

Ninjacart_CV_Classification

July 16, 2025

[2] : `## NINJACART`

Problem Statement: Analyzing the dataset to develop a program that takes an image as input and recognizes the vegetable item(s).

[3] : `## Loading the data`

```
!gdown 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=0c298109-cd86-4785-b93a-f334db9f7c74  
To: /content/ninjacart_data.zip  
100% 275M/275M [00:03<00:00, 91.3MB/s]
```

[4] : `## Unzipping the folder`

```
!unzip -o ninjacart_data.zip
```

```
Archive:  ninjacart_data.zip  
  creating: ninjacart_data/test/  
  creating: ninjacart_data/test/indian market/  
  inflating: ninjacart_data/test/indian market/bhl.jpeg  
  inflating: ninjacart_data/test/indian market/bhv.jpeg  
  inflating: ninjacart_data/test/indian market/bn.jpeg  
  inflating: ninjacart_data/test/indian market/hjx.jpeg  
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  inflating: ninjacart_data/test/indian market/in.jpeg  
  inflating: ninjacart_data/test/indian market/india-4898453_340.jpg  
  inflating: ninjacart_data/test/indian market/indianmarket10.jpeg  
  inflating: ninjacart_data/test/indian market/indianmarket12.jpeg  
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  inflating: ninjacart_data/test/indian market/indianmarket19.jpeg
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inflating: ninjacart_data/train/onion/XDZWQL6WCVNF.jpg
inflating: ninjacart_data/train/onion/XEKOG39UQKXX.jpg
inflating: ninjacart_data/train/onion/XG381PT101B5.jpg
inflating: ninjacart_data/train/onion/XGH2DU1WL39G.jpg
inflating: ninjacart_data/train/onion/XH5M75HNNGC1.jpg
inflating: ninjacart_data/train/onion/XIKYYJFUBA8H.jpg
inflating: ninjacart_data/train/onion/XJB56LG1L9B8.jpg
inflating: ninjacart_data/train/onion/XNOLV3UT5VI3.jpg
inflating: ninjacart_data/train/onion/XN89RHCEDS9B.jpg
inflating: ninjacart_data/train/onion/XRPRDWUF03UH.jpg
inflating: ninjacart_data/train/onion/XSJZ87H45DGR.jpg
inflating: ninjacart_data/train/onion/XT7DY3514469.jpg
inflating: ninjacart_data/train/onion/XWJE40YGO1OK.jpg
inflating: ninjacart_data/train/onion/XYSQOT2G10DW.jpg
inflating: ninjacart_data/train/onion/XZ86WTPHFL7M.jpg
inflating: ninjacart_data/train/onion/Y1SHQ8XJ8MHN.jpg
inflating: ninjacart_data/train/onion/Y4W9C0GKKI90.jpg
inflating: ninjacart_data/train/onion/Y7YEKS6X9C4W.jpg
inflating: ninjacart_data/train/onion/YAUFXAC6I7BC.jpg
inflating: ninjacart_data/train/onion/YCUQULJBABYX.jpg
inflating: ninjacart_data/train/onion/YDZTNCLIGA05.jpg
inflating: ninjacart_data/train/onion/YMLP07B4DM2F.jpg
inflating: ninjacart_data/train/onion/YOZHTZ00WN20.jpg
inflating: ninjacart_data/train/onion/YP3GRQKM2P1I.jpg
inflating: ninjacart_data/train/onion/YZR2BJ7TI85L.jpg
inflating: ninjacart_data/train/onion/Z1EQSZWKVLRD.jpg
inflating: ninjacart_data/train/onion/Z1T8SEKFAU57.jpg
inflating: ninjacart_data/train/onion/Z7QK5UJV7ZOC.jpg
inflating: ninjacart_data/train/onion/Z8VQUQIR4GOF.jpg
inflating: ninjacart_data/train/onion/ZCBP6F4I4ADZ.jpg
inflating: ninjacart_data/train/onion/ZCMRMQRQOTXP.jpg

```
inflating: ninjacart_data/train/onion/ZD8AVJSPCK1G.jpg
inflating: ninjacart_data/train/onion/ZDBOWZLLWLF0.jpg
inflating: ninjacart_data/train/onion/ZDF60849MYTN.jpg
inflating: ninjacart_data/train/onion/ZE6T1YAS6MSW.jpg
inflating: ninjacart_data/train/onion/ZG4RLBJF2PKB.jpg
inflating: ninjacart_data/train/onion/ZIGLNCMQP5DP.jpg
inflating: ninjacart_data/train/onion/ZILGUSSWLRWT.jpg
inflating: ninjacart_data/train/onion/ZJA79URI5H4U.jpg
inflating: ninjacart_data/train/onion/ZJJZFKITMGHS.jpg
inflating: ninjacart_data/train/onion/ZKH5Z3ECM27Z.jpg
inflating: ninjacart_data/train/onion/ZMWSJLYAEWAH.jpg
inflating: ninjacart_data/train/onion/ZPN3YNXE8U98.jpg
inflating: ninjacart_data/train/onion/ZQX8SQNTJQUZ.jpg
inflating: ninjacart_data/train/onion/ZVU06W1FI7N4.jpg
inflating: ninjacart_data/train/onion/ZVWTYBWQ4UE4.jpg
inflating: ninjacart_data/train/onion/ZXRU8BCOV7P6.jpg
    creating: ninjacart_data/train/potato/
inflating: ninjacart_data/train/potato/potato11001 (1).jpeg
inflating: ninjacart_data/train/potato/potato11001 (2).jpeg
inflating: ninjacart_data/train/potato/potato11001.jpeg
inflating: ninjacart_data/train/potato/potato11002 (1).jpeg
inflating: ninjacart_data/train/potato/potato11002 (2).jpeg
inflating: ninjacart_data/train/potato/potato11002.jpeg
inflating: ninjacart_data/train/potato/potato11003 (1).jpeg
inflating: ninjacart_data/train/potato/potato11003.jpeg
extracting: ninjacart_data/train/potato/potato11003.png
inflating: ninjacart_data/train/potato/potato11004 (1).jpeg
inflating: ninjacart_data/train/potato/potato11004 (2).jpeg
inflating: ninjacart_data/train/potato/potato11004.jpeg
inflating: ninjacart_data/train/potato/potato11005 (1).jpeg
inflating: ninjacart_data/train/potato/potato11005 (2).jpeg
inflating: ninjacart_data/train/potato/potato11005.jpeg
inflating: ninjacart_data/train/potato/potato11006 (1).jpeg
inflating: ninjacart_data/train/potato/potato11006 (2).jpeg
inflating: ninjacart_data/train/potato/potato11006.jpeg
inflating: ninjacart_data/train/potato/potato11007 (1).jpeg
inflating: ninjacart_data/train/potato/potato11007 (2).jpeg
inflating: ninjacart_data/train/potato/potato11007.jpeg
inflating: ninjacart_data/train/potato/potato11008 (1).jpeg
inflating: ninjacart_data/train/potato/potato11008 (2).jpeg
inflating: ninjacart_data/train/potato/potato11008.jpeg
inflating: ninjacart_data/train/potato/potato11009 (1).jpeg
inflating: ninjacart_data/train/potato/potato11009 (2).jpeg
inflating: ninjacart_data/train/potato/potato11009.jpeg
inflating: ninjacart_data/train/potato/potato11010 (1).jpeg
inflating: ninjacart_data/train/potato/potato11010 (2).jpeg
inflating: ninjacart_data/train/potato/potato11010.jpeg
inflating: ninjacart_data/train/potato/potato11011 (1).jpeg
```



```
inflating: ninjacart_data/train/tomato/tomato882.png
inflating: ninjacart_data/train/tomato/tomato883.png
inflating: ninjacart_data/train/tomato/tomato884.png
inflating: ninjacart_data/train/tomato/tomato885.png
inflating: ninjacart_data/train/tomato/tomato886.png
inflating: ninjacart_data/train/tomato/tomato887.png
inflating: ninjacart_data/train/tomato/tomato888.png
inflating: ninjacart_data/train/tomato/tomato889.png
inflating: ninjacart_data/train/tomato/tomato89.png
inflating: ninjacart_data/train/tomato/tomato890.png
inflating: ninjacart_data/train/tomato/tomato891.png
inflating: ninjacart_data/train/tomato/tomato892.png
inflating: ninjacart_data/train/tomato/tomato893.png
inflating: ninjacart_data/train/tomato/tomato894.png
inflating: ninjacart_data/train/tomato/tomato9.png
inflating: ninjacart_data/train/tomato/tomato90.png
inflating: ninjacart_data/train/tomato/tomato91.png
inflating: ninjacart_data/train/tomato/tomato92.png
inflating: ninjacart_data/train/tomato/tomato93.png
inflating: ninjacart_data/train/tomato/tomato94.png
inflating: ninjacart_data/train/tomato/tomato95.png
inflating: ninjacart_data/train/tomato/tomato96.png
inflating: ninjacart_data/train/tomato/tomato97.png
inflating: ninjacart_data/train/tomato/tomato98.png
inflating: ninjacart_data/train/tomato/tomato99.png
```

[5]: ls

```
ninjacart_data/  ninjacart_data.zip  sample_data/
```

Exploratory Data Analysis

Observation On Data

[6]: *## Defining the data paths*

```
datapath = 'ninjacart_data'  
!ls {datapath}
```

test train

[7]: *import tensorflow as tf*

```
train_path = f'{datapath}/train'  
test_path = f'{datapath}/test'
```

[8]: *## Loading the data sets*

```
train_ds = tf.keras.preprocessing.image_dataset_from_directory(train_path,  
    image_size = (224,224), batch_size = 32)  
test_ds = tf.keras.preprocessing.image_dataset_from_directory(test_path,  
    image_size = (224,224), batch_size = 32)
```

Found 3135 files belonging to 4 classes.
Found 351 files belonging to 4 classes.

[9]: *## Printing the class names for train and test*

```
class_names_train = train_ds.class_names  
print("Class names_train:",class_names_train)  
  
class_names_test = test_ds.class_names  
print("class_names_test:",class_names_test)
```

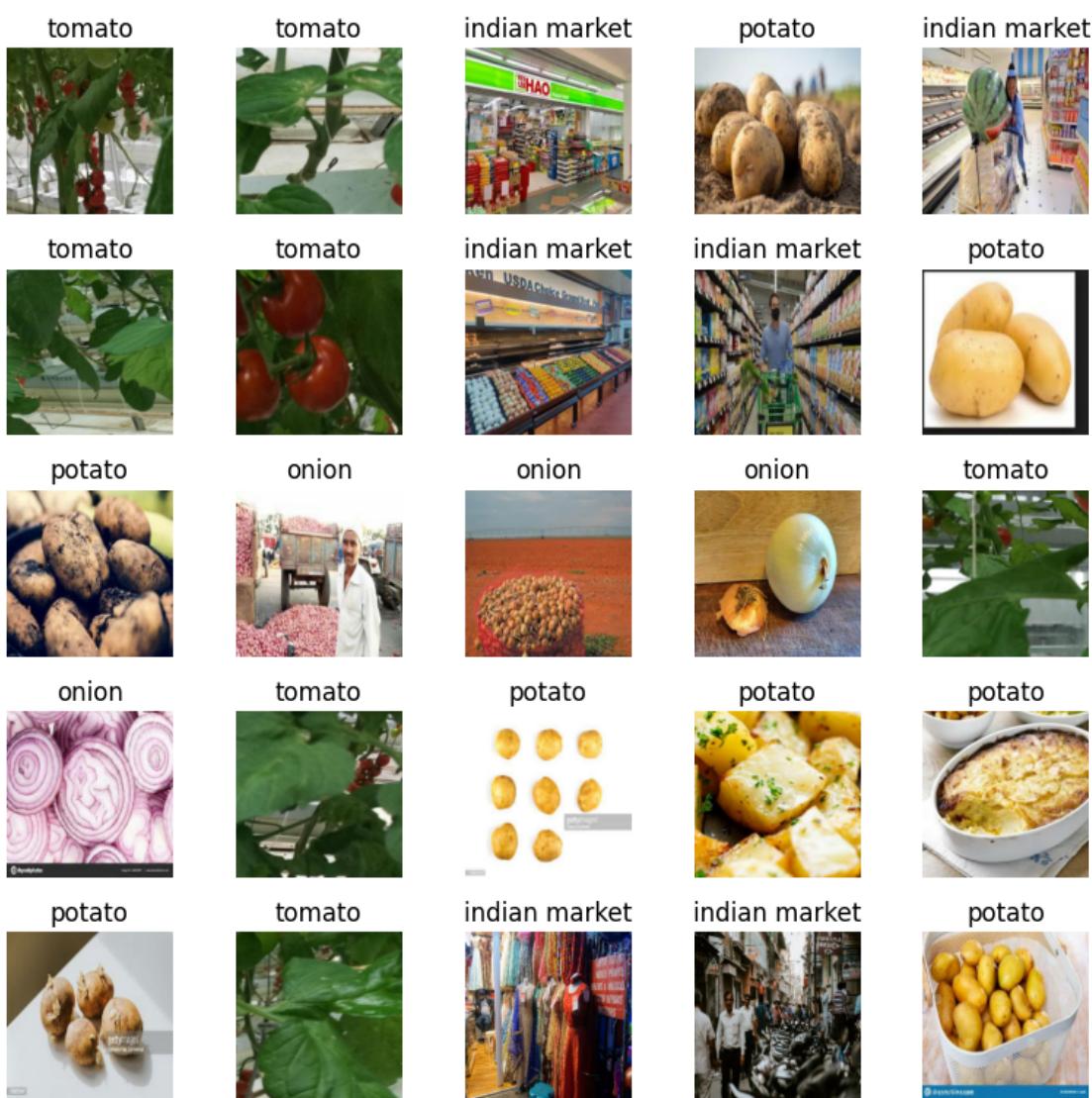
Class names_train: ['indian market', 'onion', 'potato', 'tomato']
class_names_test: ['indian market', 'onion', 'potato', 'tomato']

Plotting Data

[10]: *## Visualizing the data*

