

✓ Trash Classification

```
from google.colab import drive  
drive.mount('/content/drive')
```

Mounted at /content/drive

✓ Import all the Dependencies

```
import tensorflow as tf  
from tensorflow.keras import models, layers  
import matplotlib.pyplot as plt  
from IPython.display import HTML
```

✓ Set all the Constants

```
BATCH_SIZE = 32  
IMAGE_SIZE = 256  
CHANNELS=3  
EPOCHS=50
```

✓ Import data into tensorflow dataset object

```
import os  
import tensorflow as tf  
  
# Step 1: Unzip the file from Google Drive to a local directory  
zip_path = '/content/drive/MyDrive/DL_Project/Trash_Dataset'  
  
dataset = tf.keras.preprocessing.image_dataset_from_directory(  
    zip_path,  
    seed=123,  
    shuffle=True,  
    image_size=(IMAGE_SIZE, IMAGE_SIZE),  
    batch_size=BATCH_SIZE  
)
```

Found 1798 files belonging to 3 classes.

```
class_names = dataset.class_names  
class_names  
  
['e-waste', 'paper', 'plastic']
```

```
for image_batch, labels_batch in dataset.take(1):  
    print(image_batch.shape)  
    print(labels_batch.numpy())  
  
(32, 256, 256, 3)  
[1 1 0 2 1 0 0 1 1 0 2 1 0 1 2 1 0 0 2 1 2 2 1 1 1 2 2 1 2 1 2 0]
```

As you can see above, each element in the dataset is a tuple. First element is a batch of 32 elements of images. Second element is a batch of 32 elements of class labels

✓ Visualize some of the images from our dataset

```
plt.figure(figsize=(10, 10))
for image_batch, labels_batch in dataset.take(1):
    for i in range(12):
        ax = plt.subplot(3, 4, i + 1)
        plt.imshow(image_batch[i].numpy().astype("uint8"))
        plt.title(class_names[labels_batch[i]])
        plt.axis("off")
```

paper



paper



e-waste



plastic



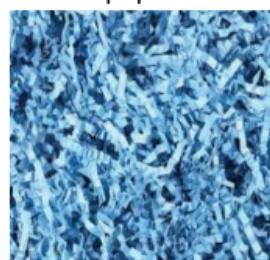
e-waste



plastic



paper



plastic



plastic



plastic



e-waste



e-waste



✓ Function to Split Dataset

Dataset should be bifurcated into 3 subsets, namely:

1. Training: Dataset to be used while training
2. Validation: Dataset to be tested against while training
3. Test: Dataset to be tested against after we trained a model

```
len(dataset)
```

57

```
train_size = 0.8  
len(dataset)*train_size
```

45.6

```
train_ds = dataset.take(45)  
len(train_ds)
```

45

```
test_ds = dataset.skip(45)  
len(test_ds)
```

12

```
val_size=0.1  
len(dataset)*val_size
```

5.7

```
val_ds = test_ds.take(5)  
len(val_ds)
```

5

```
test_ds = test_ds.skip(5)  
len(test_ds)
```

7

```
def get_dataset_partitions_tf(ds, train_split=0.8, val_split=0.1, test_split=0.1, shuffle=True, shuffle_size=10000):  
    assert (train_split + test_split + val_split) == 1  
  
    ds_size = len(ds)  
  
    if shuffle:  
        ds = ds.shuffle(shuffle_size, seed=12)  
  
    train_size = int(train_split * ds_size)  
    val_size = int(val_split * ds_size)  
  
    train_ds = ds.take(train_size)  
    val_ds = ds.skip(train_size).take(val_size)  
    test_ds = ds.skip(train_size).skip(val_size)  
  
    return train_ds, val_ds, test_ds
```

```
train_ds, val_ds, test_ds = get_dataset_partitions_tf(dataset)
```

```
len(train_ds)
```

45

```
len(val_ds)
```

5

```
len(test_ds)
```

```
7
```

▼ Cache, Shuffle, and Prefetch the Dataset

```
train_ds = train_ds.cache().shuffle(1000).prefetch(buffer_size=tf.data.AUTOTUNE)
val_ds = val_ds.cache().shuffle(1000).prefetch(buffer_size=tf.data.AUTOTUNE)
test_ds = test_ds.cache().shuffle(1000).prefetch(buffer_size=tf.data.AUTOTUNE)
```

▼ Building the Model

▼ Creating a Layer for Resizing and Normalization

Before we feed our images to network, we should be resizing it to the desired size. Moreover, to improve model performance, we should normalize the image pixel value (keeping them in range 0 and 1 by dividing by 256). This should happen while training as well as inference. Hence we can add that as a layer in our Sequential Model.

