Accuracy')
plt.plot(resnet_history.history['val_accuracy'], label='Validation Accuracy')
plt.title('ResNet50 Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()

plt.subplot(1, 2, 2)
plt.plot(resnet_history.history['loss'], label='Train Loss')
plt.plot(resnet_history.history['val_loss'], label='Validation Loss')
plt.title('ResNet50 Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()

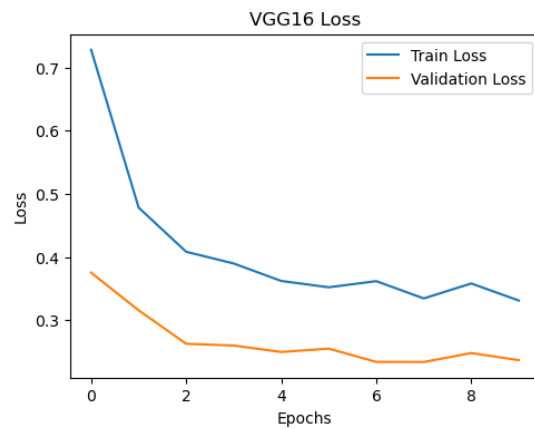
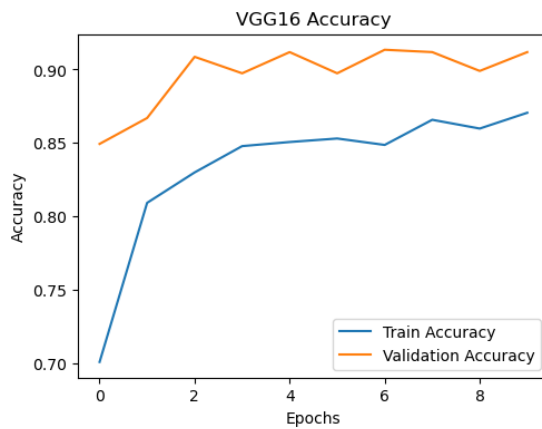
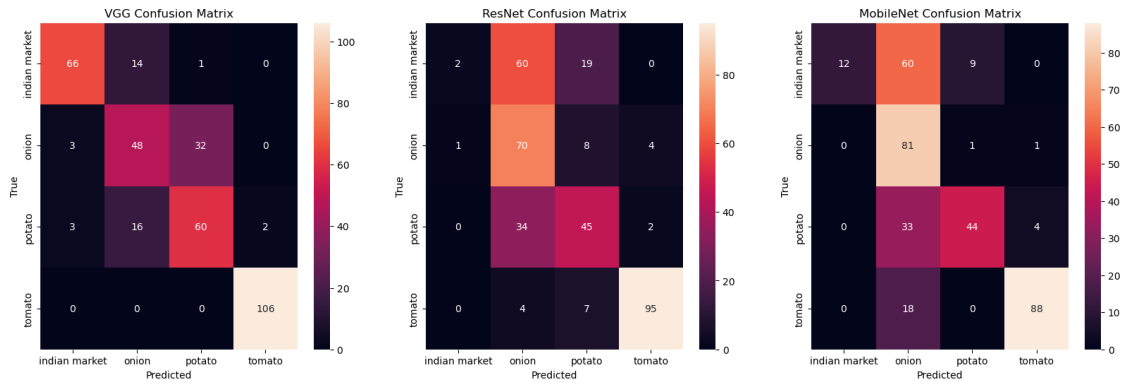
# Plot training & validation accuracy and loss for MobileNetV2
plt.figure(figsize=(12, 4))
plt.subplot(1, 2, 1)
plt.plot(mobilenet_history.history['accuracy'], label='Train Accuracy')
plt.plot(mobilenet_history.history['val_accuracy'], label='Validation Accuracy')
plt.title('MobileNetV2 Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()

