rsnet_external_analysis

December 12, 2024

```
[1]: # Install basic modules and make sure they are available with the latest pip␣
     ↪version.
     # Always updating PIP could be either good or bad, you just have to choose one␣
     ↪base on the situation around.

     # I use --quiet and --no-warn-script-location to hide the output of my␣
     ↪directory paths
     import sys
     import os

     !{sys.executable} -m pip install --upgrade pip matplotlib numpy␣
      ↪tensorflow-macos tensorflow-metal scikit-learn --quiet␣
      ↪--no-warn-script-location
```

```
[1]: from sklearn.model_selection import train_test_split
     from tensorflow.keras.utils import to_categorical
     import tensorflow as tf
     from tensorflow.keras import layers, models
     from tensorflow.keras import Model
     import numpy as np
     import os
     from PIL import Image
     import glob

     # Define dataset path
     dataset_path = os.path.join(os.getcwd().replace("investigation",␣
      ↪"kaggledataset"), 'garbage_classification')

     # Load all images and labels
     image_data = []
     labels = []
     class_names = sorted(os.listdir(dataset_path))
     print(f"Classes: {class_names}")

     for class_idx, class_name in enumerate(class_names):
         class_folder = os.path.join(dataset_path, class_name)
         if os.path.isdir(class_folder):
```

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        for img_file in glob.glob(os.path.join(class_folder, "*.jpg")):
            try:
                # Open the image, resize, and normalize
                img = Image.open(img_file).convert("RGB").resize((256, 256))
                image_data.append(np.array(img) / 255.0)  # Normalize to 0-1␣
  ↪range
                labels.append(class_idx)
            except Exception as e:
                print(f"Error loading image {img_file}: {e}")


# Convert to NumPy arrays
image_data = np.array(image_data, dtype="float32")
labels = np.array(labels)

# One-hot encode the labels
labels_one_hot = to_categorical(labels, num_classes=len(class_names))

# Split data into 80/20 train/validation
train_data, test_data, train_labels, test_labels = train_test_split(
    image_data, labels_one_hot, test_size=0.2, random_state=42, stratify=labels
)

print(f"Train data shape: {train_data.shape}")
print(f"Train labels shape: {train_labels.shape}")
print(f"Validation data shape: {test_data.shape}")
print(f"Validation labels shape: {test_labels.shape}")
```

```
Classes: ['battery', 'biological', 'brown-glass', 'cardboard', 'clothes',
'green-glass', 'metal', 'paper', 'plastic', 'shoes', 'trash', 'white-glass']
Train data shape: (12412, 256, 256, 3)
Train labels shape: (12412, 12)
Validation data shape: (3103, 256, 256, 3)
Validation labels shape: (3103, 12)
```

```python
[2]: from tensorflow.keras.applications import ResNet50
from tensorflow.keras.layers import Dense, GlobalAveragePooling2D, Dropout
from tensorflow.keras.models import Model
from tensorflow.keras.callbacks import EarlyStopping, LearningRateScheduler
from sklearn.utils.class_weight import compute_class_weight

num_classes = len(class_names)  # Number of classes in the dataset

# Load the ResNet50 model with pretrained weights
base_model = ResNet50(
    weights='imagenet',     # Use pretrained weights
    include_top=False,      # Exclude the fully connected top layers
    input_shape=(256, 256, 3)  # Input shape must match your data
```

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)

# Freeze the base model layers (optional, for transfer learning)
for layer in base_model.layers:
    layer.trainable = False

# Add custom layers for your dataset
x = base_model.output
x = GlobalAveragePooling2D()(x)  # Replace Flatten with GlobalAveragePooling2D
 ↪for better performance
x = Dense(512, activation=None, kernel_initializer='he_normal',
 ↪kernel_regularizer=tf.keras.regularizers.l2(0.01))(x)
x = layers.BatchNormalization()(x)
x = layers.ReLU()(x)
x = Dropout(0.5)(x)
output = Dense(num_classes, activation='softmax',
 ↪kernel_initializer='he_normal')(x)

# Create the final model
model = Model(inputs=base_model.input, outputs=output)

model.summary()
```

```
2024-12-12 15:07:01.469760: I metal_plugin/src/device/metal_device.cc:1154]
Metal device set to: Apple M3 Max
2024-12-12 15:07:01.469788: I metal_plugin/src/device/metal_device.cc:296]
systemMemory: 48.00 GB
2024-12-12 15:07:01.469793: I metal_plugin/src/device/metal_device.cc:313]
maxCacheSize: 18.00 GB
2024-12-12 15:07:01.469807: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2024-12-12 15:07:01.469817: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)
```