You might be thinking why do we need to resize (256,256) image to again (256,256). You are right we don't need to but this will be useful when we are done with the training and start using the model for predictions. At that time someone can supply an image that is not (256,256) and this layer will resize it

```
resize_and_rescale = tf.keras.Sequential([
    layers.Resizing(IMAGE_SIZE, IMAGE_SIZE),
    layers.Rescaling(1./255),
])
```

▼ Data Augmentation

Data Augmentation is needed when we have less data, this boosts the accuracy of our model by augmenting the data.

```
data_augmentation = tf.keras.Sequential([
    layers.RandomFlip("horizontal_and_vertical"),
    layers.RandomRotation(0.2),
    layers.RandomZoom(0.2),
    layers.RandomContrast(0.2),
    layers.RandomBrightness(0.2),
])
```

▼ Applying Data Augmentation to Train Dataset

```
train_ds = train_ds.map(
    lambda x, y: (data_augmentation(x, training=True), y)
).prefetch(buffer_size=tf.data.AUTOTUNE)
```

▼ Model Architecture

We use a CNN coupled with a Softmax activation in the output layer. We also add the initial layers for resizing, normalization and Data Augmentation.

```

input_shape = (BATCH_SIZE, IMAGE_SIZE, IMAGE_SIZE, CHANNELS)
n_classes = len(class_names)

model = models.Sequential([
    resize_and_rescale,
    layers.Conv2D(32, kernel_size = (3,3), activation='relu', input_shape=input_shape),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64, kernel_size = (3,3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64, kernel_size = (3,3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Flatten(),
    layers.Dense(64, activation='relu'),
    layers.Dense(n_classes, activation='softmax'),
])

model.build(input_shape)

```

/usr/local/lib/python3.12/dist-packages/keras/src/layers/convolutional/base_conv.py:113: UserWarning: Do no
super().__init__(activity_regularizer=activity_regularizer, **kwargs)

```
model.summary()
```

Model: "sequential_2"

Layer (type)	Output Shape	Param #
sequential (Sequential)	(32, 256, 256, 3)	0
conv2d (Conv2D)	(32, 254, 254, 32)	896
max_pooling2d (MaxPooling2D)	(32, 127, 127, 32)	0
conv2d_1 (Conv2D)	(32, 125, 125, 64)	18,496
max_pooling2d_1 (MaxPooling2D)	(32, 62, 62, 64)	0
conv2d_2 (Conv2D)	(32, 60, 60, 64)	36,928
max_pooling2d_2 (MaxPooling2D)	(32, 30, 30, 64)	0
conv2d_3 (Conv2D)	(32, 28, 28, 64)	36,928
max_pooling2d_3 (MaxPooling2D)	(32, 14, 14, 64)	0
conv2d_4 (Conv2D)	(32, 12, 12, 64)	36,928
max_pooling2d_4 (MaxPooling2D)	(32, 6, 6, 64)	0
conv2d_5 (Conv2D)	(32, 4, 4, 64)	36,928
max_pooling2d_5 (MaxPooling2D)	(32, 2, 2, 64)	0
flatten (Flatten)	(32, 256)	0
dense (Dense)	(32, 64)	16,448
dense_1 (Dense)	(32, 3)	195

Total params: 183,747 (717.76 KB)

Trainable params: 183,747 (717.76 KB)

