**Waste Management Using CNN Model**

pip install opencv-python

Defaulting to user installation because normal site-packages is not writeable

Requirement already satisfied: opencv-python in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (4.11.0.86)

Requirement already satisfied: numpy>=1.21.2 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from opencv-python) (1.26.4)

Note: you may need to restart the kernel to use updated packages.

pip install tensorflow

Defaulting to user installation because normal site-packages is not writeable

Requirement already satisfied: tensorflow in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (2.18.0)

Requirement already satisfied: tensorflow-intel==2.18.0 in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (from tensorflow) (2.18.0)

Requirement already satisfied: absl-py>=1.0.0 in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (2.1.0)

Requirement already satisfied: astunparse>=1.6.0 in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (1.6.3)

Requirement already satisfied: flatbuffers>=24.3.25 in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (25.1.24)

Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (0.6.0)

Requirement already satisfied: google-pasta>=0.1.1 in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (0.2.0)

Requirement already satisfied: libclang>=13.0.0 in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (18.1.1)

Requirement already satisfied: opt-einsum>=2.3.2 in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (3.4.0)

Requirement already satisfied: packaging in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (24.1)

Requirement already satisfied: protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!=4.21.5,<6.0.0dev,>=3.20.3 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (4.25.3)

Requirement already satisfied: requests<3,>=2.21.0 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (2.32.3)

Requirement already satisfied: setuptools in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (75.1.0)

Requirement already satisfied: six>=1.12.0 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (1.16.0)

Requirement already satisfied: termcolor>=1.1.0 in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (2.5.0)

Requirement already satisfied: typing-extensions>=3.6.6 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (4.11.0)

Requirement already satisfied: wrapt>=1.11.0 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (1.14.1)

Requirement already satisfied: grpcio<2.0,>=1.24.3 in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (1.70.0)

Requirement already satisfied: tensorboard<2.19,>=2.18 in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (2.18.0)

Requirement already satisfied: keras>=3.5.0 in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (3.8.0)

Requirement already satisfied: numpy<2.1.0,>=1.26.0 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (1.26.4)

Requirement already satisfied: h5py>=3.11.0 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (3.11.0)

Requirement already satisfied: ml-dtypes<0.5.0,>=0.4.0 in [c:\users\computercenter3\appdata\roaming\python\python312\site-packages](file:///C:\users\computercenter3\appdata\roaming\python\python312\site-packages) (from tensorflow-intel==2.18.0->tensorflow) (0.4.1)

Requirement already satisfied: wheel<1.0,>=0.23.0 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from astunparse>=1.6.0->tensorflow-intel==2.18.0->tensorflow) (0.44.0)

...

Requirement already satisfied: markdown-it-py>=2.2.0 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from rich->keras>=3.5.0->tensorflow-intel==2.18.0->tensorflow) (2.2.0)

Requirement already satisfied: pygments<3.0.0,>=2.13.0 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from rich->keras>=3.5.0->tensorflow-intel==2.18.0->tensorflow) (2.15.1)

Requirement already satisfied: mdurl~=0.1 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from markdown-it-py>=2.2.0->rich->keras>=3.5.0->tensorflow-intel==2.18.0->tensorflow) (0.1.0)

Note: you may need to restart the kernel to use updated packages.

*Output is truncated. View as a* [*scrollable element*](command:cellOutput.enableScrolling?48c5c8bf-588c-4882-a550-ae1cf3c44734) *or open in a* [*text editor*](command:workbench.action.openLargeOutput?48c5c8bf-588c-4882-a550-ae1cf3c44734)*. Adjust cell output* [*settings*](command:workbench.action.openSettings?%5B%22%40tag%3AnotebookOutputLayout%22%5D)*...*

pip install numpy

Defaulting to user installation because normal site-packages is not writeable

Requirement already satisfied: numpy in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (1.26.4)

Note: you may need to restart the kernel to use updated packages.

pip install pandas

Defaulting to user installation because normal site-packages is not writeable

Requirement already satisfied: pandas in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (2.2.2)

Requirement already satisfied: numpy>=1.26.0 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from pandas) (1.26.4)

Requirement already satisfied: python-dateutil>=2.8.2 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from pandas) (2.9.0.post0)

Requirement already satisfied: pytz>=2020.1 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from pandas) (2024.1)

Requirement already satisfied: tzdata>=2022.7 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from pandas) (2023.3)