Model: "functional"

Layer (type)	Output Shape	Param #	Connected to
input_layer (InputLayer)	(None, 256, 256, 3)	0	-

Layer	Output Shape	Param #	Connected to
conv1_pad (ZeroPadding2D)	(None, 262, 262, 3)	0	input_layer[0][0]
conv1_conv (Conv2D)	(None, 128, 128, 64)	9,472	conv1_pad[0][0]
conv1_bn (BatchNormalizatio…)	(None, 128, 128, 64)	256	conv1_conv[0][0]
conv1_relu (Activation)	(None, 128, 128, 64)	0	conv1_bn[0][0]
pool1_pad (ZeroPadding2D)	(None, 130, 130, 64)	0	conv1_relu[0][0]
pool1_pool (MaxPooling2D)	(None, 64, 64, 64)	0	pool1_pad[0][0]
conv2_block1_1_conv (Conv2D)	(None, 64, 64, 64)	4,160	pool1_pool[0][0]
conv2_block1_1_bn (BatchNormalizatio…)	(None, 64, 64, 64)	256	conv2_block1_1_c…
conv2_block1_1_relu (Activation)	(None, 64, 64, 64)	0	conv2_block1_1_b…
conv2_block1_2_conv (Conv2D)	(None, 64, 64, 64)	36,928	conv2_block1_1_r…
conv2_block1_2_bn (BatchNormalizatio…)	(None, 64, 64, 64)	256	conv2_block1_2_c…
conv2_block1_2_relu (Activation)	(None, 64, 64, 64)	0	conv2_block1_2_b…
conv2_block1_0_conv (Conv2D)	(None, 64, 64, 256)	16,640	pool1_pool[0][0]
conv2_block1_3_conv (Conv2D)	(None, 64, 64, 256)	16,640	conv2_block1_2_r…
conv2_block1_0_bn (BatchNormalizatio…)	(None, 64, 64, 256)	1,024	conv2_block1_0_c…
conv2_block1_3_bn (BatchNormalizatio…)	(None, 64, 64, 256)	1,024	conv2_block1_3_c…

conv2_block1_add (Add)	(None, 64, 64, 256)	0	conv2_block1_0_b… conv2_block1_3_b…
conv2_block1_out (Activation)	(None, 64, 64, 256)	0	conv2_block1_add…
conv2_block2_1_conv (Conv2D)	(None, 64, 64, 64)	16,448	conv2_block1_out…
conv2_block2_1_bn (BatchNormalizatio…)	(None, 64, 64, 64)	256	conv2_block2_1_c…
conv2_block2_1_relu (Activation)	(None, 64, 64, 64)	0	conv2_block2_1_b…
conv2_block2_2_conv (Conv2D)	(None, 64, 64, 64)	36,928	conv2_block2_1_r…
conv2_block2_2_bn (BatchNormalizatio…)	(None, 64, 64, 64)	256	conv2_block2_2_c…
conv2_block2_2_relu (Activation)	(None, 64, 64, 64)	0	conv2_block2_2_b…
conv2_block2_3_conv (Conv2D)	(None, 64, 64, 256)	16,640	conv2_block2_2_r…
conv2_block2_3_bn (BatchNormalizatio…)	(None, 64, 64, 256)	1,024	conv2_block2_3_c…
conv2_block2_add (Add)	(None, 64, 64, 256)	0	conv2_block1_out… conv2_block2_3_b…
conv2_block2_out (Activation)	(None, 64, 64, 256)	0	conv2_block2_add…
conv2_block3_1_conv (Conv2D)	(None, 64, 64, 64)	16,448	conv2_block2_out…
conv2_block3_1_bn (BatchNormalizatio…)	(None, 64, 64, 64)	256	conv2_block3_1_c…
conv2_block3_1_relu (Activation)	(None, 64, 64, 64)	0	conv2_block3_1_b…
conv2_block3_2_conv (Conv2D)	(None, 64, 64, 64)	36,928	conv2_block3_1_r…