Compiling the Model

We use `adam` Optimizer, `SparseCategoricalCrossentropy` for losses, `accuracy` as a metric

```
model.compile(  
    optimizer='adam',  
    loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=False),  
    metrics=['accuracy'])
```

```
history = model.fit(  
    train_ds,  
    batch_size=BATCH_SIZE,  
    validation_data=val_ds,  
    verbose=1,  
    epochs=100,  
)
```

```
45/45 ━━━━━━━━━━ 25s 557ms/step - accuracy: 0.8584 - loss: 0.3434 - val_accuracy: 0.9187 - val_loss: 0.2860
Epoch 98/100
45/45 ━━━━━━━━━━ 25s 562ms/step - accuracy: 0.8898 - loss: 0.2736 - val_accuracy: 0.8938 - val_loss: 0.2860
Epoch 99/100
45/45 ━━━━━━━━━━ 25s 560ms/step - accuracy: 0.8757 - loss: 0.2969 - val_accuracy: 0.9187 - val_loss: 0.2860
Epoch 100/100
45/45 ━━━━━━━━━━ 25s 549ms/step - accuracy: 0.8780 - loss: 0.2960 - val_accuracy: 0.9062 - val_loss: 0.2860
```

```
scores = model.evaluate(test_ds)
7/7 ━━━━━━━━━━ 8s 22ms/step - accuracy: 0.8825 - loss: 0.3725
```

You can see above that we get 100.00% accuracy for our test dataset. This is considered to be a pretty good accuracy

```
scores
[0.3048180937767029, 0.8928571343421936]
```

Scores is just a list containing loss and accuracy value

Plotting the Accuracy and Loss Curves

```
history
<keras.src.callbacks.history.History at 0x7936442b3a10>
history.params
{'verbose': 1, 'epochs': 100, 'steps': 45}
history.history.keys()
dict_keys(['accuracy', 'loss', 'val_accuracy', 'val_loss'])
```

loss, accuracy, val loss etc are a python list containing values of loss, accuracy etc at the end of each epoch

```
type(history.history['loss'])
list
len(history.history['loss'])
100
history.history['loss'][:5] # show loss for first 5 epochs
[1.0622648000717163,
 0.9984421730041504,
 0.9278591871261597,
 0.8509713411331177,
 0.804690420627594]
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']

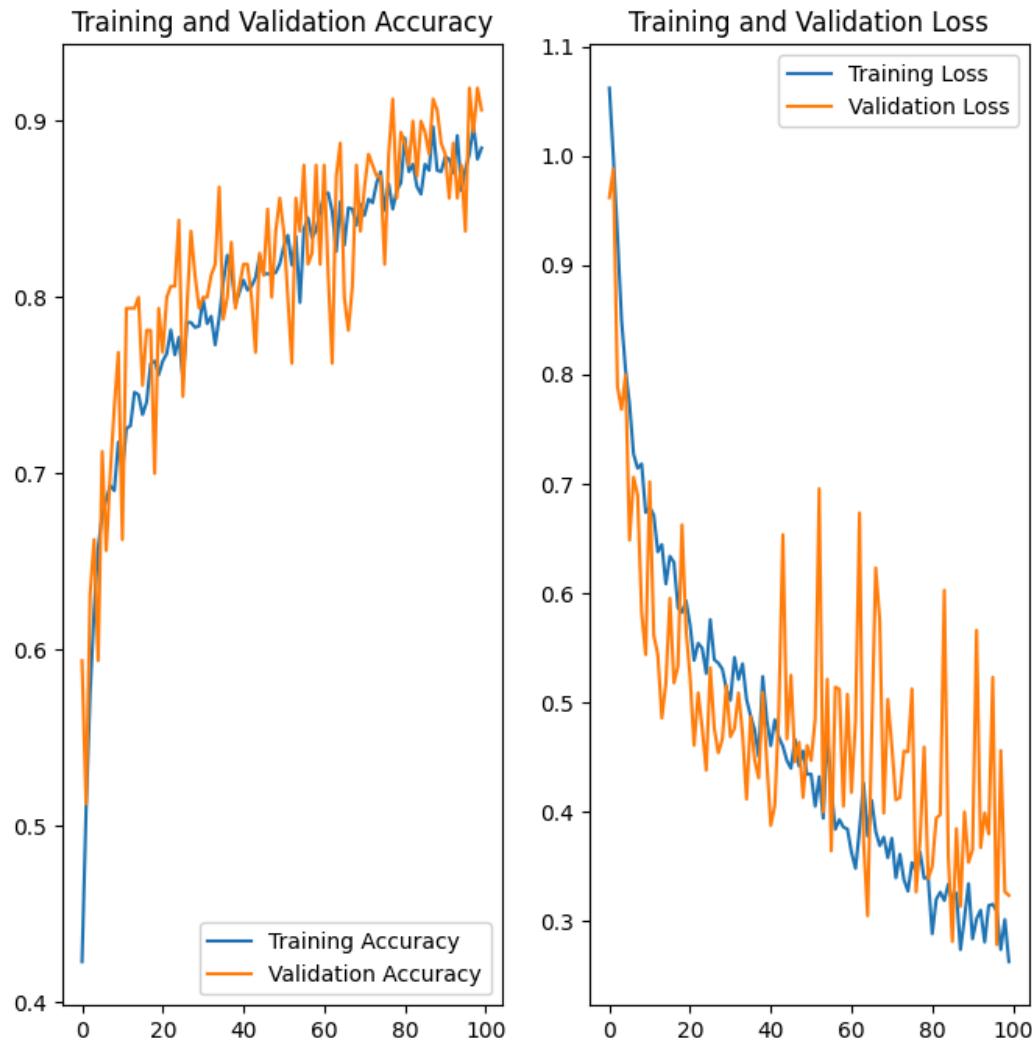
loss = history.history['loss']
val_loss = history.history['val_loss']
```

```

plt.figure(figsize=(8, 8))
plt.subplot(1, 2, 1)
plt.plot(range(len(acc)), acc, label='Training Accuracy')
plt.plot(range(len(val_acc)), val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

plt.subplot(1, 2, 2)
plt.plot(range(len(loss)), loss, label='Training Loss')
plt.plot(range(len(val_loss)), val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')
plt.show()