Requirement already satisfied: six>=1.5 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from python-dateutil>=2.8.2->pandas) (1.16.0)

Note: you may need to restart the kernel to use updated packages.

pip install matplotlib

Defaulting to user installation because normal site-packages is not writeable

Requirement already satisfied: matplotlib in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (3.9.2)

Requirement already satisfied: contourpy>=1.0.1 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from matplotlib) (1.2.0)

Requirement already satisfied: cycler>=0.10 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from matplotlib) (0.11.0)

Requirement already satisfied: fonttools>=4.22.0 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from matplotlib) (4.51.0)

Requirement already satisfied: kiwisolver>=1.3.1 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from matplotlib) (1.4.4)

Requirement already satisfied: numpy>=1.23 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from matplotlib) (1.26.4)

Requirement already satisfied: packaging>=20.0 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from matplotlib) (24.1)

Requirement already satisfied: pillow>=8 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from matplotlib) (10.4.0)

Requirement already satisfied: pyparsing>=2.3.1 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from matplotlib) (3.1.2)

Requirement already satisfied: python-dateutil>=2.7 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from matplotlib) (2.9.0.post0)

Requirement already satisfied: six>=1.5 in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from python-dateutil>=2.7->matplotlib) (1.16.0)

Note: you may need to restart the kernel to use updated packages.

pip install tqdm

Defaulting to user installation because normal site-packages is not writeable

Requirement already satisfied: tqdm in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (4.66.5)

Requirement already satisfied: colorama in [c:\programdata\anaconda3\lib\site-packages](file:///C:\programdata\anaconda3\lib\site-packages) (from tqdm) (0.4.6)

Note: you may need to restart the kernel to use updated packages.

pip install warnings

Defaulting to user installation because normal site-packages is not writeable

Note: you may need to restart the kernel to use updated packages.

ERROR: Could not find a version that satisfies the requirement warnings (from versions: none)

ERROR: No matching distribution found for warnings

# Importing necessary libraries

import numpy as np

import pandas as pd

import matplotlib.pyplot as plt

import cv2

from tqdm import tqdm

import warnings

warnings.filterwarnings('ignore')

train\_path = "DATASET/TRAIN"

test\_path = "DATASET/TRAIN"

# Importing Libraries

from tensorflow.keras.models import Sequential

from tensorflow.keras.layers import Conv2D, MaxPooling2D, Activation, Dropout, Flatten, Dense, BatchNormalization

from tensorflow.keras.preprocessing.image import ImageDataGenerator, img\_to\_array, load\_img

from tensorflow.keras.utils import plot\_model

from glob import glob

# Visualization

from cv2 import cvtColor

x\_data = []

y\_data = []

for category in glob(train\_path+'/\*'):

    for file in tqdm(glob(category+'/\*')):

        img\_array = cv2.imread(file)

        img\_array = cv2.cvtColor(img\_array, cv2.COLOR\_BGR2RGB)

        x\_data.append(img\_array)

        y\_data.append(category.split('/')[-1])

data = pd.DataFrame({'image':x\_data, 'label':y\_data})

100%|██████████| 12565/12565 [00:08<00:00, 1558.20it/s]

100%|██████████| 9999/9999 [00:06<00:00, 1630.38it/s]

data.shape

(22564, 2)

colors = ['#a0d157', '#c48bb8']

plt.pie(data.label.value\_counts(), labels=['Organic', 'Recyclable'], autopct='%0.2f%%', colors = colors, startangle = 90,  explode=[0.05, 0.05])

plt.show()

A green and purple pie chart

Description automatically generated

plt.figure(figsize=(20, 15))

for i in range(9):

    plt.subplot(4, 3,(i%12)+1)

    index = np.random.randint(15000)

    plt.title('This is of {0}'.format(data.label[index]))

    plt.imshow(data.image[index])

    plt.tight\_layout()

A collage of different foods

Description automatically generated

**CNN - Convolution Neural Network**

model = Sequential()

model.add(Conv2D(32, (3, 3), input\_shape = (224, 224, 3)))

model.add(Activation('relu'))

model.add(MaxPooling2D())

model.add(Conv2D(64,(3, 3)))

model.add(Activation('relu'))

model.add(MaxPooling2D())

model.add(Conv2D(128,(3, 3)))

model.add(Activation('relu'))

model.add(MaxPooling2D())

model.add(Flatten())

model.add(Dense(256))

model.add(Activation('relu'))

model.add(Dropout(0.5))

model.add(Dense(64))

model.add(Activation('relu'))

model.add(Dropout(0.5))

model.add(Dense(2))

model.add(Activation('sigmoid'))

model.compile(loss = "binary\_crossentropy",

              optimizer = "adam",

              metrics = ["accuracy"])

batch\_size = 256

model.summary()