conv2_block3_2_bn (BatchNormalizatio…	(None, 64, 64, 64)	256	conv2_block3_2_c…
conv2_block3_2_relu (Activation)	(None, 64, 64, 64)	0	conv2_block3_2_b…
conv2_block3_3_conv (Conv2D)	(None, 64, 64, 256)	16,640	conv2_block3_2_r…
conv2_block3_3_bn (BatchNormalizatio…	(None, 64, 64, 256)	1,024	conv2_block3_3_c…
conv2_block3_add (Add)	(None, 64, 64, 256)	0	conv2_block2_out… conv2_block3_3_b…
conv2_block3_out (Activation)	(None, 64, 64, 256)	0	conv2_block3_add…
conv3_block1_1_conv (Conv2D)	(None, 32, 32, 128)	32,896	conv2_block3_out…
conv3_block1_1_bn (BatchNormalizatio…	(None, 32, 32, 128)	512	conv3_block1_1_c…
conv3_block1_1_relu (Activation)	(None, 32, 32, 128)	0	conv3_block1_1_b…
conv3_block1_2_conv (Conv2D)	(None, 32, 32, 128)	147,584	conv3_block1_1_r…
conv3_block1_2_bn (BatchNormalizatio…	(None, 32, 32, 128)	512	conv3_block1_2_c…
conv3_block1_2_relu (Activation)	(None, 32, 32, 128)	0	conv3_block1_2_b…
conv3_block1_0_conv (Conv2D)	(None, 32, 32, 512)	131,584	conv2_block3_out…
conv3_block1_3_conv (Conv2D)	(None, 32, 32, 512)	66,048	conv3_block1_2_r…
conv3_block1_0_bn (BatchNormalizatio…	(None, 32, 32, 512)	2,048	conv3_block1_0_c…
conv3_block1_3_bn (BatchNormalizatio…	(None, 32, 32, 512)	2,048	conv3_block1_3_c…

Layer	Output Shape	Param #	Connected to
conv3_block1_add (Add)	(None, 32, 32, 512)	0	conv3_block1_0_b… conv3_block1_3_b…
conv3_block1_out (Activation)	(None, 32, 32, 512)	0	conv3_block1_add…
conv3_block2_1_conv (Conv2D)	(None, 32, 32, 128)	65,664	conv3_block1_out…
conv3_block2_1_bn (BatchNormalizatio…)	(None, 32, 32, 128)	512	conv3_block2_1_c…
conv3_block2_1_relu (Activation)	(None, 32, 32, 128)	0	conv3_block2_1_b…
conv3_block2_2_conv (Conv2D)	(None, 32, 32, 128)	147,584	conv3_block2_1_r…
conv3_block2_2_bn (BatchNormalizatio…)	(None, 32, 32, 128)	512	conv3_block2_2_c…
conv3_block2_2_relu (Activation)	(None, 32, 32, 128)	0	conv3_block2_2_b…
conv3_block2_3_conv (Conv2D)	(None, 32, 32, 512)	66,048	conv3_block2_2_r…
conv3_block2_3_bn (BatchNormalizatio…)	(None, 32, 32, 512)	2,048	conv3_block2_3_c…
conv3_block2_add (Add)	(None, 32, 32, 512)	0	conv3_block1_out… conv3_block2_3_b…
conv3_block2_out (Activation)	(None, 32, 32, 512)	0	conv3_block2_add…
conv3_block3_1_conv (Conv2D)	(None, 32, 32, 128)	65,664	conv3_block2_out…
conv3_block3_1_bn (BatchNormalizatio…)	(None, 32, 32, 128)	512	conv3_block3_1_c…
conv3_block3_1_relu (Activation)	(None, 32, 32, 128)	0	conv3_block3_1_b…
conv3_block3_2_conv (Conv2D)	(None, 32, 32, 128)	147,584	conv3_block3_1_r…