```
import matplotlib.pyplot as plt  
  
Images_per_batch = 25  
rows= 5  
columns = 5  
max_batcxhes = 3  
  
for batch_num, (images,labels) in enumerate(train_ds):  
    if batch_num > max_batcxhes:  
        break  
  
    plt.figure(figsize = (8,8))  
    for i in range(min(Images_per_batch, len(images))):  
        ax = plt.subplot(rows, columns, i+1)  
        plt.imshow(images[i].numpy().astype("uint8"))  
        plt.title(class_names_train[labels[i]])  
        plt.axis("off")  
  
    plt.suptitle(f'Batch({batch_num +1} ', fontsize = 10)  
    plt.tight_layout()  
    plt.show()
```

Batch(1)



Batch(2)

indian market



indian market



onion



indian market



potato



tomato



indian market



potato



tomato



potato



potato



potato



indian market



potato



tomato



tomato



onion



tomato



potato



indian market



indian market



potato



tomato



onion



potato



Batch(3)

indian market



tomato



onion



potato



potato



potato



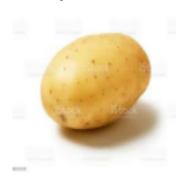
tomato



tomato



potato



onion



onion



potato



indian market



potato



potato



tomato



tomato



tomato



indian market



potato

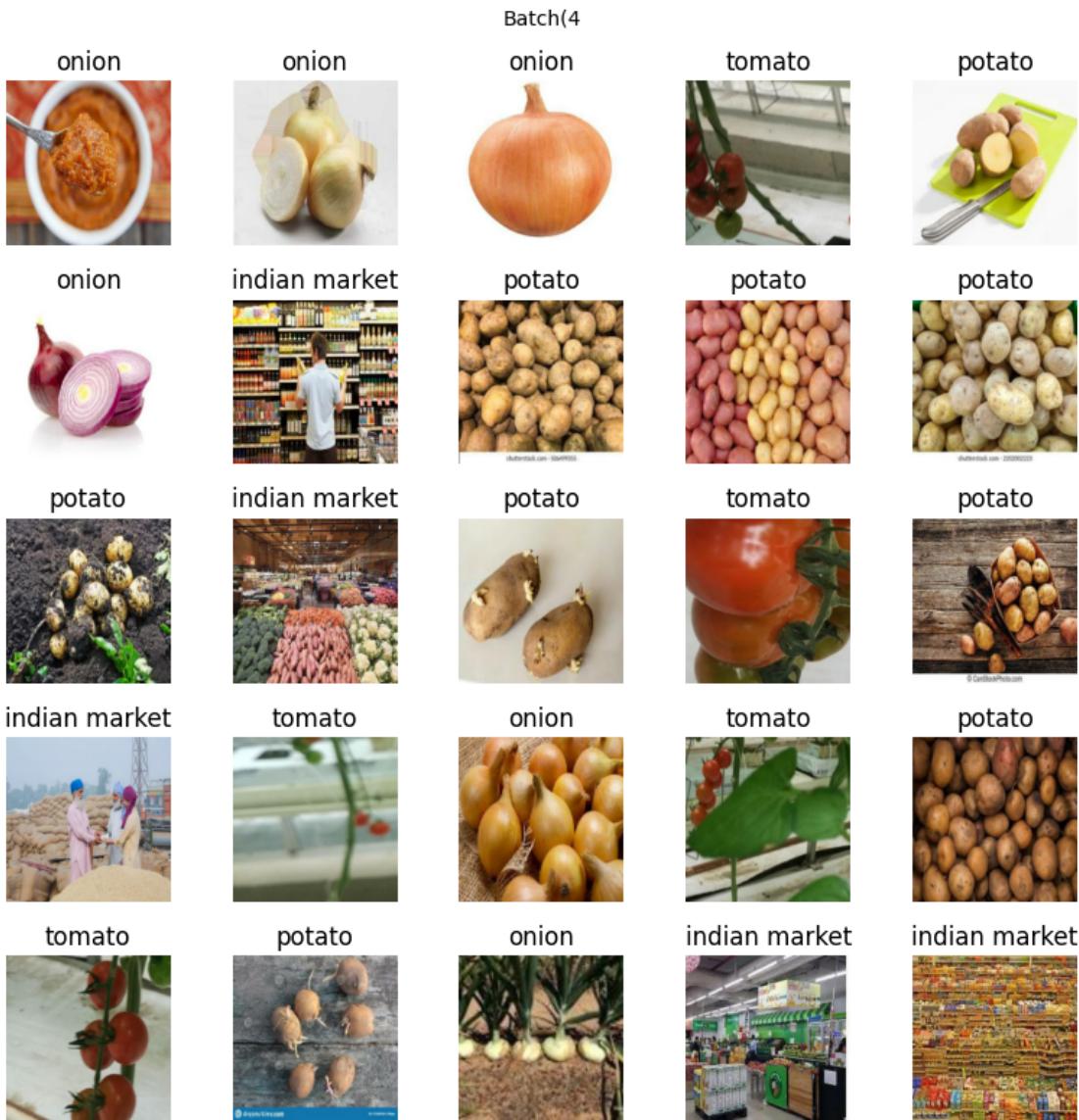


tomato



potato





```
[11]: ## Understanding the paths of the images in the data
```

```
import os

def list_sample_files(folder_path, max_files=10):
    print(f"\nSample files in {folder_path}:\n")
    count = 0
    for root, dirs, files in os.walk(folder_path):
        for file in files:
            print(f"{file} → in: {root}")
            count += 1
            if count >= max_files:
```

```

    return

list_sample_files('/content/ninjacart_data/train')
list_sample_files('/content/ninjacart_data/test')

```

Sample files in /content/ninjacart_data/train:

```

photo-1589470288084-ecad61835772.jpeg → in:
/content/ninjacart_data/train/indian market
village-market-827122_340.jpg → in: /content/ninjacart_data/train/indian
market
market11186.jpeg → in: /content/ninjacart_data/train/indian market
market11320.jpeg → in: /content/ninjacart_data/train/indian market
istockphoto-1213544046-612x612.jpg → in: /content/ninjacart_data/train/indian
market
market11111.jpeg → in: /content/ninjacart_data/train/indian market
market11335.jpeg → in: /content/ninjacart_data/train/indian market
market11302.jpeg → in: /content/ninjacart_data/train/indian market
photo-1639575668833-563e2b735e77.jpeg → in:
/content/ninjacart_data/train/indian market
market11137.jpeg → in: /content/ninjacart_data/train/indian market

```

Sample files in /content/ninjacart_data/test:

```

indianmarket58.jpeg → in: /content/ninjacart_data/test/indian market
indianmarket62.jpeg → in: /content/ninjacart_data/test/indian market
indianmarket38.jpeg → in: /content/ninjacart_data/test/indian market
indianmarket50.jpeg → in: /content/ninjacart_data/test/indian market
indianmarket57.jpeg → in: /content/ninjacart_data/test/indian market
indianmarket29.jpeg → in: /content/ninjacart_data/test/indian market
indianmarket20.jpeg → in: /content/ninjacart_data/test/indian market
indianmarket25.jpeg → in: /content/ninjacart_data/test/indian market
indianmarket47.jpeg → in: /content/ninjacart_data/test/indian market
indianmarket56.jpeg → in: /content/ninjacart_data/test/indian market

```

Its all in the png format

```
[12]: ## Creating a list containing all the image paths in the training folder

train_path = '/content/ninjacart_data/train'

train_image_paths = []
for root, dirs, files in os.walk(train_path):
    for file in files:
        image_path = os.path.join(root, file)
        train_image_paths.append(image_path)
```

```
print("Number of images in the training folder:", len(train_image_paths))
```

Number of images in the training folder: 3135

```
[13]: train_image_paths[:5]
```

```
[13]: ['/content/ninjacart_data/train/indian  
market/photo-1589470288084-ecad61835772.jpeg',  
'/content/ninjacart_data/train/indian market/village-market-827122_340.jpg',  
'/content/ninjacart_data/train/indian market/market11186.jpeg',  
'/content/ninjacart_data/train/indian market/market11320.jpeg',  
'/content/ninjacart_data/train/indian  
market/istockphoto-1213544046-612x612.jpg']
```

The images are now being created as a list

```
[14]: ## Checking for continuous/ Categorical Variables in the train data
```

```
class_names = train_ds.class_names  
print("class labels(categories):",class_names)  
print("no of classes:",len(class_names))
```

```
class labels(categories): ['indian market', 'onion', 'potato', 'tomato']  
no of classes: 4
```

There exists no continuous variables in the data, all we have is categorical.

```
[15]: df = datapath  
df
```

```
[15]: 'ninjacart_data'
```

```
[16]: ## Observing the shape of data,datatype,size of the individual image
```

```
for images,labels in train_ds.take(1):  
    print("shape of images:",images.shape)  
    print("datatype of images:",images.dtype)
```

```
shape of images: (32, 224, 224, 3)  
datatype of images: <dtype: 'float32'>
```

This confirms each image is 224*224 and has 3 channels(RGB) with batch shape as 32

```
[17]: ## Range of pixel values
```

```
for images,labels in train_ds.take(1):  
    print("min pixel value:",tf.reduce_min(images))  
    print("max pixel value:",tf.reduce_max(images))
```

```
min pixel value: tf.Tensor(0.0, shape=(), dtype=float32)
max pixel value: tf.Tensor(255.0, shape=(), dtype=float32)
```

The tensor is float type ranging pixel values from 0 to 255

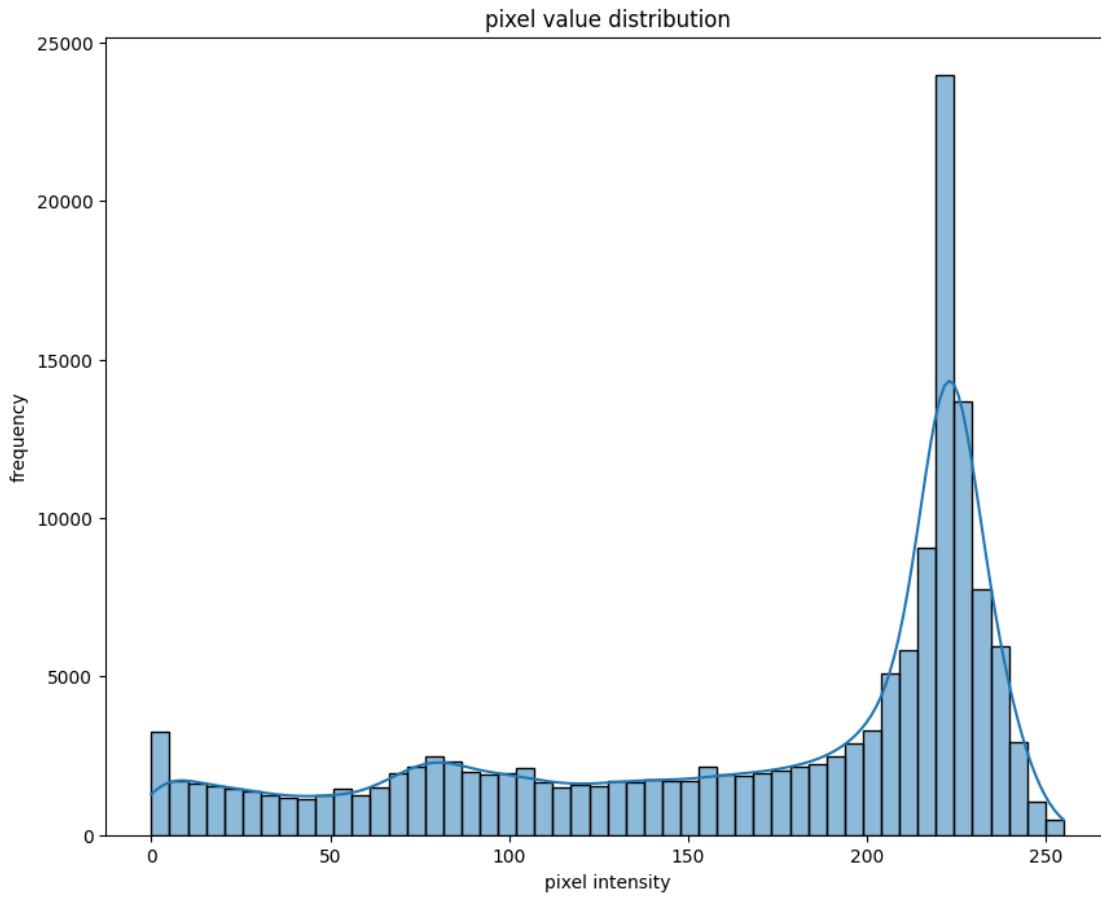
```
[18]: import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np