```



- Run prediction on a sample image

```

import numpy as np
for images_batch, labels_batch in test_ds.take(1):

    first_image = images_batch[0].numpy().astype('uint8')
    first_label = labels_batch[0].numpy()

    print("first image to predict")
    plt.imshow(first_image)
    print("actual label:", class_names[first_label])

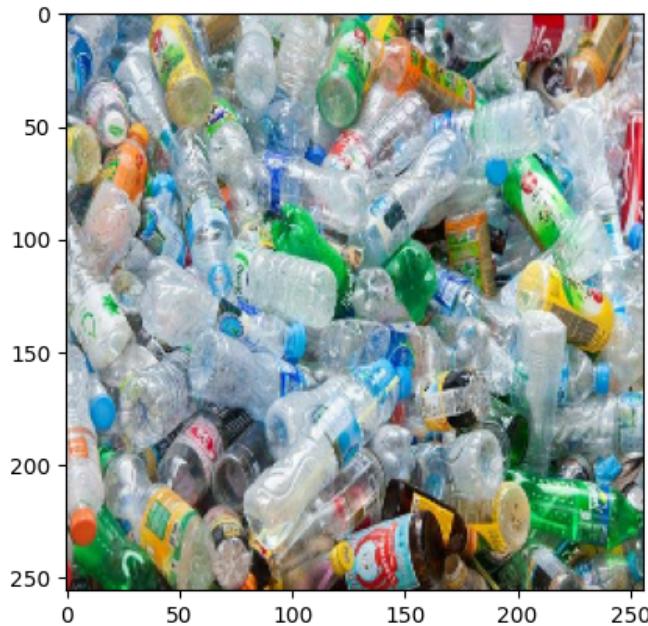
```

```

batch_prediction = model.predict(images_batch)
print("predicted label:", class_names[np.argmax(batch_prediction[0])])

first image to predict
actual label: plastic
1/1 ━━━━━━ 1s 515ms/step
predicted label: e-waste

```



✓ Write a function for inference

```

def predict(model, img):
    img_array = tf.keras.preprocessing.image.img_to_array(images[i].numpy())
    img_array = tf.expand_dims(img_array, 0)

    predictions = model.predict(img_array)

    predicted_class = class_names[np.argmax(predictions[0])]
    confidence = round(100 * (np.max(predictions[0])), 2)
    return predicted_class, confidence