conv3_block3_2_bn (BatchNormalizatio…)	(None, 32, 32, 128)	512	conv3_block3_2_c…
conv3_block3_2_relu (Activation)	(None, 32, 32, 128)	0	conv3_block3_2_b…
conv3_block3_3_conv (Conv2D)	(None, 32, 32, 512)	66,048	conv3_block3_2_r…
conv3_block3_3_bn (BatchNormalizatio…)	(None, 32, 32, 512)	2,048	conv3_block3_3_c…
conv3_block3_add (Add)	(None, 32, 32, 512)	0	conv3_block2_out… conv3_block3_3_b…
conv3_block3_out (Activation)	(None, 32, 32, 512)	0	conv3_block3_add…
conv3_block4_1_conv (Conv2D)	(None, 32, 32, 128)	65,664	conv3_block3_out…
conv3_block4_1_bn (BatchNormalizatio…)	(None, 32, 32, 128)	512	conv3_block4_1_c…
conv3_block4_1_relu (Activation)	(None, 32, 32, 128)	0	conv3_block4_1_b…
conv3_block4_2_conv (Conv2D)	(None, 32, 32, 128)	147,584	conv3_block4_1_r…
conv3_block4_2_bn (BatchNormalizatio…)	(None, 32, 32, 128)	512	conv3_block4_2_c…
conv3_block4_2_relu (Activation)	(None, 32, 32, 128)	0	conv3_block4_2_b…
conv3_block4_3_conv (Conv2D)	(None, 32, 32, 512)	66,048	conv3_block4_2_r…
conv3_block4_3_bn (BatchNormalizatio…)	(None, 32, 32, 512)	2,048	conv3_block4_3_c…
conv3_block4_add (Add)	(None, 32, 32, 512)	0	conv3_block3_out… conv3_block4_3_b…
conv3_block4_out (Activation)	(None, 32, 32, 512)	0	conv3_block4_add…

conv4_block1_1_conv (Conv2D)	(None, 16, 16, 256)	131,328	conv3_block4_out…
conv4_block1_1_bn (BatchNormalizatio…)	(None, 16, 16, 256)	1,024	conv4_block1_1_c…
conv4_block1_1_relu (Activation)	(None, 16, 16, 256)	0	conv4_block1_1_b…
conv4_block1_2_conv (Conv2D)	(None, 16, 16, 256)	590,080	conv4_block1_1_r…
conv4_block1_2_bn (BatchNormalizatio…)	(None, 16, 16, 256)	1,024	conv4_block1_2_c…
conv4_block1_2_relu (Activation)	(None, 16, 16, 256)	0	conv4_block1_2_b…
conv4_block1_0_conv (Conv2D)	(None, 16, 16, 1024)	525,312	conv3_block4_out…
conv4_block1_3_conv (Conv2D)	(None, 16, 16, 1024)	263,168	conv4_block1_2_r…
conv4_block1_0_bn (BatchNormalizatio…)	(None, 16, 16, 1024)	4,096	conv4_block1_0_c…
conv4_block1_3_bn (BatchNormalizatio…)	(None, 16, 16, 1024)	4,096	conv4_block1_3_c…
conv4_block1_add (Add)	(None, 16, 16, 1024)	0	conv4_block1_0_b… conv4_block1_3_b…
conv4_block1_out (Activation)	(None, 16, 16, 1024)	0	conv4_block1_add…
conv4_block2_1_conv (Conv2D)	(None, 16, 16, 256)	262,400	conv4_block1_out…
conv4_block2_1_bn (BatchNormalizatio…)	(None, 16, 16, 256)	1,024	conv4_block2_1_c…
conv4_block2_1_relu (Activation)	(None, 16, 16, 256)	0	conv4_block2_1_b…
conv4_block2_2_conv (Conv2D)	(None, 16, 16, 256)	590,080	conv4_block2_1_r…

conv4_block2_2_bn (BatchNormalizatio…	(None, 16, 16, 256)	1,024	conv4_block2_2_c…
conv4_block2_2_relu (Activation)	(None, 16, 16, 256)	0	conv4_block2_2_b…
conv4_block2_3_conv (Conv2D)	(None, 16, 16, 1024)	263,168	conv4_block2_2_r…
conv4_block2_3_bn (BatchNormalizatio…	(None, 16, 16, 1024)	4,096	conv4_block2_3_c…
conv4_block2_add (Add)	(None, 16, 16, 1024)	0	conv4_block1_out… conv4_block2_3_b…
conv4_block2_out (Activation)	(None, 16, 16, 1024)	0	conv4_block2_add…
conv4_block3_1_conv (Conv2D)	(None, 16, 16, 256)	262,400	conv4_block2_out…
conv4_block3_1_bn (BatchNormalizatio…	(None, 16, 16, 256)	1,024	conv4_block3_1_c…
conv4_block3_1_relu (Activation)	(None, 16, 16, 256)	0	conv4_block3_1_b…
conv4_block3_2_conv (Conv2D)	(None, 16, 16, 256)	590,080	conv4_block3_1_r…
conv4_block3_2_bn (BatchNormalizatio…	(None, 16, 16, 256)	1,024	conv4_block3_2_c…
conv4_block3_2_relu (Activation)	(None, 16, 16, 256)	0	conv4_block3_2_b…
conv4_block3_3_conv (Conv2D)	(None, 16, 16, 1024)	263,168	conv4_block3_2_r…
conv4_block3_3_bn (BatchNormalizatio…	(None, 16, 16, 1024)	4,096	conv4_block3_3_c…
conv4_block3_add (Add)	(None, 16, 16, 1024)	0	conv4_block2_out… conv4_block3_3_b…
conv4_block3_out (Activation)	(None, 16, 16, 1024)	0	conv4_block3_add…