#Taking one image from batch

for images,labels in train_ds.take(1):
    img = images[0].numpy().astype('uint8')
    break

# Flattening the image arry and plotting pixel distribution

plt.figure(figsize=(10,8))
sns.histplot(img.ravel(),bins=50,kde=True)
plt.title('pixel value distribution')
plt.xlabel('pixel intensity')
plt.ylabel('frequency')
plt.show()
```



```
[19]: ## Plotting a few images of each class to check their dimensions

import os
import matplotlib.pyplot as plt
from PIL import Image

# Get only folders (class names)
class_names = [d for d in os.listdir(train_path) if os.path.isdir(os.path.
    ↪join(train_path, d))]

print(f" Found {len(class_names)} class folders: {class_names}")

for class_name in class_names:
    class_path = os.path.join(train_path, class_name)

    print(f"\n Class: {class_name}")

    # Get first 3 image files
```

```

image_filenames = [f for f in os.listdir(class_path) if f.lower() .
→endswith('.png', '.jpg', '.jpeg'))][:3]

if not image_filenames:
    print("  No image files found in this class folder!")
    continue

# Plot
plt.figure(figsize=(10, 4))
plt.suptitle(f"Class: {class_name}", fontsize=16)

for idx, image_name in enumerate(image_filenames):
    image_path = os.path.join(class_path, image_name)
    img = Image.open(image_path)

    plt.subplot(1, 3, idx + 1)
    plt.imshow(img)
    plt.axis('off')
    plt.title(f"Size: {img.size}")

    print(f"  Image {idx + 1}: {image_name}, Size: {img.size}")

plt.tight_layout()
plt.show()

```

Found 4 class folders: ['indian market', 'onion', 'potato', 'tomato']

Class: indian market

Image 1: photo-1589470288084-ecad61835772.jpeg, Size: (870, 580)
Image 2: village-market-827122_340.jpg, Size: (510, 340)
Image 3: market11186.jpeg, Size: (292, 173)

Class: indian market



Class: onion

Image 1: onion11085.jpeg, Size: (259, 194)
Image 2: W31035LB78BZ.jpg, Size: (387, 387)
Image 3: onion11061.jpeg, Size: (272, 185)



Class: potato
Image 1: potato11164 (2).jpeg, Size: (276, 183)
Image 2: potato11236 (1).jpeg, Size: (275, 183)
Image 3: potato11210.jpeg, Size: (312, 162)



Class: tomato
Image 1: tomato421.png, Size: (400, 500)
Image 2: tomato343.png, Size: (400, 500)
Image 3: tomato61.png, Size: (500, 400)



```
[20]: ## Verifying the count of images in train and test folder
```

```
def count_images_in_folders(data_path):
    class_counts = {}

    for class_name in os.listdir(data_path):
        class_path = os.path.join(data_path, class_name)

        if os.path.isdir(class_path):
            num_images = len([f for f in os.listdir(class_path) if f.lower().endswith('.png', '.jpg', '.jpeg')])
            class_counts[class_name] = num_images

    return class_counts

train_counts = count_images_in_folders(train_path)
test_counts = count_images_in_folders(test_path)

print("Train Image Count:", train_counts)
print("Test Image Count:", test_counts)
```

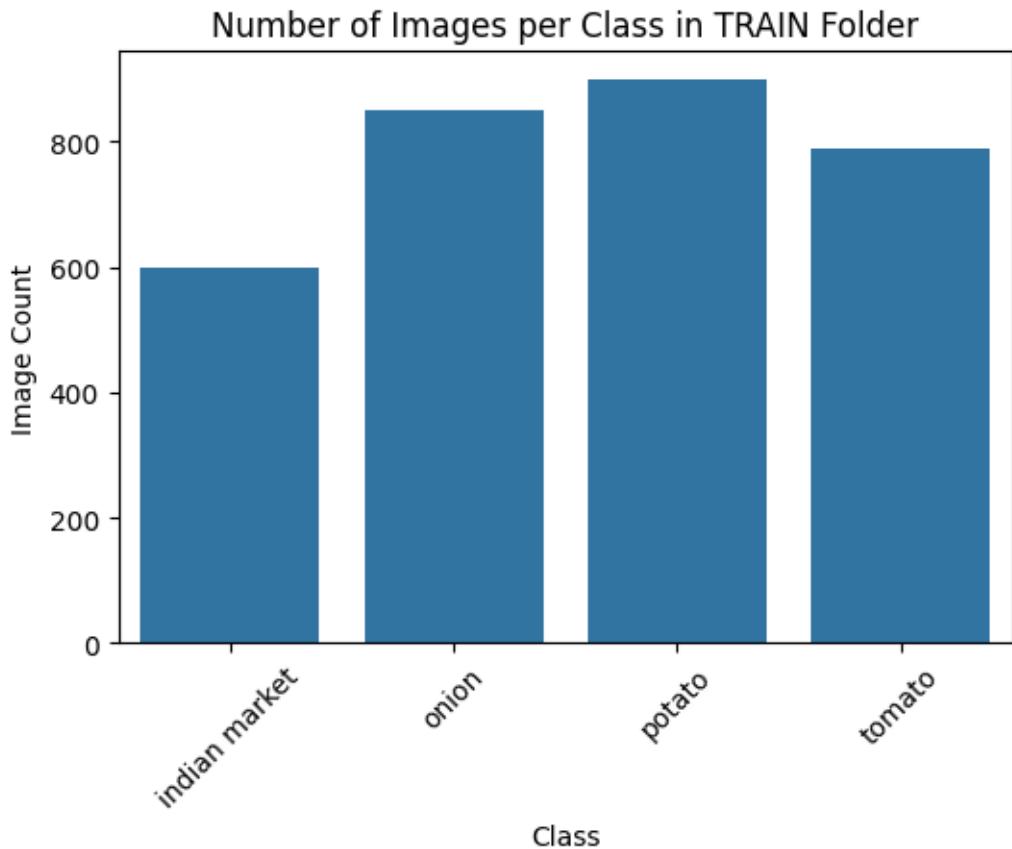
```
Train Image Count: {'indian market': 599, 'onion': 849, 'potato': 898, 'tomato': 789}
```

```
Test Image Count: {'indian market': 81, 'onion': 83, 'potato': 81, 'tomato': 106}
```

```
[21]: ## Visualizing the above Train data
```

```
plt.figure(figsize=(6,4))
sns.barplot(x=list(train_counts.keys()), y=list(train_counts.values()))
plt.title("Number of Images per Class in TRAIN Folder")
```

```
plt.xlabel("Class")
plt.ylabel("Image Count")
plt.xticks(rotation=45)
plt.show()
```



[22]: *## Visualizing the above Test data*

```
plt.figure(figsize=(6,4))
sns.barplot(x=list(test_counts.keys()), y=list(test_counts.values()))
plt.title("Number of Images per Class in TRAIN Folder")
plt.xlabel("Class")
plt.ylabel("Image Count")
plt.xticks(rotation=45)
plt.show()
```



```
[23]: ## Verifying each folder to see if the no of images matches the reported number
```

```
def get_actual_image_counts(folder_path):
    actual_counts = {}

    for class_name in os.listdir(folder_path):
        class_path = os.path.join(folder_path, class_name)

        if os.path.isdir(class_path):
            # Count only image files
            image_files = [f for f in os.listdir(class_path)
                           if f.lower().endswith('.png', '.jpg', '.jpeg')]
            actual_counts[class_name] = len(image_files)

    return actual_counts

reported_train_counts = train_counts
reported_test_counts = test_counts

actual_train_counts = get_actual_image_counts(train_path)
```

```

actual_test_counts = get_actual_image_counts(test_path)

## Comparing train counts

print("\n Verifying TRAIN Folder Image Counts:")
for class_name in actual_train_counts:
    reported = reported_train_counts.get(class_name, 0)
    actual = actual_train_counts[class_name]
    status = "Match" if reported == actual else f"Mismatch (Expected:{reported}, Found: {actual})"
    print(f"Class: {class_name}<15] | {status}")

## Comparing test counts

print("\n Verifying TEST Folder Image Counts:")
for class_name in actual_test_counts:
    reported = reported_test_counts.get(class_name, 0)
    actual = actual_test_counts[class_name]
    status = "Match" if reported == actual else f"Mismatch (Expected:{reported}, Found: {actual})"
    print(f"Class: {class_name}<15] | {status}")

```

Verifying TRAIN Folder Image Counts:

```

Class: indian market | Match
Class: onion          | Match
Class: potato         | Match
Class: tomato          | Match

```

Verifying TEST Folder Image Counts:

```

Class: indian market | Match
Class: onion          | Match
Class: potato         | Match
Class: tomato          | Match

```

The data matches perfectly.

Data Pre Processing

Irregular Size Treatment

[24]: ## Rescaling images to the range(0,1)

```

import tensorflow as tf

normalization_layer = tf.keras.layers.Rescaling(1./255)

train_ds = train_ds.map(lambda x, y: (normalization_layer(x), y))
test_ds = test_ds.map(lambda x, y: (normalization_layer(x), y))

```

```

## confirm the rescaling

for images, labels in train_ds.take(1):
    print("Min pixel value:", tf.reduce_min(images).numpy())
    print("Max pixel value:", tf.reduce_max(images).numpy())
    break

```

Min pixel value: 0.0
Max pixel value: 1.0

[25]: image_size = (224,224)

The images are already in a square dimension 224*224 and requires no resizing

Class Imbalance Treatment

[26]: test_counts

[26]: {'indian market': 81, 'onion': 83, 'potato': 81, 'tomato': 106}

[27]: train_counts

[27]: {'indian market': 599, 'onion': 849, 'potato': 898, 'tomato': 789}

[28]: ## Rotating the images to diff angles for class with less samples i.e., indian market with 599 images

```

def rotate_and_save_images_limited(class_path, num_rotations=3, limit=134):
    image_filenames = [f for f in os.listdir(class_path) if f.lower().endswith('.png', '.jpg', '.jpeg')]

    image_filenames = image_filenames[:limit] # Only first N images to augment

    for image_name in image_filenames:
        image_path = os.path.join(class_path, image_name)
        image = Image.open(image_path).convert("RGB")
        img_tensor = tf.convert_to_tensor(np.array(image), dtype=tf.uint8)

        for k in range(1, num_rotations + 1):
            rotated_img = tf.image.rot90(img_tensor, k=k)
            rotated_pil = Image.fromarray(rotated_img.numpy())

            new_image_name = f"{os.path.splitext(image_name)[0]}_rot{k}.png"
            rotated_pil.save(os.path.join(class_path, new_image_name))

            print(f" Rotated and saved {num_rotations} versions for {limit} images in {os.path.basename(class_path)}")

```

```

indian_market_path = '/content/ninjacart_data/train/indian market'

# Call the function to rotate only some
rotate_and_save_images_limited(indian_market_path, num_rotations=3, limit=134)

```

Rotated and saved 3 versions for 134 images in 'indian market'

```

[29]: # Path to the class folder
class_path = '/content/ninjacart_data/train/indian market'

# Listing all image files
image_files = sorted([f for f in os.listdir(class_path) if f.lower().
                     endswith('.png', '.jpg', '.jpeg')])

# Filtering out one base image and its rotated versions
sample_set = []
for f in image_files:
    if "_rot1" not in f and "_rot2" not in f and "_rot3" not in f:
        base_name = os.path.splitext(f)[0]
        rot1 = f"{base_name}_rot1.png"
        rot2 = f"{base_name}_rot2.png"
        rot3 = f"{base_name}_rot3.png"

        if rot1 in image_files and rot2 in image_files and rot3 in image_files:
            sample_set = [f, rot1, rot2, rot3]
            break # Just take one full set

# Plotting original + 3 rotated versions
plt.figure(figsize=(12, 4))
titles = ['Original', 'Rotated 90°', 'Rotated 180°', 'Rotated 270°']

for i, filename in enumerate(sample_set):
    image_path = os.path.join(class_path, filename)
    img = Image.open(image_path)

    plt.subplot(1, 4, i+1)
    plt.imshow(img)
    plt.axis('off')
    plt.title(titles[i])

plt.suptitle("Augmented Samples from 'indian market'", fontsize=16)
plt.tight_layout()
plt.show()

```