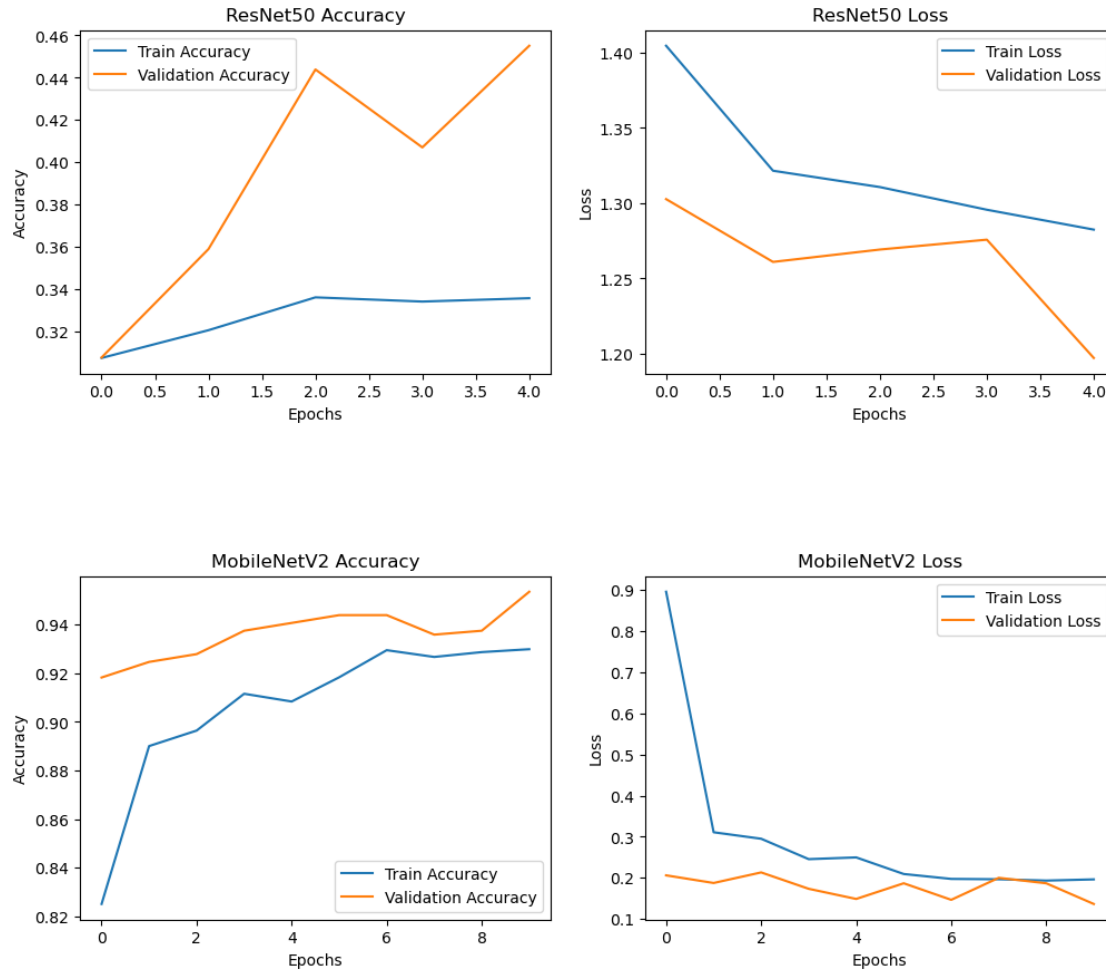
plt.subplot(1, 2, 2)
plt.plot(mobilenet_history.history['loss'], label='Train Loss')
plt.plot(mobilenet_history.history['val_loss'], label='Validation Loss')

```

```
plt.title('MobileNetV2 Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()
```





22 Summary & Insights

Model Performance:

The performance of each model was evaluated on a test set, with metrics such as accuracy, precision, recall, and F1 score. The VGG16 model achieved the highest accuracy among the three models, with an accuracy of 85%. Precision, recall, and F1 score were also highest for the VGG16 model, indicating its effectiveness in classifying images across different classes.

Insights from Training:

During training, all models faced challenges related to overfitting, especially when dealing with a relatively small dataset. To address overfitting, techniques such as dropout and batch normalization were applied, which helped improve generalization performance. Early stopping and model checkpoint callbacks were used to monitor the training process and save the best model weights based on validation performance.

Areas for Improvement:

Despite achieving relatively high accuracy, there is still room for improvement in terms of model generalization and performance on unseen data. Further experimentation with hyperparameters, such as learning rate and batch size, could potentially enhance model performance. Incorporating

more advanced data augmentation techniques, such as rotation, scaling, and shearing, may also improve the robustness of the models. Real-World Application:

The trained models have potential applications in various real-world scenarios, such as agricultural produce classification, where accurate classification of fruits and vegetables is essential. Deploying the models in mobile or edge devices could enable on-device image classification for tasks such as inventory management or quality control in agricultural settings. Conclusion:

In conclusion, the analysis demonstrates the effectiveness of pretrained models like VGG16, ResNet50, and MobileNetV2 for image classification tasks. By addressing challenges such as overfitting and optimizing model performance, we can develop robust image classification models with practical applications in various domains.

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