```
# Mount to Google Drive for downloading dataset file

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

```
Mounted at /content/gdrive/
```

```
# Unzip the dataset file

!unzip /content/gdrive/MyDrive/deep-learning-recycle-item-classification-main.zip
```

```
Archive:  /content/gdrive/MyDrive/deep-learning-recycle-item-classification-main.zip
33ae657e01683187bb19c4351555cd56aa5329d3
   creating: deep-learning-recycle-item-classification-main/
  inflating: deep-learning-recycle-item-classification-main/LICENSE
  inflating: deep-learning-recycle-item-classification-main/README.md
   creating: deep-learning-recycle-item-classification-main/code/
  inflating: deep-learning-recycle-item-classification-main/code/deep-learning-real-life-item-classification.ipynb
  inflating: deep-learning-recycle-item-classification-main/code/deep-learning-real-life-item-classification.pdf
   creating: deep-learning-recycle-item-classification-main/dataset/
  inflating: deep-learning-recycle-item-classification-main/dataset/Dataset.zip
   creating: deep-learning-recycle-item-classification-main/images/
  inflating: deep-learning-recycle-item-classification-main/images/accuracy-validation.png
  inflating: deep-learning-recycle-item-classification-main/images/confusion-matrix.png
  inflating: deep-learning-recycle-item-classification-main/images/item-classification-deep-learning.png
  inflating: deep-learning-recycle-item-classification-main/images/loss-validation.png
```

```
import pandas as pd
import numpy as np
import glob
import os
from datetime import datetime
from packaging import version

import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.applications import EfficientNetB0
from tensorflow.keras.preprocessing import image_dataset_from_directory
from tensorflow.keras.preprocessing.image import load_img, img_to_array
from tensorflow.keras.callbacks import ModelCheckpoint, History

from tensorflow.keras.models import Sequential, load_model
from tensorflow.keras.layers import Conv2D, Lambda, MaxPooling2D, Dense, Dropout, Flatten
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.utils import to_categorical

from skimage.io import imread, imshow
from skimage.transform import resize
from IPython import display
import matplotlib.pyplot as plt
import seaborn as sns
from seaborn import heatmap
from sklearn.metrics import confusion_matrix
```

```
!unzip /content/deep-learning-recycle-item-classification-main/dataset/Dataset.zip
```

```
          inflating: Dataset/Train/Non-recyclable/O_51.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_51.jpg
          inflating: Dataset/Train/Non-recyclable/O_45.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_45.jpg
          inflating: Dataset/Train/Non-recyclable/O_79.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_79.jpg
          inflating: Dataset/Train/Non-recyclable/O_41.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_41.jpg
          inflating: Dataset/Train/Non-recyclable/O_55.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_55.jpg
          inflating: Dataset/Train/Non-recyclable/O_69.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_69.jpg
          inflating: Dataset/Train/Non-recyclable/O_82.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_82.jpg
          inflating: Dataset/Train/Non-recyclable/O_96.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_96.jpg
          inflating: Dataset/Train/Non-recyclable/O_264.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_264.jpg
          inflating: Dataset/Train/Non-recyclable/O_270.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_270.jpg
          inflating: Dataset/Train/Non-recyclable/O_258.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_258.jpg
          inflating: Dataset/Train/Non-recyclable/O_476.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_476.jpg
          inflating: Dataset/Train/Non-recyclable/O_310.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_310.jpg
          inflating: Dataset/Train/Non-recyclable/O_304.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_304.jpg
          inflating: Dataset/Train/Non-recyclable/O_462.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_462.jpg
          inflating: Dataset/Train/Non-recyclable/O_338.jpg
          inflating: __MACOSX/Dataset/Train/Non-recyclable/._O_338.jpg
          inflating: Dataset/Train/Non-recyclable/O_6.jpg
```

```
# Define train and test image folder path

train_folder = "/content/Dataset/Train"
test_folder = "/content/Dataset/Test"


from tensorflow.keras.applications.efficientnet import preprocess_input

# Data augmentation for training
train_datagen = ImageDataGenerator(
    preprocessing_function=preprocess_input,  # EfficientNetB0-specific preprocessing
    rotation_range=30,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True,
    fill_mode='nearest'
)