```
[30]: import tensorflow as tf

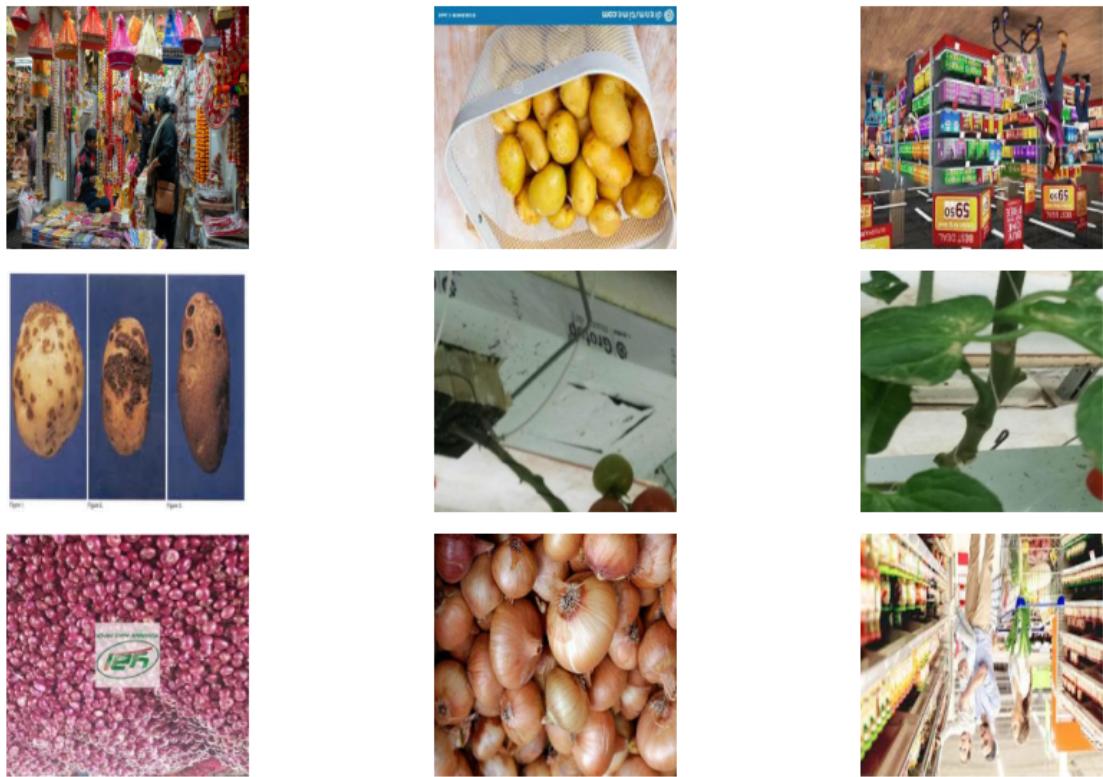
# Only applying flipping, no rescaling here
data_augmentation = tf.keras.Sequential([
    tf.keras.layers.RandomFlip("horizontal_and_vertical")
])

# Applying to already-rescaled dataset
train_ds_augmented = train_ds.map(lambda x, y: (data_augmentation(x, training=True), y))
```

```
[31]: import matplotlib.pyplot as plt

for images, labels in train_ds_augmented.take(1):
    plt.figure(figsize=(10, 6))
    for i in range(9):
        ax = plt.subplot(3, 3, i + 1)
        plt.imshow(images[i].numpy())
        plt.axis("off")
    plt.suptitle("Randomly Flipped Images", fontsize=14)
    plt.tight_layout()
    plt.show()
    break
```

Randomly Flipped Images



Model Building

Splitting the data into 80% of Training and 20% of testing

```
[32]: from sklearn.model_selection import train_test_split
import pandas as pd

train_dir = '/content/ninjacart_data/train'

train_ds = tf.keras.preprocessing.image_dataset_from_directory(
    train_dir,
    validation_split=0.2,
    subset="training",
    seed=42,
    image_size=(224,224),
    batch_size= 32
)
```

Found 3537 files belonging to 4 classes.
Using 2830 files for training.

```
[33]: val_ds = tf.keras.preprocessing.image_dataset_from_directory(
    train_dir,
    validation_split=0.2,
    subset="validation",
    seed=42,
    image_size=(224,224),
    batch_size= 32
)
```

Found 3537 files belonging to 4 classes.

Using 707 files for validation.

Building CNN from scratch

```
[34]: import tensorflow as tf
from tensorflow.keras import layers, models

model = models.Sequential([
    # Layer 1: Convolutional Layer
    layers.Conv2D(32, (3, 3), activation='relu', input_shape=(224, 224, 3)),
    layers.MaxPooling2D((2, 2)),

    # Layer 2: More Filters
    layers.Conv2D(64, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),

    # Layer 3: Even More Filters
    layers.Conv2D(128, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),

    # Flatten output to 1D
    layers.Flatten(),

    # Fully connected (Dense) layer
    layers.Dense(128, activation='relu'),
    layers.Dropout(0.3), # Reduces overfitting

    # Output layer
    layers.Dense(4, activation='softmax') # Because dataset have 4 classes
])
```

```
/usr/local/lib/python3.11/dist-
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)
```

```
[35]: ## Compiling the model
```

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

```
[36]: model.summary()
```

Model: "sequential_1"

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 222, 222, 32)	896
max_pooling2d (MaxPooling2D)	(None, 111, 111, 32)	0
conv2d_1 (Conv2D)	(None, 109, 109, 64)	18,496
max_pooling2d_1 (MaxPooling2D)	(None, 54, 54, 64)	0
conv2d_2 (Conv2D)	(None, 52, 52, 128)	73,856
max_pooling2d_2 (MaxPooling2D)	(None, 26, 26, 128)	0
flatten (Flatten)	(None, 86528)	0
dense (Dense)	(None, 128)	11,075,712
dropout (Dropout)	(None, 128)	0
dense_1 (Dense)	(None, 4)	516

Total params: 11,169,476 (42.61 MB)

Trainable params: 11,169,476 (42.61 MB)

Non-trainable params: 0 (0.00 B)

```
[37]: ## training the model
```

```

history = model.fit(
    train_ds,                      # training dataset
    validation_data=val_ds,         # 20% validation dataset
    epochs=10                       # Number of passes through the data
)

```

```

Epoch 1/10
89/89      24s 188ms/step -
accuracy: 0.3689 - loss: 107.8577 - val_accuracy: 0.2588 - val_loss: 1.3615
Epoch 2/10
89/89      11s 122ms/step -
accuracy: 0.3362 - loss: 1.3214 - val_accuracy: 0.3479 - val_loss: 1.3531
Epoch 3/10
89/89      19s 110ms/step -
accuracy: 0.4624 - loss: 1.1934 - val_accuracy: 0.3635 - val_loss: 1.4720
Epoch 4/10
89/89      11s 118ms/step -
accuracy: 0.5120 - loss: 1.2443 - val_accuracy: 0.3663 - val_loss: 1.3121
Epoch 5/10
89/89      10s 117ms/step -
accuracy: 0.5235 - loss: 1.1078 - val_accuracy: 0.4455 - val_loss: 1.3447
Epoch 6/10
89/89      20s 116ms/step -
accuracy: 0.6391 - loss: 0.8988 - val_accuracy: 0.4653 - val_loss: 1.4021
Epoch 7/10
89/89      21s 118ms/step -
accuracy: 0.6650 - loss: 0.8602 - val_accuracy: 0.4752 - val_loss: 1.4597
Epoch 8/10
89/89      20s 113ms/step -
accuracy: 0.6950 - loss: 0.7773 - val_accuracy: 0.4809 - val_loss: 1.6461
Epoch 9/10
89/89      11s 122ms/step -
accuracy: 0.7398 - loss: 0.7346 - val_accuracy: 0.5064 - val_loss: 1.7756
Epoch 10/10
89/89      20s 117ms/step -
accuracy: 0.7905 - loss: 0.5329 - val_accuracy: 0.5134 - val_loss: 2.0477

```

Training accuracy kept decreasing but the validation accuracy keeps increasing showing that the model is overfitting.

[38]: *## generalizing the model better by data augmenting again*

```

data_augmentation = tf.keras.Sequential([
    tf.keras.layers.RandomFlip("horizontal"),
    tf.keras.layers.RandomRotation(0.2),
    tf.keras.layers.RandomZoom(0.2),
])

```

```
##applying it for the model
```

```
train_ds_augmented = train_ds.map(lambda x, y: (data_augmentation(x, ↴  
↳=True), y))  
train_ds_augmented
```

[38]: <_MapDataset element_spec=(TensorSpec(shape=(None, 224, 224, 3),
dtype=tf.float32, name=None), TensorSpec(shape=(None,), dtype=tf.int32,
name=None))>

[39]: ## Adding early stopping

```
from tensorflow.keras.callbacks import EarlyStopping  
  
early_stop = EarlyStopping(monitor='val_loss', patience=3, restore_best_weights= True)  
  
model.fit(train_ds, validation_data=val_ds, epochs=10, callbacks=[early_stop])
```

```
Epoch 1/10  
89/89          13s 142ms/step -  
accuracy: 0.8320 - loss: 0.4421 - val_accuracy: 0.4851 - val_loss: 2.8173  
Epoch 2/10  
89/89          10s 116ms/step -  
accuracy: 0.8289 - loss: 0.4431 - val_accuracy: 0.5389 - val_loss: 2.4506  
Epoch 3/10  
89/89          26s 175ms/step -  
accuracy: 0.8024 - loss: 0.5288 - val_accuracy: 0.5092 - val_loss: 2.4155  
Epoch 4/10  
89/89          15s 117ms/step -  
accuracy: 0.8523 - loss: 0.3930 - val_accuracy: 0.5728 - val_loss: 3.2479  
Epoch 5/10  
89/89          20s 114ms/step -  
accuracy: 0.8465 - loss: 0.4983 - val_accuracy: 0.5290 - val_loss: 2.4407  
Epoch 6/10  
89/89          10s 113ms/step -  
accuracy: 0.8718 - loss: 0.3860 - val_accuracy: 0.5799 - val_loss: 2.0474  
Epoch 7/10  
89/89          12s 131ms/step -  
accuracy: 0.8700 - loss: 0.3932 - val_accuracy: 0.5573 - val_loss: 2.0840  
Epoch 8/10  
89/89          19s 117ms/step -  
accuracy: 0.8517 - loss: 0.4988 - val_accuracy: 0.5870 - val_loss: 2.6281  
Epoch 9/10  
89/89          10s 117ms/step -  
accuracy: 0.8956 - loss: 0.2985 - val_accuracy: 0.6040 - val_loss: 2.6237
```

```
[39]: <keras.src.callbacks.history.History at 0x7c5e501ee550>
```

The validation loss is still increasing and the model is still overfitting.

```
[40]: for images,labels in train_ds.take(1):
    print(labels.numpy())
```

```
[1 2 0 0 2 1 0 2 0 3 3 3 1 1 1 0 0 0 0 0 3 0 2 2 2 2 0 1 2 0 3]
```

Dataset is already in integer labels, tensorflow will be handling this efficiently. So using sparse categorical crossentropy.