Layer (type)	Output Shape	Param #	Connected to
conv4_block4_1_conv (Conv2D)	(None, 16, 16, 256)	262,400	conv4_block3_out…
conv4_block4_1_bn (BatchNormalizatio…)	(None, 16, 16, 256)	1,024	conv4_block4_1_c…
conv4_block4_1_relu (Activation)	(None, 16, 16, 256)	0	conv4_block4_1_b…
conv4_block4_2_conv (Conv2D)	(None, 16, 16, 256)	590,080	conv4_block4_1_r…
conv4_block4_2_bn (BatchNormalizatio…)	(None, 16, 16, 256)	1,024	conv4_block4_2_c…
conv4_block4_2_relu (Activation)	(None, 16, 16, 256)	0	conv4_block4_2_b…
conv4_block4_3_conv (Conv2D)	(None, 16, 16, 1024)	263,168	conv4_block4_2_r…
conv4_block4_3_bn (BatchNormalizatio…)	(None, 16, 16, 1024)	4,096	conv4_block4_3_c…
conv4_block4_add (Add)	(None, 16, 16, 1024)	0	conv4_block3_out… conv4_block4_3_b…
conv4_block4_out (Activation)	(None, 16, 16, 1024)	0	conv4_block4_add…
conv4_block5_1_conv (Conv2D)	(None, 16, 16, 256)	262,400	conv4_block4_out…
conv4_block5_1_bn (BatchNormalizatio…)	(None, 16, 16, 256)	1,024	conv4_block5_1_c…
conv4_block5_1_relu (Activation)	(None, 16, 16, 256)	0	conv4_block5_1_b…
conv4_block5_2_conv (Conv2D)	(None, 16, 16, 256)	590,080	conv4_block5_1_r…
conv4_block5_2_bn (BatchNormalizatio…)	(None, 16, 16, 256)	1,024	conv4_block5_2_c…
conv4_block5_2_relu (Activation)	(None, 16, 16, 256)	0	conv4_block5_2_b…

conv4_block5_3_conv (Conv2D)	(None, 16, 16, 1024)	263,168	conv4_block5_2_r…
conv4_block5_3_bn (BatchNormalizatio…)	(None, 16, 16, 1024)	4,096	conv4_block5_3_c…
conv4_block5_add (Add)	(None, 16, 16, 1024)	0	conv4_block4_out… conv4_block5_3_b…
conv4_block5_out (Activation)	(None, 16, 16, 1024)	0	conv4_block5_add…
conv4_block6_1_conv (Conv2D)	(None, 16, 16, 256)	262,400	conv4_block5_out…
conv4_block6_1_bn (BatchNormalizatio…)	(None, 16, 16, 256)	1,024	conv4_block6_1_c…
conv4_block6_1_relu (Activation)	(None, 16, 16, 256)	0	conv4_block6_1_b…
conv4_block6_2_conv (Conv2D)	(None, 16, 16, 256)	590,080	conv4_block6_1_r…
conv4_block6_2_bn (BatchNormalizatio…)	(None, 16, 16, 256)	1,024	conv4_block6_2_c…
conv4_block6_2_relu (Activation)	(None, 16, 16, 256)	0	conv4_block6_2_b…
conv4_block6_3_conv (Conv2D)	(None, 16, 16, 1024)	263,168	conv4_block6_2_r…
conv4_block6_3_bn (BatchNormalizatio…)	(None, 16, 16, 1024)	4,096	conv4_block6_3_c…
conv4_block6_add (Add)	(None, 16, 16, 1024)	0	conv4_block5_out… conv4_block6_3_b…
conv4_block6_out (Activation)	(None, 16, 16, 1024)	0	conv4_block6_add…
conv5_block1_1_conv (Conv2D)	(None, 8, 8, 512)	524,800	conv4_block6_out…
conv5_block1_1_bn (BatchNormalizatio…)	(None, 8, 8, 512)	2,048	conv5_block1_1_c…