**Model: "sequential\_2"**

|  |  |  |
| --- | --- | --- |
| **Layer (type)** | **Output Shape** | **Param #** |
| conv2d\_6 (Conv2D) | (None, 222, 222, 32) | 896 |
| activation\_12 (Activation) | (None, 222, 222, 32) | 0 |
| max\_pooling2d\_6 (MaxPooling2D) | (None, 111, 111, 32) | 0 |
| conv2d\_7 (Conv2D) | (None, 109, 109, 64) | 18,496 |
| activation\_13 (Activation) | (None, 109, 109, 64) | 0 |
| max\_pooling2d\_7 (MaxPooling2D) | (None, 54, 54, 64) | 0 |
| conv2d\_8 (Conv2D) | (None, 52, 52, 128) | 73,856 |
| activation\_14 (Activation) | (None, 52, 52, 128) | 0 |
| max\_pooling2d\_8 (MaxPooling2D) | (None, 26, 26, 128) | 0 |
| flatten\_2 (Flatten) | (None, 86528) | 0 |
| dense\_6 (Dense) | (None, 256) | 22,151,424 |
| activation\_15 (Activation) | (None, 256) | 0 |
| dropout\_4 (Dropout) | (None, 256) | 0 |
| dense\_7 (Dense) | (None, 64) | 16,448 |
| activation\_16 (Activation) | (None, 64) | 0 |
| dropout\_5 (Dropout) | (None, 64) | 0 |
| dense\_8 (Dense) | (None, 2) | 130 |
| activation\_17 (Activation) | (None, 2) | 0 |

**Total params:** 22,261,250 (84.92 MB)

**Trainable params:** 22,261,250 (84.92 MB)

**Non-trainable params:** 0 (0.00 B)

train\_datagen = ImageDataGenerator(rescale = 1./ 255)

test\_datagen = ImageDataGenerator(rescale = 1./ 255)

train\_generator = train\_datagen.flow\_from\_directory(

    train\_path,

    target\_size = (224, 224),

    batch\_size = batch\_size,

    color\_mode = "rgb",

    class\_mode = "categorical"

)

test\_generator = test\_datagen.flow\_from\_directory(

    test\_path,

    target\_size = (224, 224),

    batch\_size = batch\_size,

    color\_mode = "rgb",

    class\_mode = "categorical"

)

Found 22564 images belonging to 2 classes.

Found 22564 images belonging to 2 classes.

hist = model.fit(

    train\_generator,

    epochs = 10,

    validation\_data = test\_generator

)

Epoch 1/10

**89/89** ━━━━━━━━━━━━━━━━━━━━ **420s** 5s/step - accuracy: 0.7145 - loss: 0.5994 - val\_accuracy: 0.8224 - val\_loss: 0.4068

Epoch 2/10

**89/89** ━━━━━━━━━━━━━━━━━━━━ **435s** 5s/step - accuracy: 0.8305 - loss: 0.4157 - val\_accuracy: 0.8452 - val\_loss: 0.3606

Epoch 3/10

**89/89** ━━━━━━━━━━━━━━━━━━━━ **445s** 5s/step - accuracy: 0.8449 - loss: 0.3732 - val\_accuracy: 0.8701 - val\_loss: 0.3194

Epoch 4/10

**89/89** ━━━━━━━━━━━━━━━━━━━━ **426s** 5s/step - accuracy: 0.8649 - loss: 0.3344 - val\_accuracy: 0.8814 - val\_loss: 0.2907

Epoch 5/10

**89/89** ━━━━━━━━━━━━━━━━━━━━ **416s** 5s/step - accuracy: 0.8749 - loss: 0.3205 - val\_accuracy: 0.8924 - val\_loss: 0.2707

Epoch 6/10

**89/89** ━━━━━━━━━━━━━━━━━━━━ **414s** 5s/step - accuracy: 0.8900 - loss: 0.2814 - val\_accuracy: 0.9109 - val\_loss: 0.2280