```
[41]: ##Checking its SCE
```

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

```
[42]: # # using transfer learning concept and applying resnet by training it with
      ↵appropriate batch size
```

```
import tensorflow as tf
from tensorflow.keras import layers, models
from tensorflow.keras.applications import ResNet50
from tensorflow.keras.applications.resnet50 import preprocess_input

image_size = (224,224)
batch_size = 32
class_numbers = 4

## pre processing the data for rssnet

AUTOTUNE = tf.data.AUTOTUNE

def preprocess(image,label):
    image = preprocess(image)
    return image,label

train_ds = train_ds.map(preprocess, num_parallel_calls = AUTOTUNE)
val_ds = val_ds.map(preprocess, num_parallel_calls = AUTOTUNE)

train_ds = train_ds.batch(batch_size).prefetch(AUTOTUNE)
val_ds = val_ds.batch(batch_size).prefetch(AUTOTUNE)
```

```
[43]: ## Loading pre trained Resnet 50 and freezing it
```

```
base_model = ResNet50(weights = 'imagenet', input_shape = (224,224,3), ↵
                      include_top = False)
```

```
base_model.trainable = False
```

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

```
[44]: base_model.summary()
```

Model: "resnet50"

Layer (type)	Output Shape	Param #	Connected to
input_layer_3 (InputLayer)	(None, 224, 224, 3)	0	-
conv1_pad (ZeroPadding2D)	(None, 230, 230, 3)	0	input_layer_3[0]...
conv1_conv (Conv2D)	(None, 112, 112, 64)	9,472	conv1_pad[0] [0]
conv1_bn (BatchNormalization)	(None, 112, 112, 64)	256	conv1_conv[0] [0]
conv1_relu (Activation)	(None, 112, 112, 64)	0	conv1_bn[0] [0]
pool1_pad (ZeroPadding2D)	(None, 114, 114, 64)	0	conv1_relu[0] [0]
pool1_pool (MaxPooling2D)	(None, 56, 56, 64)	0	pool1_pad[0] [0]
conv2_block1_1_conv (Conv2D)	(None, 56, 56, 64)	4,160	pool1_pool[0] [0]
conv2_block1_1_bn (BatchNormalization)	(None, 56, 56, 64)	256	conv2_block1_1_c...
conv2_block1_1_relu (Activation)	(None, 56, 56, 64)	0	conv2_block1_1_b...
conv2_block1_2_conv (Conv2D)	(None, 56, 56, 64)	36,928	conv2_block1_1_r...

conv2_block1_2_bn (BatchNormalizatio...)	(None, 56, 56, 64)	256	conv2_block1_2_c...
conv2_block1_2_relu (Activation)	(None, 56, 56, 64)	0	conv2_block1_2_b...
conv2_block1_0_conv (Conv2D)	(None, 56, 56, 256)	16,640	pool1_pool[0] [0]
conv2_block1_3_conv (Conv2D)	(None, 56, 56, 256)	16,640	conv2_block1_2_r...
conv2_block1_0_bn (BatchNormalizatio...)	(None, 56, 56, 256)	1,024	conv2_block1_0_c...
conv2_block1_3_bn (BatchNormalizatio...)	(None, 56, 56, 256)	1,024	conv2_block1_3_c...
conv2_block1_add (Add)	(None, 56, 56, 256)	0	conv2_block1_0_b... conv2_block1_3_b...
conv2_block1_out (Activation)	(None, 56, 56, 256)	0	conv2_block1_add...
conv2_block2_1_conv (Conv2D)	(None, 56, 56, 64)	16,448	conv2_block1_out...
conv2_block2_1_bn (BatchNormalizatio...)	(None, 56, 56, 64)	256	conv2_block2_1_c...
conv2_block2_1_relu (Activation)	(None, 56, 56, 64)	0	conv2_block2_1_b...
conv2_block2_2_conv (Conv2D)	(None, 56, 56, 64)	36,928	conv2_block2_1_r...
conv2_block2_2_bn (BatchNormalizatio...)	(None, 56, 56, 64)	256	conv2_block2_2_c...
conv2_block2_2_relu (Activation)	(None, 56, 56, 64)	0	conv2_block2_2_b...
conv2_block2_3_conv (Conv2D)	(None, 56, 56, 256)	16,640	conv2_block2_2_r...
conv2_block2_3_bn (BatchNormalizatio...)	(None, 56, 56, 256)	1,024	conv2_block2_3_c...

conv2_block2_add (Add)	(None, 56, 56, 256)	0	conv2_block1_out... conv2_block2_3_b...
conv2_block2_out (Activation)	(None, 56, 56, 256)	0	conv2_block2_add...
conv2_block3_1_conv (Conv2D)	(None, 56, 56, 64)	16,448	conv2_block2_out...
conv2_block3_1_bn (BatchNormalizatio...)	(None, 56, 56, 64)	256	conv2_block3_1_c...
conv2_block3_1_relu (Activation)	(None, 56, 56, 64)	0	conv2_block3_1_b...
conv2_block3_2_conv (Conv2D)	(None, 56, 56, 64)	36,928	conv2_block3_1_r...
conv2_block3_2_bn (BatchNormalizatio...)	(None, 56, 56, 64)	256	conv2_block3_2_c...
conv2_block3_2_relu (Activation)	(None, 56, 56, 64)	0	conv2_block3_2_b...
conv2_block3_3_conv (Conv2D)	(None, 56, 56, 256)	16,640	conv2_block3_2_r...
conv2_block3_3_bn (BatchNormalizatio...)	(None, 56, 56, 256)	1,024	conv2_block3_3_c...
conv2_block3_add (Add)	(None, 56, 56, 256)	0	conv2_block2_out... conv2_block3_3_b...
conv2_block3_out (Activation)	(None, 56, 56, 256)	0	conv2_block3_add...
conv3_block1_1_conv (Conv2D)	(None, 28, 28, 128)	32,896	conv2_block3_out...
conv3_block1_1_bn (BatchNormalizatio...)	(None, 28, 28, 128)	512	conv3_block1_1_c...
conv3_block1_1_relu (Activation)	(None, 28, 28, 128)	0	conv3_block1_1_b...
conv3_block1_2_conv (Conv2D)	(None, 28, 28, 128)	147,584	conv3_block1_1_r...

conv3_block1_2_bn (BatchNormalizatio...)	(None, 28, 28, 128)	512	conv3_block1_2_c...
conv3_block1_2_relu (Activation)	(None, 28, 28, 128)	0	conv3_block1_2_b...
conv3_block1_0_conv (Conv2D)	(None, 28, 28, 512)	131,584	conv2_block3_out...
conv3_block1_3_conv (Conv2D)	(None, 28, 28, 512)	66,048	conv3_block1_2_r...
conv3_block1_0_bn (BatchNormalizatio...)	(None, 28, 28, 512)	2,048	conv3_block1_0_c...
conv3_block1_3_bn (BatchNormalizatio...)	(None, 28, 28, 512)	2,048	conv3_block1_3_c...
conv3_block1_add (Add)	(None, 28, 28, 512)	0	conv3_block1_0_b... conv3_block1_3_b...
conv3_block1_out (Activation)	(None, 28, 28, 512)	0	conv3_block1_add...
conv3_block2_1_conv (Conv2D)	(None, 28, 28, 128)	65,664	conv3_block1_out...
conv3_block2_1_bn (BatchNormalizatio...)	(None, 28, 28, 128)	512	conv3_block2_1_c...
conv3_block2_1_relu (Activation)	(None, 28, 28, 128)	0	conv3_block2_1_b...
conv3_block2_2_conv (Conv2D)	(None, 28, 28, 128)	147,584	conv3_block2_1_r...
conv3_block2_2_bn (BatchNormalizatio...)	(None, 28, 28, 128)	512	conv3_block2_2_c...
conv3_block2_2_relu (Activation)	(None, 28, 28, 128)	0	conv3_block2_2_b...
conv3_block2_3_conv (Conv2D)	(None, 28, 28, 512)	66,048	conv3_block2_2_r...
conv3_block2_3_bn (BatchNormalizatio...)	(None, 28, 28, 512)	2,048	conv3_block2_3_c...

conv3_block2_add (Add)	(None, 28, 28, 512)	0	conv3_block1_out... conv3_block2_3_b...
conv3_block2_out (Activation)	(None, 28, 28, 512)	0	conv3_block2_add...
conv3_block3_1_conv (Conv2D)	(None, 28, 28, 128)	65,664	conv3_block2_out... conv3_block3_1_c...
conv3_block3_1_bn (BatchNormalizatio...)	(None, 28, 28, 128)	512	conv3_block3_1_c...
conv3_block3_1_relu (Activation)	(None, 28, 28, 128)	0	conv3_block3_1_b...
conv3_block3_2_conv (Conv2D)	(None, 28, 28, 128)	147,584	conv3_block3_1_r... conv3_block3_2_c...
conv3_block3_2_bn (BatchNormalizatio...)	(None, 28, 28, 128)	512	conv3_block3_2_c...
conv3_block3_2_relu (Activation)	(None, 28, 28, 128)	0	conv3_block3_2_b...
conv3_block3_3_conv (Conv2D)	(None, 28, 28, 512)	66,048	conv3_block3_2_r... conv3_block3_3_c...
conv3_block3_3_bn (BatchNormalizatio...)	(None, 28, 28, 512)	2,048	conv3_block3_3_c...
conv3_block3_add (Add)	(None, 28, 28, 512)	0	conv3_block2_out... conv3_block3_3_b...
conv3_block3_out (Activation)	(None, 28, 28, 512)	0	conv3_block3_add...
conv3_block4_1_conv (Conv2D)	(None, 28, 28, 128)	65,664	conv3_block3_out... conv3_block4_1_c...
conv3_block4_1_bn (BatchNormalizatio...)	(None, 28, 28, 128)	512	conv3_block4_1_c...
conv3_block4_1_relu (Activation)	(None, 28, 28, 128)	0	conv3_block4_1_b...
conv3_block4_2_conv (Conv2D)	(None, 28, 28, 128)	147,584	conv3_block4_1_r...

conv3_block4_2_bn (BatchNormalizatio...)	(None, 28, 28, 128)	512	conv3_block4_2_c...
conv3_block4_2_relu (Activation)	(None, 28, 28, 128)	0	conv3_block4_2_b...
conv3_block4_3_conv (Conv2D)	(None, 28, 28, 512)	66,048	conv3_block4_2_r...
conv3_block4_3_bn (BatchNormalizatio...)	(None, 28, 28, 512)	2,048	conv3_block4_3_c...
conv3_block4_add (Add)	(None, 28, 28, 512)	0	conv3_block3_out... conv3_block4_3_b...
conv3_block4_out (Activation)	(None, 28, 28, 512)	0	conv3_block4_add...
conv4_block1_1_conv (Conv2D)	(None, 14, 14, 256)	131,328	conv3_block4_out...
conv4_block1_1_bn (BatchNormalizatio...)	(None, 14, 14, 256)	1,024	conv4_block1_1_c...
conv4_block1_1_relu (Activation)	(None, 14, 14, 256)	0	conv4_block1_1_b...
conv4_block1_2_conv (Conv2D)	(None, 14, 14, 256)	590,080	conv4_block1_1_r...
conv4_block1_2_bn (BatchNormalizatio...)	(None, 14, 14, 256)	1,024	conv4_block1_2_c...
conv4_block1_2_relu (Activation)	(None, 14, 14, 256)	0	conv4_block1_2_b...
conv4_block1_0_conv (Conv2D)	(None, 14, 14, 1024)	525,312	conv3_block4_out...
conv4_block1_3_conv (Conv2D)	(None, 14, 14, 1024)	263,168	conv4_block1_2_r...
conv4_block1_0_bn (BatchNormalizatio...)	(None, 14, 14, 1024)	4,096	conv4_block1_0_c...
conv4_block1_3_bn (BatchNormalizatio...)	(None, 14, 14, 1024)	4,096	conv4_block1_3_c...

conv4_block1_add (Add)	(None, 14, 14, 1024)	0	conv4_block1_0_b... conv4_block1_3_b...
conv4_block1_out (Activation)	(None, 14, 14, 1024)	0	conv4_block1_add...
conv4_block2_1_conv (Conv2D)	(None, 14, 14, 256)	262,400	conv4_block1_out...
conv4_block2_1_bn (BatchNormalizatio...)	(None, 14, 14, 256)	1,024	conv4_block2_1_c...
conv4_block2_1_relu (Activation)	(None, 14, 14, 256)	0	conv4_block2_1_b...
conv4_block2_2_conv (Conv2D)	(None, 14, 14, 256)	590,080	conv4_block2_1_r...
conv4_block2_2_bn (BatchNormalizatio...)	(None, 14, 14, 256)	1,024	conv4_block2_2_c...
conv4_block2_2_relu (Activation)	(None, 14, 14, 256)	0	conv4_block2_2_b...
conv4_block2_3_conv (Conv2D)	(None, 14, 14, 1024)	263,168	conv4_block2_2_r...
conv4_block2_3_bn (BatchNormalizatio...)	(None, 14, 14, 1024)	4,096	conv4_block2_3_c...
conv4_block2_add (Add)	(None, 14, 14, 1024)	0	conv4_block1_out... conv4_block2_3_b...
conv4_block2_out (Activation)	(None, 14, 14, 1024)	0	conv4_block2_add...
conv4_block3_1_conv (Conv2D)	(None, 14, 14, 256)	262,400	conv4_block2_out...
conv4_block3_1_bn (BatchNormalizatio...)	(None, 14, 14, 256)	1,024	conv4_block3_1_c...
conv4_block3_1_relu (Activation)	(None, 14, 14, 256)	0	conv4_block3_1_b...
conv4_block3_2_conv (Conv2D)	(None, 14, 14, 256)	590,080	conv4_block3_1_r...

conv4_block3_2_bn (BatchNormalizatio...)	(None, 14, 14, 256)	1,024	conv4_block3_2_c...
conv4_block3_2_relu (Activation)	(None, 14, 14, 256)	0	conv4_block3_2_b...
conv4_block3_3_conv (Conv2D)	(None, 14, 14, 1024)	263,168	conv4_block3_2_r...
conv4_block3_3_bn (BatchNormalizatio...)	(None, 14, 14, 1024)	4,096	conv4_block3_3_c...
conv4_block3_add (Add)	(None, 14, 14, 1024)	0	conv4_block2_out... conv4_block3_3_b...
conv4_block3_out (Activation)	(None, 14, 14, 1024)	0	conv4_block3_add...
conv4_block4_1_conv (Conv2D)	(None, 14, 14, 256)	262,400	conv4_block3_out...
conv4_block4_1_bn (BatchNormalizatio...)	(None, 14, 14, 256)	1,024	conv4_block4_1_c...
conv4_block4_1_relu (Activation)	(None, 14, 14, 256)	0	conv4_block4_1_b...
conv4_block4_2_conv (Conv2D)	(None, 14, 14, 256)	590,080	conv4_block4_1_r...
conv4_block4_2_bn (BatchNormalizatio...)	(None, 14, 14, 256)	1,024	conv4_block4_2_c...
conv4_block4_2_relu (Activation)	(None, 14, 14, 256)	0	conv4_block4_2_b...
conv4_block4_3_conv (Conv2D)	(None, 14, 14, 1024)	263,168	conv4_block4_2_r...
conv4_block4_3_bn (BatchNormalizatio...)	(None, 14, 14, 1024)	4,096	conv4_block4_3_c...
conv4_block4_add (Add)	(None, 14, 14, 1024)	0	conv4_block3_out... conv4_block4_3_b...
conv4_block4_out (Activation)	(None, 14, 14, 1024)	0	conv4_block4_add...

conv4_block5_1_conv (Conv2D)	(None, 14, 14, 256)	262,400	conv4_block4_out...
conv4_block5_1_bn (BatchNormalizatio...)	(None, 14, 14, 256)	1,024	conv4_block5_1_c...
conv4_block5_1_relu (Activation)	(None, 14, 14, 256)	0	conv4_block5_1_b...
conv4_block5_2_conv (Conv2D)	(None, 14, 14, 256)	590,080	conv4_block5_1_r...
conv4_block5_2_bn (BatchNormalizatio...)	(None, 14, 14, 256)	1,024	conv4_block5_2_c...
conv4_block5_2_relu (Activation)	(None, 14, 14, 256)	0	conv4_block5_2_b...
conv4_block5_3_conv (Conv2D)	(None, 14, 14, 1024)	263,168	conv4_block5_2_r...
conv4_block5_3_bn (BatchNormalizatio...)	(None, 14, 14, 1024)	4,096	conv4_block5_3_c...
conv4_block5_add (Add)	(None, 14, 14, 1024)	0	conv4_block4_out... conv4_block5_3_b...
conv4_block5_out (Activation)	(None, 14, 14, 1024)	0	conv4_block5_add...
conv4_block6_1_conv (Conv2D)	(None, 14, 14, 256)	262,400	conv4_block5_out...
conv4_block6_1_bn (BatchNormalizatio...)	(None, 14, 14, 256)	1,024	conv4_block6_1_c...
conv4_block6_1_relu (Activation)	(None, 14, 14, 256)	0	conv4_block6_1_b...
conv4_block6_2_conv (Conv2D)	(None, 14, 14, 256)	590,080	conv4_block6_1_r...
conv4_block6_2_bn (BatchNormalizatio...)	(None, 14, 14, 256)	1,024	conv4_block6_2_c...
conv4_block6_2_relu (Activation)	(None, 14, 14, 256)	0	conv4_block6_2_b...

conv4_block6_3_conv (Conv2D)	(None, 14, 14, 1024)	263,168	conv4_block6_2_r...
conv4_block6_3_bn (BatchNormalizatio...)	(None, 14, 14, 1024)	4,096	conv4_block6_3_c...
conv4_block6_add (Add)	(None, 14, 14, 1024)	0	conv4_block5_out... conv4_block6_3_b...
conv4_block6_out (Activation)	(None, 14, 14, 1024)	0	conv4_block6_add...
conv5_block1_1_conv (Conv2D)	(None, 7, 7, 512)	524,800	conv4_block6_out...
conv5_block1_1_bn (BatchNormalizatio...)	(None, 7, 7, 512)	2,048	conv5_block1_1_c...
conv5_block1_1_relu (Activation)	(None, 7, 7, 512)	0	conv5_block1_1_b...
conv5_block1_2_conv (Conv2D)	(None, 7, 7, 512)	2,359,808	conv5_block1_1_r...
conv5_block1_2_bn (BatchNormalizatio...)	(None, 7, 7, 512)	2,048	conv5_block1_2_c...
conv5_block1_2_relu (Activation)	(None, 7, 7, 512)	0	conv5_block1_2_b...
conv5_block1_0_conv (Conv2D)	(None, 7, 7, 2048)	2,099,200	conv4_block6_out...
conv5_block1_3_conv (Conv2D)	(None, 7, 7, 2048)	1,050,624	conv5_block1_2_r...
conv5_block1_0_bn (BatchNormalizatio...)	(None, 7, 7, 2048)	8,192	conv5_block1_0_c...
conv5_block1_3_bn (BatchNormalizatio...)	(None, 7, 7, 2048)	8,192	conv5_block1_3_c...
conv5_block1_add (Add)	(None, 7, 7, 2048)	0	conv5_block1_0_b... conv5_block1_3_b...
conv5_block1_out (Activation)	(None, 7, 7, 2048)	0	conv5_block1_add...

conv5_block2_1_conv	(None, 7, 7, 512)	1,049,088	conv5_block1_out...
(Conv2D)			
conv5_block2_1_bn	(None, 7, 7, 512)	2,048	conv5_block2_1_c...
(BatchNormalizatio...			
conv5_block2_1_relu	(None, 7, 7, 512)	0	conv5_block2_1_b...
(Activation)			
conv5_block2_2_conv	(None, 7, 7, 512)	2,359,808	conv5_block2_1_r...
(Conv2D)			
conv5_block2_2_bn	(None, 7, 7, 512)	2,048	conv5_block2_2_c...
(BatchNormalizatio...			
conv5_block2_2_relu	(None, 7, 7, 512)	0	conv5_block2_2_b...
(Activation)			
conv5_block2_3_conv	(None, 7, 7, 2048)	1,050,624	conv5_block2_2_r...
(Conv2D)			
conv5_block2_3_bn	(None, 7, 7, 2048)	8,192	conv5_block2_3_c...
(BatchNormalizatio...			
conv5_block2_add	(None, 7, 7, 2048)	0	conv5_block1_out...
(Add)			conv5_block2_3_b...
conv5_block2_out	(None, 7, 7, 2048)	0	conv5_block2_add...
(Activation)			
conv5_block3_1_conv	(None, 7, 7, 512)	1,049,088	conv5_block2_out...
(Conv2D)			
conv5_block3_1_bn	(None, 7, 7, 512)	2,048	conv5_block3_1_c...
(BatchNormalizatio...			
conv5_block3_1_relu	(None, 7, 7, 512)	0	conv5_block3_1_b...
(Activation)			
conv5_block3_2_conv	(None, 7, 7, 512)	2,359,808	conv5_block3_1_r...
(Conv2D)			
conv5_block3_2_bn	(None, 7, 7, 512)	2,048	conv5_block3_2_c...
(BatchNormalizatio...			
conv5_block3_2_relu	(None, 7, 7, 512)	0	conv5_block3_2_b...
(Activation)			

conv5_block3_3_conv (Conv2D)	(None, 7, 7, 2048)	1,050,624	conv5_block3_2_r...
conv5_block3_3_bn (BatchNormalizatio...)	(None, 7, 7, 2048)	8,192	conv5_block3_3_c...
conv5_block3_add (Add)	(None, 7, 7, 2048)	0	conv5_block2_out... conv5_block3_3_b...
conv5_block3_out (Activation)	(None, 7, 7, 2048)	0	conv5_block3_add...

Total params: 23,587,712 (89.98 MB)

Trainable params: 0 (0.00 B)

Non-trainable params: 23,587,712 (89.98 MB)