 # No augmentation for validation
test_datagen = ImageDataGenerator(preprocessing_function=preprocess_input)



# Load dataset
train_generator = train_datagen.flow_from_directory(
    train_folder,
    target_size=(224, 224),
    batch_size=32,
    class_mode='binary')
```

```
Found 999 images belonging to 2 classes.
```

```
test_generator = test_datagen.flow_from_directory(
    test_folder,
    target_size=(224, 224),
    batch_size=32,
    class_mode='binary',
    shuffle=False)
```

```
Found 1234 images belonging to 2 classes.
```

```
from sklearn.utils.class_weight import compute_class_weight
# Compute class weights to address imbalance
class_labels = np.array(train_generator.classes)
class_weights = compute_class_weight(class_weight='balanced', classes=np.unique(class_labels), y=class_labels)
class_weight_dict = {i: class_weights[i] for i in range(len(class_weights))}
```

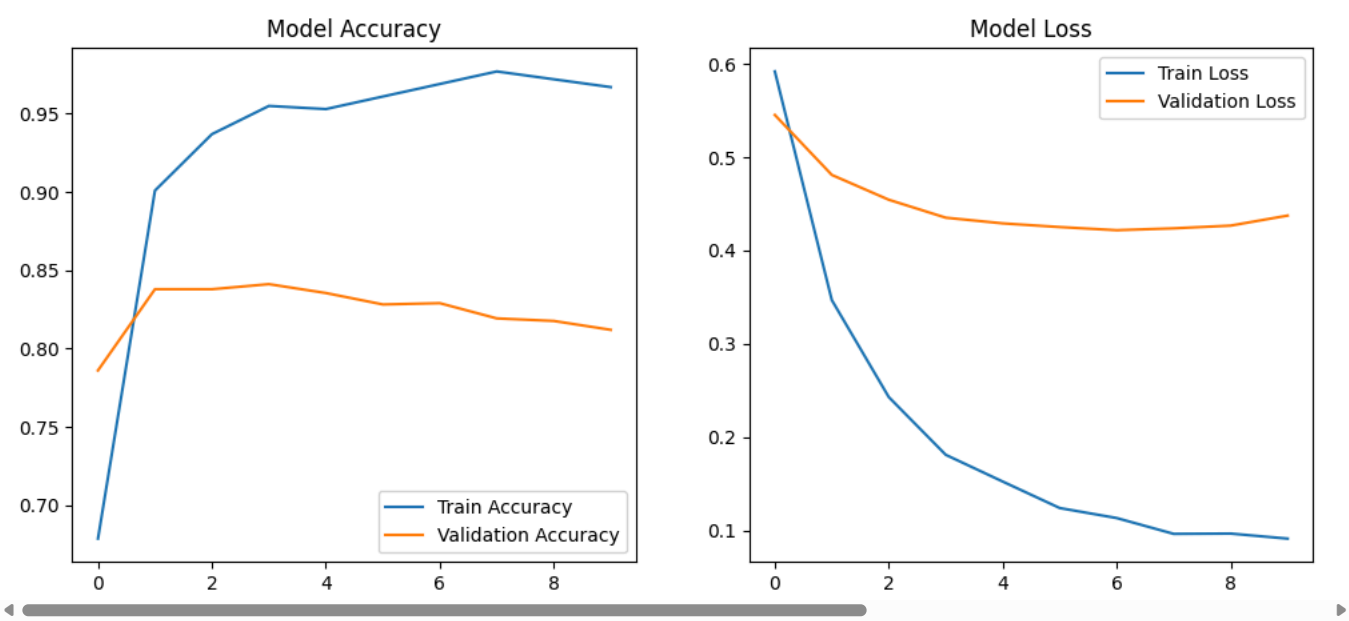
```
# Load EfficientNetB0 base model (pre-trained on ImageNet)
base_model = EfficientNetB0(weights='imagenet', include_top=False, input_shape=(224, 224, 3))
```

```
Downloading data from https://storage.googleapis.com/keras-applications/efficientnetb0_notop.h5
16705208/16705208 ━━━━━━━━━━━━━━━━━━━━ 0s 0us/step
```