Layer (type)	Output Shape	Param #	Connected to
conv5_block1_1_relu (Activation)	(None, 8, 8, 512)	0	conv5_block1_1_b…
conv5_block1_2_conv (Conv2D)	(None, 8, 8, 512)	2,359,808	conv5_block1_1_r…
conv5_block1_2_bn (BatchNormalizatio…	(None, 8, 8, 512)	2,048	conv5_block1_2_c…
conv5_block1_2_relu (Activation)	(None, 8, 8, 512)	0	conv5_block1_2_b…
conv5_block1_0_conv (Conv2D)	(None, 8, 8, 2048)	2,099,200	conv4_block6_out…
conv5_block1_3_conv (Conv2D)	(None, 8, 8, 2048)	1,050,624	conv5_block1_2_r…
conv5_block1_0_bn (BatchNormalizatio…	(None, 8, 8, 2048)	8,192	conv5_block1_0_c…
conv5_block1_3_bn (BatchNormalizatio…	(None, 8, 8, 2048)	8,192	conv5_block1_3_c…
conv5_block1_add (Add)	(None, 8, 8, 2048)	0	conv5_block1_0_b… conv5_block1_3_b…
conv5_block1_out (Activation)	(None, 8, 8, 2048)	0	conv5_block1_add…
conv5_block2_1_conv (Conv2D)	(None, 8, 8, 512)	1,049,088	conv5_block1_out…
conv5_block2_1_bn (BatchNormalizatio…	(None, 8, 8, 512)	2,048	conv5_block2_1_c…
conv5_block2_1_relu (Activation)	(None, 8, 8, 512)	0	conv5_block2_1_b…
conv5_block2_2_conv (Conv2D)	(None, 8, 8, 512)	2,359,808	conv5_block2_1_r…
conv5_block2_2_bn (BatchNormalizatio…	(None, 8, 8, 512)	2,048	conv5_block2_2_c…
conv5_block2_2_relu (Activation)	(None, 8, 8, 512)	0	conv5_block2_2_b…

Layer (type)	Output Shape	Param #	Connected to
conv5_block2_3_conv (Conv2D)	(None, 8, 8, 2048)	1,050,624	conv5_block2_2_r…
conv5_block2_3_bn (BatchNormalizatio…)	(None, 8, 8, 2048)	8,192	conv5_block2_3_c…
conv5_block2_add (Add)	(None, 8, 8, 2048)	0	conv5_block1_out… conv5_block2_3_b…
conv5_block2_out (Activation)	(None, 8, 8, 2048)	0	conv5_block2_add…
conv5_block3_1_conv (Conv2D)	(None, 8, 8, 512)	1,049,088	conv5_block2_out…
conv5_block3_1_bn (BatchNormalizatio…)	(None, 8, 8, 512)	2,048	conv5_block3_1_c…
conv5_block3_1_relu (Activation)	(None, 8, 8, 512)	0	conv5_block3_1_b…
conv5_block3_2_conv (Conv2D)	(None, 8, 8, 512)	2,359,808	conv5_block3_1_r…
conv5_block3_2_bn (BatchNormalizatio…)	(None, 8, 8, 512)	2,048	conv5_block3_2_c…
conv5_block3_2_relu (Activation)	(None, 8, 8, 512)	0	conv5_block3_2_b…
conv5_block3_3_conv (Conv2D)	(None, 8, 8, 2048)	1,050,624	conv5_block3_2_r…
conv5_block3_3_bn (BatchNormalizatio…)	(None, 8, 8, 2048)	8,192	conv5_block3_3_c…
conv5_block3_add (Add)	(None, 8, 8, 2048)	0	conv5_block2_out… conv5_block3_3_b…
conv5_block3_out (Activation)	(None, 8, 8, 2048)	0	conv5_block3_add…
global_average_poo… (GlobalAveragePool…)	(None, 2048)	0	conv5_block3_out…
dense (Dense)	(None, 512)	1,049,088	global_average_p…
batch_normalization	(None, 512)	2,048	dense[0][0]

```
                 (BatchNormalizatio…

re_lu (ReLU)              (None, 512)                  0   batch_normalizat…

dropout (Dropout)         (None, 512)                  0   re_lu[0][0]

dense_1 (Dense)           (None, 12)              6,156   dropout[0][0]
```