```
[45]: ## Adding custom layers on top of ResNet
## defininf custom classification heads as this is intitally trained on 1000
↪classes and the dataset has only 4

model = tf.keras.Sequential([base_model, layers.GlobalAveragePooling2D(),
                             layers.Dropout(0.3), layers.Dense(128, activation=relu),
                             layers.Dropout(0.2), layers.Dense(class_numbers,
↪activation = softmax)])
```

```
[46]: model.summary()
```

Model: "sequential_3"

Layer (type)	Output Shape	Param #
resnet50 (Functional)	(None, 7, 7, 2048)	23,587,712
global_average_pooling2d (GlobalAveragePooling2D)	(None, 2048)	0
dropout_1 (Dropout)	(None, 2048)	0
dense_2 (Dense)	(None, 128)	262,272

dropout_2 (Dropout)	(None, 128)	0
dense_3 (Dense)	(None, 4)	516

Total params: 23,850,500 (90.98 MB)

Trainable params: 262,788 (1.00 MB)

Non-trainable params: 23,587,712 (89.98 MB)

Total params is the total weights of the model along with the dataset, and is currently training only 262,788 which is realted to data set. The non trainable params are the one that was initially freezed.

[47]: *## Compiling the model*

```
model.compile(optimizer=tf.keras.optimizers.Adam(),
              loss = 'sparse_categorical_crossentropy',
              metrics = ['Accuracy']
            )
```

[48]: *## Training the model*

```
history_base = model.fit(
    train_ds,
    validation_data = val_ds,
    epochs = 5
)
```

```
Epoch 1/5
89/89        36s 254ms/step -
Accuracy: 0.8063 - loss: 0.5201 - val_Accuracy: 0.9547 - val_loss: 0.1107
Epoch 2/5
89/89        11s 124ms/step -
Accuracy: 0.9645 - loss: 0.0987 - val_Accuracy: 0.9675 - val_loss: 0.0735
Epoch 3/5
89/89        13s 147ms/step -
Accuracy: 0.9765 - loss: 0.0731 - val_Accuracy: 0.9618 - val_loss: 0.0828
Epoch 4/5
89/89        19s 128ms/step -
Accuracy: 0.9800 - loss: 0.0500 - val_Accuracy: 0.9703 - val_loss: 0.0801
Epoch 5/5
89/89        11s 126ms/step -
Accuracy: 0.9848 - loss: 0.0426 - val_Accuracy: 0.9760 - val_loss: 0.0644
```

High accuracy can be seen in both training and validation data with very low loss, validation accuracy keeps up with the training accuracy leading to no overfitting.

```
[49]: ## saving the model
```

```
model.save("nинjacart_model.keras")
```

```
[50]: ## Fine tuning the restnet by unfreezing the weights in order for the model to learn more
```

```
base_model.trainable = True
```

```
##recompiling
```

```
model.compile(  
    optimizer=tf.keras.optimizers.Adam(1e-5),  
    loss='sparse_categorical_crossentropy',  
    metrics=['accuracy'])  
)
```

```
# Fine-tuning
```

```
fine_tune_history = model.fit(train_ds, validation_data=val_ds, epochs=3)
```

```
Epoch 1/3
```

```
89/89      110s 593ms/step -
```

```
accuracy: 0.9388 - loss: 0.1703 - val_accuracy: 0.9717 - val_loss: 0.1116
```

```
Epoch 2/3
```

```
89/89      33s 307ms/step -
```

```
accuracy: 0.9793 - loss: 0.0441 - val_accuracy: 0.9774 - val_loss: 0.0759
```

```
Epoch 3/3
```

```
89/89      41s 307ms/step -
```

```
accuracy: 0.9917 - loss: 0.0280 - val_accuracy: 0.9830 - val_loss: 0.0672
```

```
[51]: ## Saving the above model too
```

```
model.save("nинjacart_model_finetuned.keras")
```

```
[52]: ## Comparing both the models to identify the better one
```

```
from tensorflow import keras
```

```
model_base = keras.models.load_model("nинjacart_model.keras")
```

```
model_finetuned = keras.models.load_model("nинjacart_model_finetuned.keras")
```

```
# Evaluating base model
```

```
base_loss, base_accuracy = model_base.evaluate(val_ds)
```

```
print(f"Base Model Accuracy: {base_accuracy:.4f}, Loss: {base_loss:.4f}")
```

```
# Evaluating fine-tuned model
ft_loss, ft_accuracy = model_finetuned.evaluate(val_ds)
print(f"Fine-Tuned Model Accuracy: {ft_accuracy:.4f}, Loss: {ft_loss:.4f}")
```

```
23/23      9s 155ms/step -
Accuracy: 0.9694 - loss: 0.0844
Base Model Accuracy: 0.9760, Loss: 0.0644
23/23      9s 141ms/step -
accuracy: 0.9737 - loss: 0.1110
Fine-Tuned Model Accuracy: 0.9830, Loss: 0.0672
```

The base model is better here as it has the minimal loss when compared to the fine tuned model.

[53]: *## Checking the performance of the model using confusion matrix*

```
from sklearn.metrics import confusion_matrix, classification_report

class_names = train_ds.class_names

y_true = []
y_pred = []

for images, labels in val_ds:
    preds = model_base.predict(images)
    y_true.extend(labels.numpy())
    y_pred.extend(np.argmax(preds, axis=1))