```
base_model.trainable = False


model = keras.Sequential([
    base_model,
    keras.layers.GlobalAveragePooling2D(),
    keras.layers.Dense(128, activation='relu'),
    keras.layers.Dropout(0.5),
    keras.layers.Dense(1, activation='sigmoid')
])



from tensorflow.keras.optimizers import Adam
#Compile the model
model.compile(optimizer=Adam(learning_rate=0.0001), loss='binary_crossentropy', metrics=['accuracy'])


# Train model
history = model.fit(
    train_generator,
    epochs=10,
    validation_data=test_generator,
    class_weight=class_weight_dict)
```

```
/usr/local/lib/python3.11/dist-packages/keras/src/trainers/data_adapters/py_dataset_adapter.py:121: UserWarning: Your `PyDataset` cl
  self._warn_if_super_not_called()
Epoch 1/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 208s 6s/step - accuracy: 0.5819 - loss: 0.6742 - val_accuracy: 0.7861 - val_loss: 0.5451
Epoch 2/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 186s 6s/step - accuracy: 0.8917 - loss: 0.3703 - val_accuracy: 0.8379 - val_loss: 0.4809
Epoch 3/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 194s 6s/step - accuracy: 0.9405 - loss: 0.2452 - val_accuracy: 0.8379 - val_loss: 0.4544
Epoch 4/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 188s 6s/step - accuracy: 0.9487 - loss: 0.1903 - val_accuracy: 0.8412 - val_loss: 0.4351
Epoch 5/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 232s 7s/step - accuracy: 0.9443 - loss: 0.1633 - val_accuracy: 0.8355 - val_loss: 0.4291
Epoch 6/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 240s 8s/step - accuracy: 0.9587 - loss: 0.1329 - val_accuracy: 0.8282 - val_loss: 0.4251
Epoch 7/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 191s 6s/step - accuracy: 0.9734 - loss: 0.1166 - val_accuracy: 0.8290 - val_loss: 0.4218
Epoch 8/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 199s 6s/step - accuracy: 0.9754 - loss: 0.1056 - val_accuracy: 0.8193 - val_loss: 0.4237
Epoch 9/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 199s 6s/step - accuracy: 0.9695 - loss: 0.0998 - val_accuracy: 0.8177 - val_loss: 0.4267
Epoch 10/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 237s 8s/step - accuracy: 0.9699 - loss: 0.0943 - val_accuracy: 0.8120 - val_loss: 0.4374
```