Epoch 7/10 **89/89** ━━━━━━━━━━━━━━━━━━━━ **0s** 4s/step - accuracy: 0.9050 - loss: 0.2485

Epoch 8/10

**89/89** ━━━━━━━━━━━━━━━━━━━━ **421s** 5s/step - accuracy: 0.9187 - loss: 0.2115 - val\_accuracy: 0.9254 - val\_loss: 0.1793

Epoch 9/10

**89/89** ━━━━━━━━━━━━━━━━━━━━ **422s** 5s/step - accuracy: 0.9297 - loss: 0.1838 - val\_accuracy: 0.9344 - val\_loss: 0.1580

Epoch 10/10

**89/89** ━━━━━━━━━━━━━━━━━━━━ **407s** 5s/step - accuracy: 0.9444 - loss: 0.1481 - val\_accuracy: 0.9671 - val\_loss: 0.0866

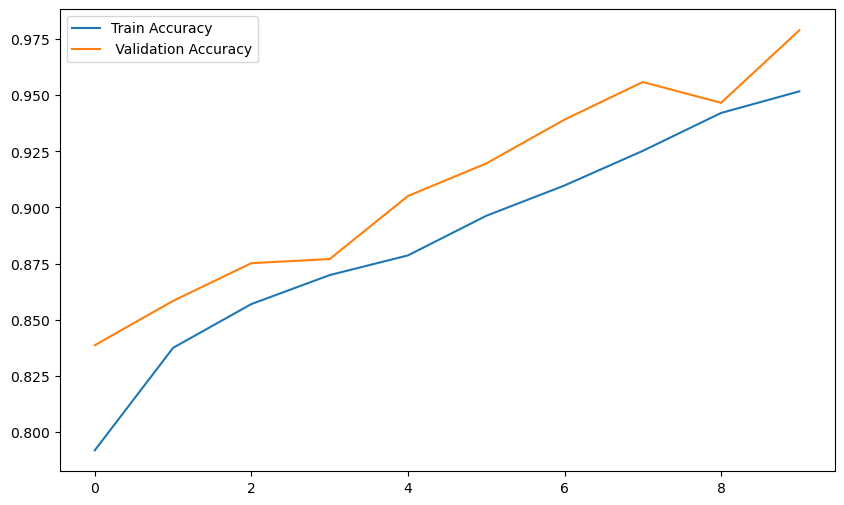
plt.figure(figsize=(10,6))

plt.plot(hist.history['accuracy'], label='Train Accuracy')

plt.plot(hist.history['val\_accuracy'], label=' Validation Accuracy')

plt.legend()

plt.show()



plt.figure(figsize=(10,6))

plt.plot(hist.history['loss'], label='Training Loss')

plt.plot(hist.history['val\_loss'], label='Validation Loss')

plt.legend()

plt.show()

A line graph with blue and orange lines

Description automatically generated

def predict\_fun(img):

  plt.figure(figsize=(6, 4))

  plt.imshow(cv2.cvtColor(img, cv2.COLOR\_BGR2RGB))

  plt.tight\_layout()

  img = cv2.resize(img, (224, 224))

  img = np.reshape(img, [-1, 224, 224, 3])

  result = np.argmax(model.predict(img))

  if result == 0:

    print('The image shown is Recyclable Waste')

  elif result == 1:

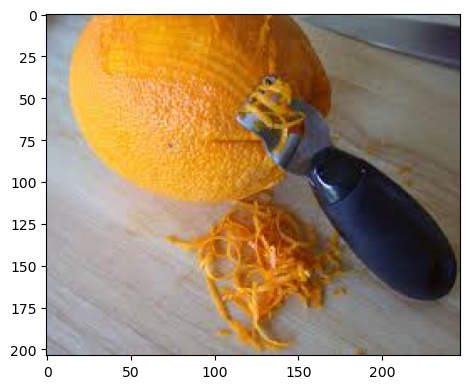
    print('The image shown is Organic Waste')

test\_img = cv2.imread('DATASET/TEST/O/O\_13963.jpg')

predict\_fun(test\_img)

**1/1** ━━━━━━━━━━━━━━━━━━━━ **0s** 133ms/step

The image shown is Organic Waste



test\_img = cv2.imread('DATASET/TEST/R/R\_10005.jpg')

predict\_fun(test\_img)

**1/1** ━━━━━━━━━━━━━━━━━━━━ **0s** 32ms/step

The image shown is Recyclable Waste