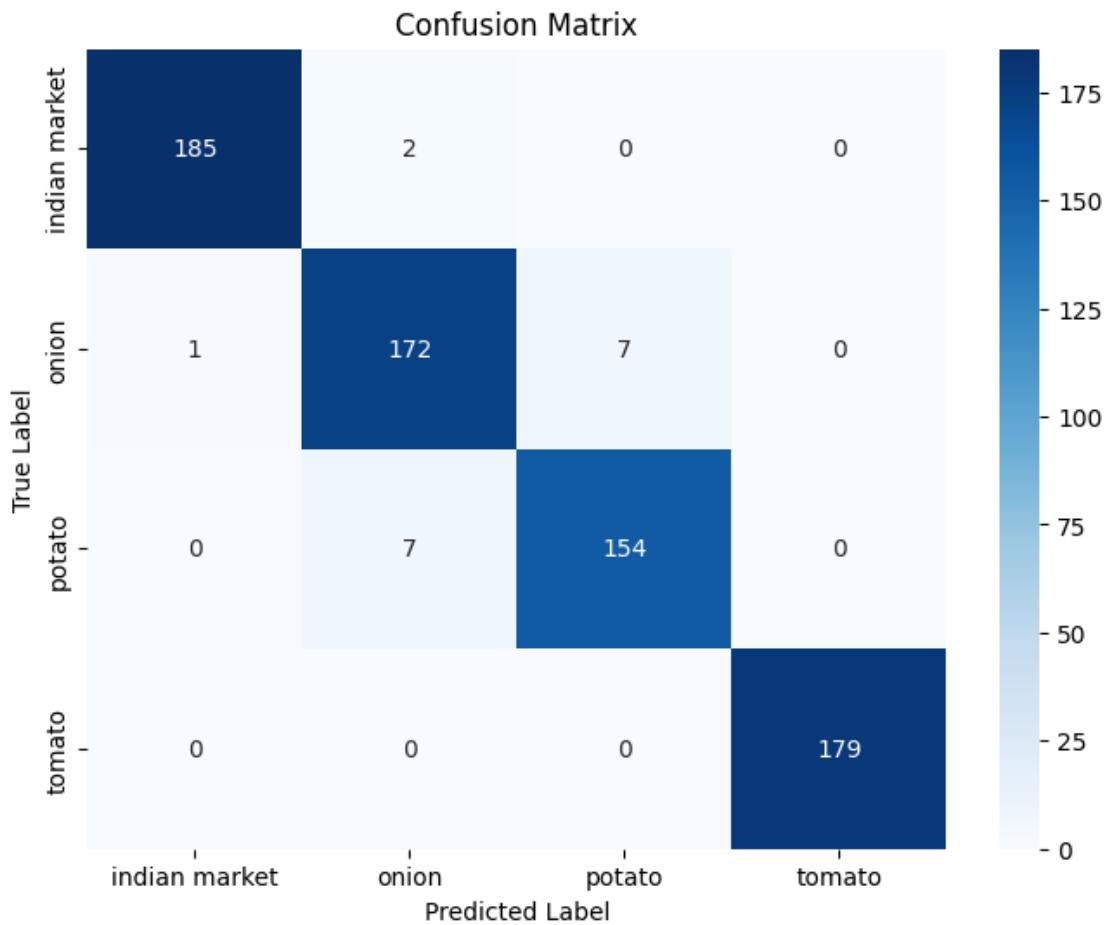
y_true = np.array(y_true)
y_pred = np.array(y_pred)
```

```
1/1      4s 4s/step
1/1      0s 161ms/step
1/1      0s 132ms/step
1/1      0s 138ms/step
1/1      0s 136ms/step
1/1      0s 138ms/step
1/1      0s 141ms/step
1/1      0s 137ms/step
1/1      0s 142ms/step
1/1      0s 118ms/step
1/1      0s 140ms/step
1/1      0s 129ms/step
1/1      0s 109ms/step
1/1      0s 134ms/step
1/1      0s 174ms/step
1/1      0s 161ms/step
1/1      0s 155ms/step
```

```
1/1          0s 147ms/step  
1/1          0s 119ms/step  
1/1          0s 121ms/step  
1/1          0s 122ms/step  
1/1          0s 118ms/step  
1/1          4s 4s/step
```

```
[54]: cm = confusion_matrix(y_true, y_pred)

plt.figure(figsize=(8,6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues', xticklabels=class_names, yticklabels=class_names)
plt.title("Confusion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```



```
[55]: print("Classification Report:\n")
print(classification_report(y_true, y_pred, target_names=class_names))
```

Classification Report:

	precision	recall	f1-score	support
indian market	0.99	0.99	0.99	187
onion	0.95	0.96	0.95	180
potato	0.96	0.96	0.96	161
tomato	1.00	1.00	1.00	179
accuracy			0.98	707
macro avg	0.98	0.98	0.98	707
weighted avg	0.98	0.98	0.98	707

Tomato & Indian Market classes are predicted almost perfectly. Onion and Potato are also doing very well (96%+), but could potentially benefit from slightly more training data or augmentation to push performance closer to 100%.

```
[56]: ## Adding TensorBoard to Model Training
```

```
import datetime

log_dir = "logs/fit/" + datetime.datetime.now().strftime("%Y%m%d-%H%M%S")

tensorboard_callback = tf.keras.callbacks.TensorBoard(
    log_dir=log_dir,
    histogram_freq=1,
    write_graph=True,
    write_images=True
)

## training the model with this callback

history = model.fit(
    train_ds,
    validation_data=val_ds,
    epochs=5,
    callbacks=[tensorboard_callback]
)

%load_ext tensorboard
%tensorboard --logdir logs/fit
```

```
Epoch 1/5
89/89          39s 428ms/step -
```

```

accuracy: 0.9938 - loss: 0.0219 - val_accuracy: 0.9830 - val_loss: 0.0586
Epoch 2/5
89/89          41s 429ms/step -
accuracy: 0.9967 - loss: 0.0140 - val_accuracy: 0.9816 - val_loss: 0.0600
Epoch 3/5
89/89          40s 422ms/step -
accuracy: 0.9957 - loss: 0.0151 - val_accuracy: 0.9859 - val_loss: 0.0539
Epoch 4/5
89/89          38s 425ms/step -
accuracy: 0.9960 - loss: 0.0109 - val_accuracy: 0.9830 - val_loss: 0.0584
Epoch 5/5
89/89          41s 424ms/step -
accuracy: 0.9967 - loss: 0.0093 - val_accuracy: 0.9830 - val_loss: 0.0614
<IPython.core.display.Javascript object>

```

[93]: *## Plotting the train/validation accuracy*

```

import matplotlib.pyplot as plt

def plot_accuracy(history, title='Model Accuracy'):
    keys = history.history.keys()
    print("Available keys:", keys)

    # Determining correct key format
    if 'accuracy' in keys and 'val_accuracy' in keys:
        acc = history.history['accuracy']
        val_acc = history.history['val_accuracy']
    elif 'Accuracy' in keys and 'val_Accuracy' in keys:
        acc = history.history['Accuracy']
        val_acc = history.history['val_Accuracy']
    else:
        raise KeyError("No valid accuracy keys found in history.")

    epochs = range(1, len(acc) + 1)

    plt.figure(figsize=(8, 5))
    plt.plot(epochs, acc, 'bo-', label='Training Accuracy')
    plt.plot(epochs, val_acc, 'go-', label='Validation Accuracy')
    plt.title(title)
    plt.xlabel('Epochs')
    plt.ylabel('Accuracy')
    plt.legend()
    plt.grid(True)
    plt.show()

```

[94]: *## Plotting the train/validation loss*

```

def plot_loss(history, title='Model Loss'):
    loss = history.history['loss']
    val_loss = history.history['val_loss']
    epochs = range(1, len(loss) + 1)

    plt.figure(figsize=(8,5))
    plt.plot(epochs, loss, 'ro-', label='Training Loss')
    plt.plot(epochs, val_loss, 'mo-', label='Validation Loss')
    plt.title(title)
    plt.xlabel('Epochs')
    plt.ylabel('Loss')
    plt.legend()
    plt.grid(True)
    plt.show()

```

[95]: `print(fine_tune_history.history.keys())`

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

[96]: `print(history_base.history.keys())`

```
dict_keys(['Accuracy', 'loss', 'val_Accuracy', 'val_loss'])
```

[97]: `print(fine_tune_history.history.keys())`

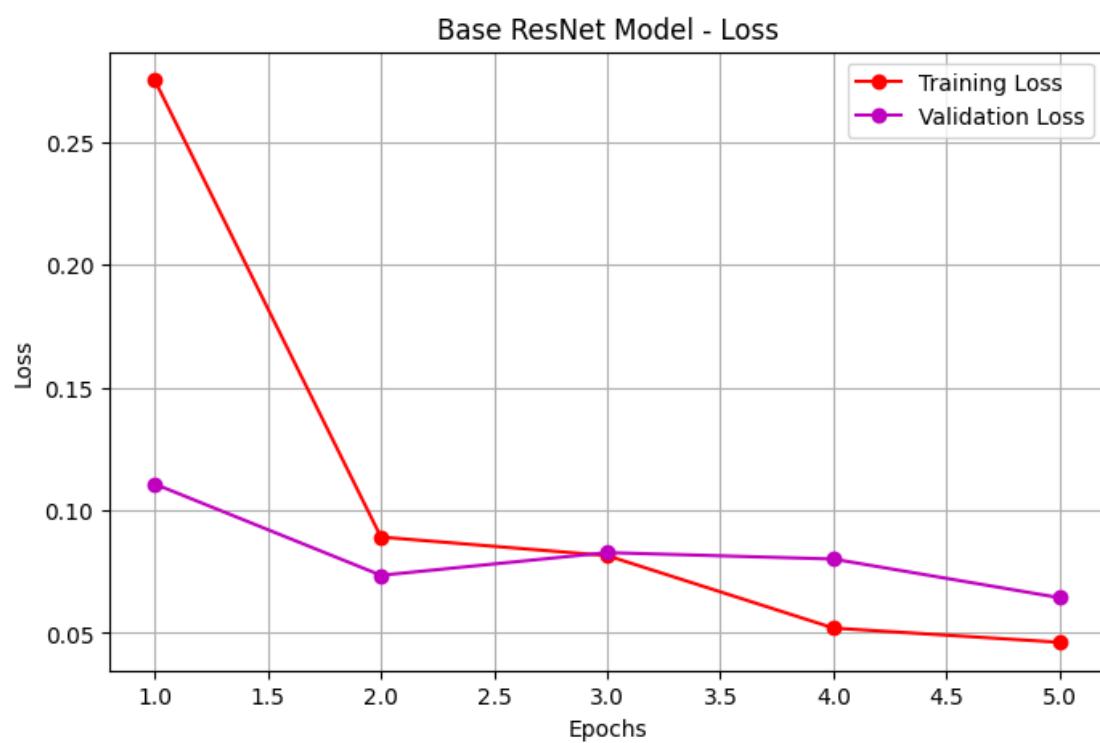
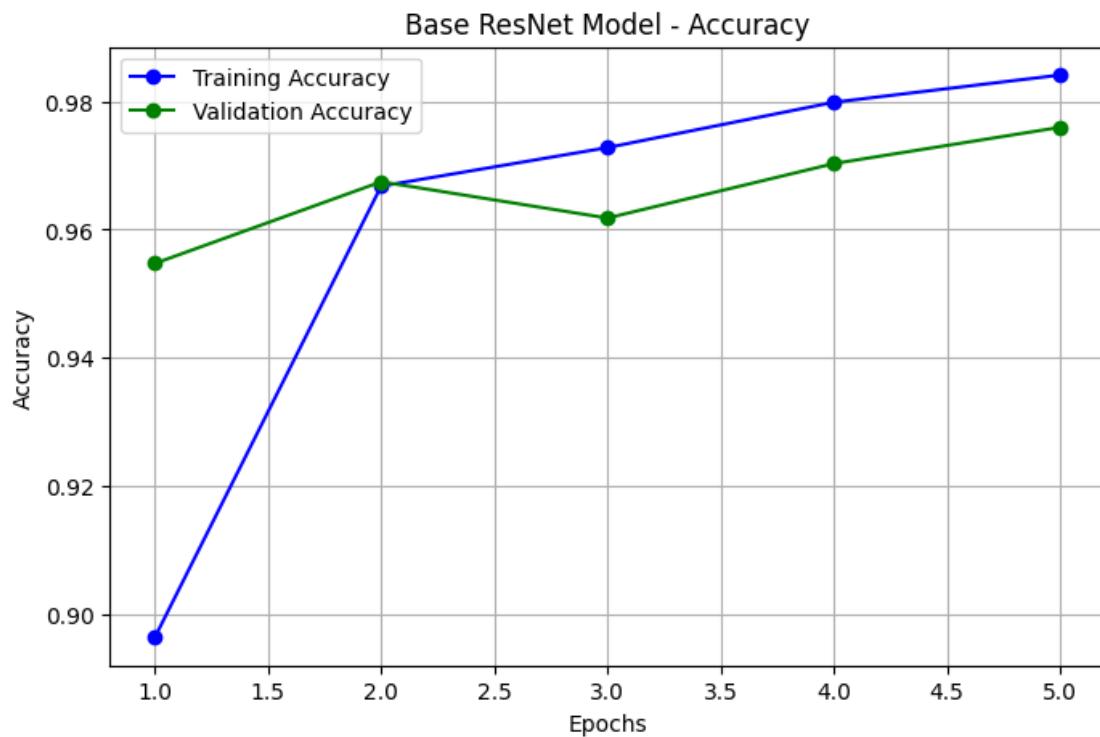
```
dict_keys(['accuracy', 'loss', 'val_accuracy', 'val_loss'])
```