Total params: 24,645,004 (94.01 MB)

Trainable params: 1,056,268 (4.03 MB)

Non-trainable params: 23,588,736 (89.98 MB)

[3]:
```python
from tensorflow.keras.optimizers import RMSprop, Adam

# Compile the model
# optimizer = RMSprop(learning_rate=0.0001)
optimizer = Adam(learning_rate=0.0001)
model.compile(
    optimizer=optimizer,
    loss='categorical_crossentropy',
    metrics=['accuracy']
)
```

[4]:
```python
# Compute class weights
class_weights = compute_class_weight('balanced', classes=np.unique(labels),
  ↪y=labels)
class_weights_dict = dict(enumerate(class_weights))

# Early stopping
early_stopping = EarlyStopping(monitor='val_accuracy', patience=15, verbose=1,
  ↪restore_best_weights=True)

# Cyclical Learning Rate
def cyclic_lr(epoch):
    base_lr = 1e-5
    max_lr = 1e-3
    step_size = 10
    cycle = np.floor(1 + epoch / (2 * step_size))
    x = np.abs(epoch / step_size - 2 * cycle + 1)
    lr = base_lr + (max_lr - base_lr) * max(0, (1 - x))
    return lr
```

```python
lr_scheduler = LearningRateScheduler(cyclic_lr)

# Fine-tune the model by unfreezing some layers
for layer in base_model.layers[-20:]:  # Unfreeze the last 20 layers
    layer.trainable = True

# Train the model
history = model.fit(
    train_data,
    train_labels,
    epochs=50,
    batch_size=32,
    validation_data=(test_data, test_labels),
    class_weight=class_weights_dict,
    callbacks=[early_stopping, lr_scheduler],
    verbose=1
)
```