```
# Plot accuracy and loss
fig, axes = plt.subplots(1, 2, figsize=(12, 5))
axes[0].plot(history.history['accuracy'], label='Train Accuracy')
axes[0].plot(history.history['val_accuracy'], label='Validation Accuracy')
axes[0].set_title('Model Accuracy')
axes[0].legend()
axes[1].plot(history.history['loss'], label='Train Loss')
axes[1].plot(history.history['val_loss'], label='Validation Loss')
axes[1].set_title('Model Loss')
axes[1].legend()
plt.show()
```

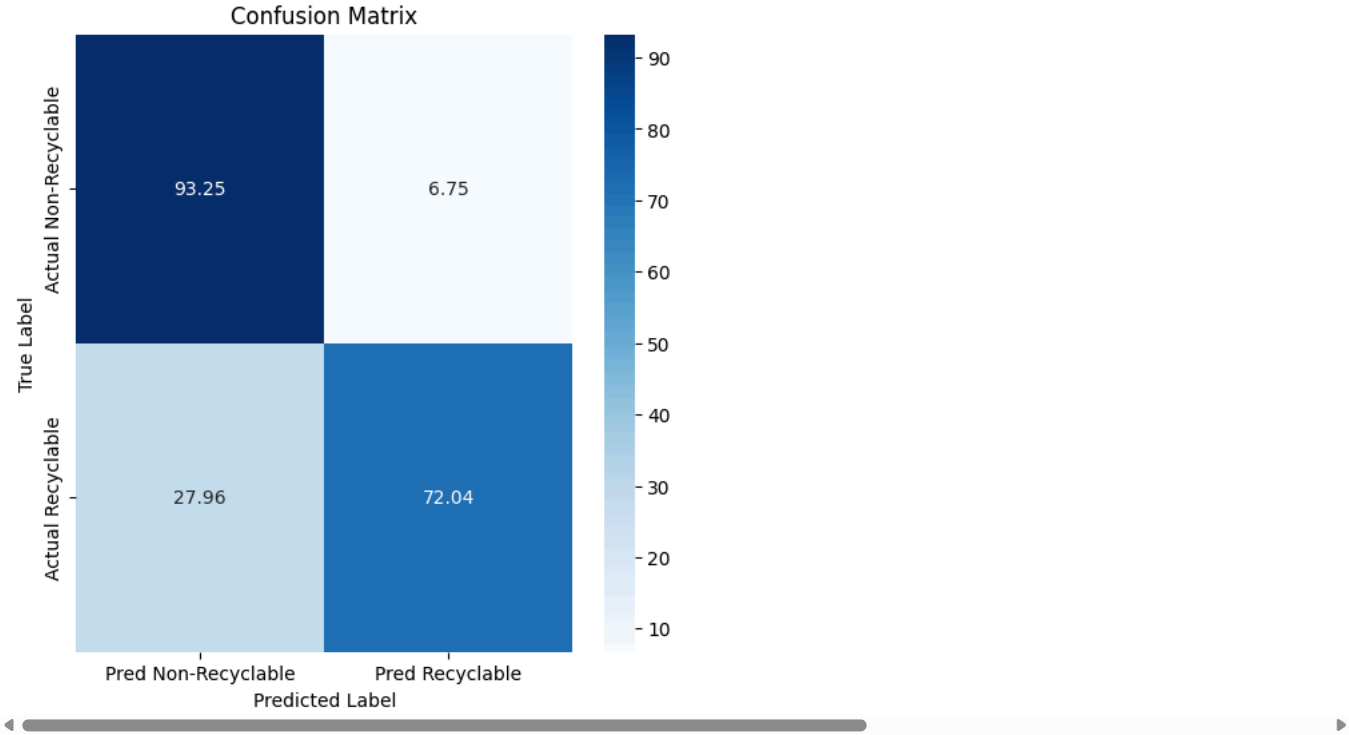



```
# Confusion matrix
y_true = test_generator.classes
y_pred = model.predict(test_generator) > 0.5
cm = confusion_matrix(y_true, y_pred)
```

```
39/39 ━━━━━━━━━━━━━━━━━━━━ 107s 3s/step
```

```
# Display confusion matrix with labels and percentages
fig, ax = plt.subplots(figsize=(6, 6))
cm_percent = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis] * 100
sns.heatmap(cm_percent, annot=True, fmt='.2f', cmap='Blues', xticklabels=['Pred Non-Recyclable', 'Pred Recyclable'],
            yticklabels=['Actual Non-Recyclable', 'Actual Recyclable'])
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.title('Confusion Matrix')
```

```
Text(0.5, 1.0, 'Confusion Matrix')
```




```
from sklearn.metrics import classification_report
# Classification report
print("Classification Report:")
print(classification_report(y_true, y_pred, target_names=['Non-Recyclable', 'Recyclable']))
```

```
Classification Report:
                precision    recall  f1-score   support
```

```
       Non-Recyclable       0.72      0.93      0.81       533
           Recyclable       0.93      0.72      0.81       701

             accuracy                           0.81      1234
            macro avg       0.83      0.83      0.81      1234
         weighted avg       0.84      0.81      0.81      1234
```

```
# Convert accuracy and loss to percentage
train_acc = [x * 100 for x in history.history['accuracy']]
val_acc = [x * 100 for x in history.history['val_accuracy']]
train_loss = [x * 100 for x in history.history['loss']]
val_loss = [x * 100 for x in history.history['val_loss']]
# Print accuracy and loss values
print("Final Training Accuracy: {:.2f}%".format(train_acc[-1]))
print("Final Validation Accuracy: {:.2f}%".format(val_acc[-1]))
print("Final Training Loss: {:.2f}%".format(train_loss[-1]))
print("Final Validation Loss: {:.2f}%".format(val_loss[-1]))
```

```
Final Training Accuracy: 96.70%
Final Validation Accuracy: 81.20%
Final Training Loss: 9.16%
Final Validation Loss: 43.74%
```