[99]: *## pltting accuracy and loss for both the models*

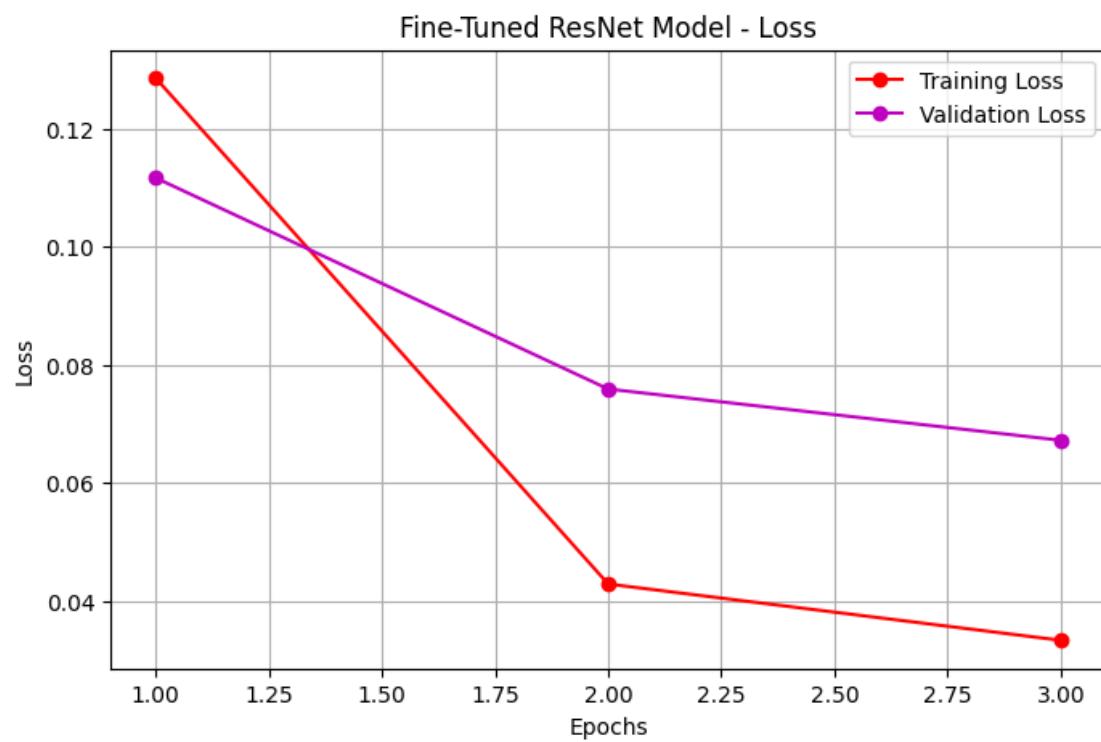
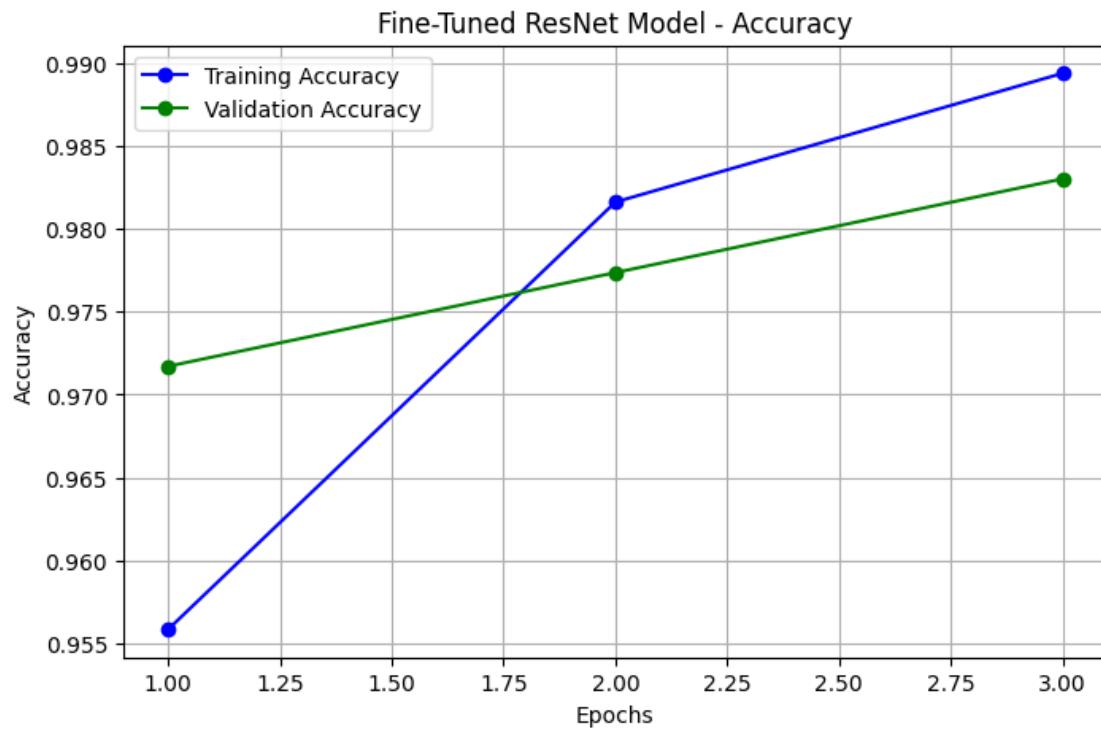
```
plot_accuracy(history_base, title='Base ResNet Model - Accuracy')
plot_loss(history_base, title='Base ResNet Model - Loss')
```

```
plot_accuracy(fine_tune_history, title='Fine-Tuned ResNet Model - Accuracy')
plot_loss(fine_tune_history, title='Fine-Tuned ResNet Model - Loss')
```

Available keys: `dict_keys(['Accuracy', 'loss', 'val_Accuracy', 'val_loss'])`



Available keys: dict_keys(['accuracy', 'loss', 'val_accuracy', 'val_loss'])



```
[101]: ## Seeing the numbers as metrics

import pandas as pd
import pandas as pd

def print_metrics_table(history, model_name='Model'):
    keys = history.history.keys()

    if 'accuracy' in keys:
        acc_key = 'accuracy'
        val_acc_key = 'val_accuracy'
    elif 'Accuracy' in keys:
        acc_key = 'Accuracy'
        val_acc_key = 'val_Accuracy'
    else:
        raise KeyError("Accuracy keys not found in history.")

    data = {
        'Epoch': list(range(1, len(history.history[acc_key]) + 1)),
        'Train Accuracy': [round(val, 4) for val in history.history[acc_key]],
        'Val Accuracy': [round(val, 4) for val in history.history[val_acc_key]],
        'Train Loss': [round(val, 4) for val in history.history['loss']],
        'Val Loss': [round(val, 4) for val in history.history['val_loss']],
    }

    df = pd.DataFrame(data)
    print(f"\n {model_name} Training History:\n")
    print(df.to_string(index=False))
```

```
[102]: ## printing metrics for both the models to compare better
```

```
print_metrics_table(history_base, "Base ResNet Model")
print_metrics_table(fine_tune_history, "Fine-Tuned ResNet Model")
```

Base ResNet Model Training History:

Epoch	Train Accuracy	Val Accuracy	Train Loss	Val Loss
1	0.8965	0.9547	0.2753	0.1107
2	0.9668	0.9675	0.0891	0.0735
3	0.9728	0.9618	0.0815	0.0828
4	0.9799	0.9703	0.0520	0.0801
5	0.9841	0.9760	0.0462	0.0644

Fine-Tuned ResNet Model Training History:

Epoch	Train Accuracy	Val Accuracy	Train Loss	Val Loss
1	0.9558	0.9717	0.1285	0.1116
2	0.9816	0.9774	0.0429	0.0759
3	0.9894	0.9830	0.0334	0.0672

The model is no more overfitting and choosed model is base resnet.

```
[109]: import matplotlib.pyplot as plt
import numpy as np

class_names = val_ds.class_names

for images, labels in val_ds.take(1):
    print("Images in batch:", images.shape[0])

    preds = model_base.predict(images, verbose=0)
    pred_labels = np.argmax(preds, axis=1)

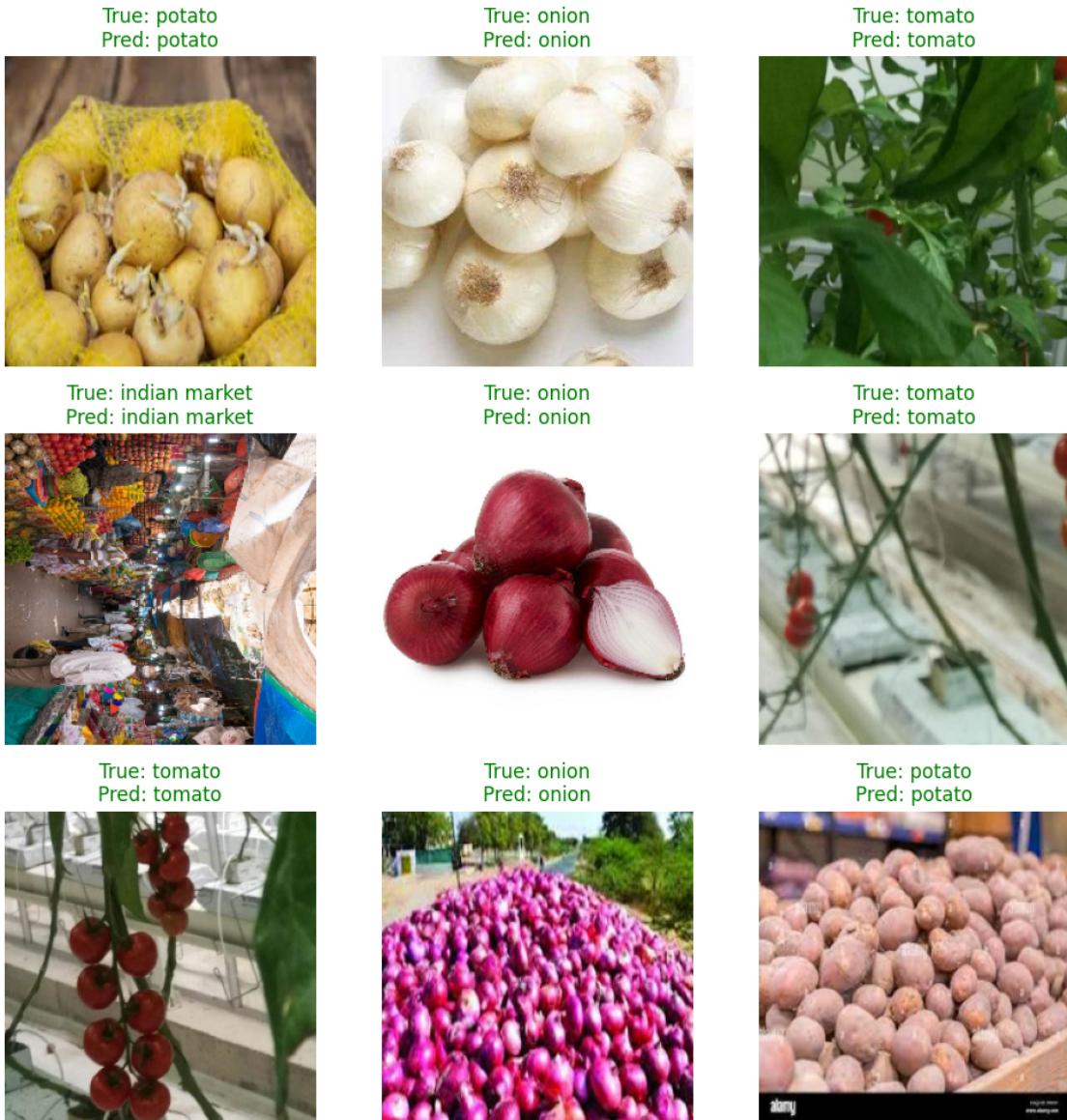
    plt.figure(figsize=(10, 10))
    for i in range(min(9, len(images))):
        ax = plt.subplot(3, 3, i + 1)
        plt.imshow(images[i].numpy().astype("uint8"))
        plt.axis('off')

        true_label = class_names[int(labels[i])]
        pred_label = class_names[int(pred_labels[i])]
        color = "green" if true_label == pred_label else "red"

        plt.title(f"True: {true_label}\nPred: {pred_label}", color=color)

    plt.tight_layout()
    plt.show()
    break
```

Images in batch: 32



Evaluation:

- Achieved Precision/Recall ~98 to ~100% across all cases
- Visualized predictions and compared against true labels

Outcome:

- ResNet with frozen base provided excellent performance.
- Fine-tuning offered marginal improvement, but with more training time and Final model is reliable for real-world classification of market images.

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