```

Now run inference on few sample images

```

plt.figure(figsize=(15, 15))
for images, labels in test_ds.take(1):
    for i in range(9):
        ax = plt.subplot(3, 3, i + 1)
        plt.imshow(images[i].numpy().astype("uint8"))

        predicted_class, confidence = predict(model, images[i].numpy())
        actual_class = class_names[labels[i]]

        plt.title(f"Actual: {actual_class},\n Predicted: {predicted_class}.\n Confidence: {confidence}%")

    plt.axis("off")

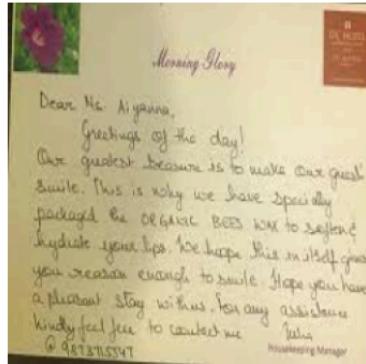
```

1/1	1s	1s/step
1/1	0s	27ms/step
1/1	0s	27ms/step
1/1	0s	27ms/step
1/1	0s	30ms/step
1/1	0s	28ms/step
1/1	0s	27ms/step
1/1	0s	26ms/step
1/1	0s	30ms/step

Actual: e-waste,
Predicted: e-waste.
Confidence: 99.94000244140625%



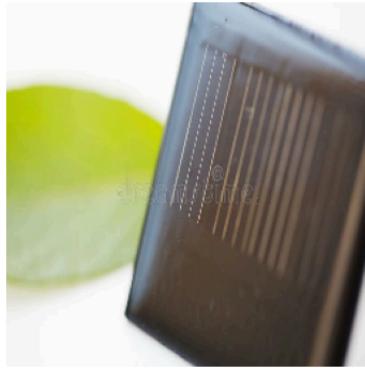
Actual: paper,
Predicted: paper.
Confidence: 98.95999908447266%



Actual: e-waste,
Predicted: e-waste.
Confidence: 100.0%



Actual: e-waste,
Predicted: e-waste.
Confidence: 99.63999938964844%



Actual: e-waste,
Predicted: e-waste.
Confidence: 92.98999786376953%



Actual: paper,
Predicted: paper.
Confidence: 79.16999816894531%



Actual: plastic,
Predicted: plastic.
Confidence: 99.9800033569336%



Actual: plastic,
Predicted: plastic.
Confidence: 99.98999786376953%



Actual: paper,
Predicted: paper.
Confidence: 99.63999938964844%



✓ Saving the Model

- ✓ We append the model to the list of models as a new version

```
model.save("../trash.keras")
```

```
import os
print(os.getcwd())

print(os.path.exists("../models"))
!ls /models

/content
False
ls: cannot access '/models': No such file or directory
```

```
import tensorflow as tf
from tensorflow.keras import metrics

model.compile(
    optimizer='adam',
    loss='binary_crossentropy',
    metrics=[
        'accuracy',
        metrics.Precision(name='precision'),
        metrics.Recall(name='recall')
    ]
)
```

Calculates the confusion matrix based on the true and predicted labels. The code plots the confusion matrix using Seaborn's heatmap, displaying the counts of true positives, false positives, and false negatives for each class. The resulting heatmap provides a visual representation of the model's classification performance, with labeled axes for easy interpretation.

```
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix

# Step 1: Generate predictions on the test dataset
y_true = []
y_pred = []

for images, labels in test_ds:
    predictions = model.predict(images)
    predicted_classes = np.argmax(predictions, axis=1)

    y_true.extend(labels.numpy())
    y_pred.extend(predicted_classes)

# Step 2: Calculate the confusion matrix
conf_matrix = confusion_matrix(y_true, y_pred)

# Step 3: Plot the confusion matrix
plt.figure(figsize=(10, 8))
sns.heatmap(conf_matrix, annot=True, fmt='d', cmap='Blues',
            xticklabels=class_names, yticklabels=class_names)
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.title('Confusion Matrix')
plt.show()
```

1/1 1s 512ms/step
1/1 0s 63ms/step
1/1 0s 64ms/step
1/1 0s 55ms/step
1/1 0s 55ms/step
1/1 0s 54ms/step
1/1 0s 56ms/step

Confusion Matrix