Epoch 1/50

2024-12-12 15:07:11.128125: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:117]
Plugin optimizer for device_type GPU is enabled.

```
388/388              54s 125ms/step -
accuracy: 0.2257 - loss: 12.7667 - val_accuracy: 0.2008 - val_loss: 12.2093 -
learning_rate: 1.0000e-05
Epoch 2/50
388/388              45s 115ms/step -
accuracy: 0.3822 - loss: 11.3914 - val_accuracy: 0.4879 - val_loss: 9.6960 -
learning_rate: 1.0900e-04
Epoch 3/50
388/388              44s 113ms/step -
accuracy: 0.4717 - loss: 8.2815 - val_accuracy: 0.4012 - val_loss: 6.1949 -
learning_rate: 2.0800e-04
Epoch 4/50
388/388              44s 113ms/step -
accuracy: 0.5320 - loss: 5.0304 - val_accuracy: 0.4360 - val_loss: 5.3312 -
learning_rate: 3.0700e-04
Epoch 5/50
388/388              44s 113ms/step -
accuracy: 0.5497 - loss: 2.9395 - val_accuracy: 0.0777 - val_loss: 7.5575 -
learning_rate: 4.0600e-04
Epoch 6/50
388/388              44s 113ms/step -
accuracy: 0.5769 - loss: 2.0506 - val_accuracy: 0.4621 - val_loss: 3.1390 -
learning_rate: 5.0500e-04
Epoch 7/50
388/388              44s 114ms/step -
```

```
accuracy: 0.6054 - loss: 1.7088 - val_accuracy: 0.5111 - val_loss: 3.2382 -
learning_rate: 6.0400e-04
Epoch 8/50
388/388               44s 114ms/step -
accuracy: 0.6197 - loss: 1.5859 - val_accuracy: 0.3951 - val_loss: 5.1337 -
learning_rate: 7.0300e-04
Epoch 9/50
388/388               44s 113ms/step -
accuracy: 0.6299 - loss: 1.5417 - val_accuracy: 0.3748 - val_loss: 9.3504 -
learning_rate: 8.0200e-04
Epoch 10/50
388/388               44s 114ms/step -
accuracy: 0.6175 - loss: 1.5553 - val_accuracy: 0.1959 - val_loss: 6.9140 -
learning_rate: 9.0100e-04
Epoch 11/50
388/388               44s 113ms/step -
accuracy: 0.6277 - loss: 1.5166 - val_accuracy: 0.4028 - val_loss: 8.4890 -
learning_rate: 0.0010
Epoch 12/50
388/388               43s 112ms/step -
accuracy: 0.6442 - loss: 1.4497 - val_accuracy: 0.4473 - val_loss: 4.4517 -
learning_rate: 9.0100e-04
Epoch 13/50
388/388               44s 114ms/step -
accuracy: 0.6658 - loss: 1.3418 - val_accuracy: 0.3680 - val_loss: 2.8241 -
learning_rate: 8.0200e-04
Epoch 14/50
388/388               44s 114ms/step -
accuracy: 0.6922 - loss: 1.2262 - val_accuracy: 0.4544 - val_loss: 3.9176 -
learning_rate: 7.0300e-04
Epoch 15/50
388/388               44s 113ms/step -
accuracy: 0.7140 - loss: 1.1162 - val_accuracy: 0.2156 - val_loss: 7.9209 -
learning_rate: 6.0400e-04
Epoch 16/50
388/388               44s 112ms/step -
accuracy: 0.7409 - loss: 1.0379 - val_accuracy: 0.3841 - val_loss: 6.4740 -
learning_rate: 5.0500e-04
Epoch 17/50
388/388               44s 112ms/step -
accuracy: 0.7595 - loss: 0.9410 - val_accuracy: 0.3174 - val_loss: 3.4081 -
learning_rate: 4.0600e-04
Epoch 18/50
388/388               44s 112ms/step -
accuracy: 0.7884 - loss: 0.8466 - val_accuracy: 0.4760 - val_loss: 2.3501 -
learning_rate: 3.0700e-04
Epoch 19/50
388/388               44s 112ms/step -
```

```
accuracy: 0.8059 - loss: 0.7439 - val_accuracy: 0.6291 - val_loss: 1.6295 -
learning_rate: 2.0800e-04
Epoch 20/50
388/388              44s 112ms/step -
accuracy: 0.8408 - loss: 0.6067 - val_accuracy: 0.6307 - val_loss: 1.3244 -
learning_rate: 1.0900e-04
Epoch 21/50
388/388              44s 113ms/step -
accuracy: 0.8606 - loss: 0.5340 - val_accuracy: 0.7309 - val_loss: 0.9703 -
learning_rate: 1.0000e-05
Epoch 22/50
388/388              44s 112ms/step -
accuracy: 0.8633 - loss: 0.5340 - val_accuracy: 0.6884 - val_loss: 1.1729 -
learning_rate: 1.0900e-04
Epoch 23/50
388/388              44s 112ms/step -
accuracy: 0.8333 - loss: 0.6141 - val_accuracy: 0.3806 - val_loss: 3.0248 -
learning_rate: 2.0800e-04
Epoch 24/50
388/388              43s 112ms/step -
accuracy: 0.8139 - loss: 0.7081 - val_accuracy: 0.5840 - val_loss: 1.8834 -
learning_rate: 3.0700e-04
Epoch 25/50
388/388              43s 112ms/step -
accuracy: 0.7987 - loss: 0.7612 - val_accuracy: 0.3922 - val_loss: 3.9104 -
learning_rate: 4.0600e-04
Epoch 26/50
388/388              43s 112ms/step -
accuracy: 0.7691 - loss: 0.8777 - val_accuracy: 0.4550 - val_loss: 6.0465 -
learning_rate: 5.0500e-04
Epoch 27/50
388/388              43s 112ms/step -
accuracy: 0.7644 - loss: 0.9339 - val_accuracy: 0.3345 - val_loss: 8.1399 -
learning_rate: 6.0400e-04
Epoch 28/50
388/388              43s 112ms/step -
accuracy: 0.7426 - loss: 1.0089 - val_accuracy: 0.2159 - val_loss: 5.8257 -
learning_rate: 7.0300e-04
Epoch 29/50
388/388              44s 114ms/step -
accuracy: 0.7419 - loss: 1.0147 - val_accuracy: 0.0848 - val_loss: 14.3691 -
learning_rate: 8.0200e-04
Epoch 30/50
388/388              44s 114ms/step -
accuracy: 0.7357 - loss: 1.0806 - val_accuracy: 0.3764 - val_loss: 5.1753 -
learning_rate: 9.0100e-04
Epoch 31/50
388/388              44s 112ms/step -
```

```
accuracy: 0.7332 - loss: 1.1026 - val_accuracy: 0.4128 - val_loss: 8.3018 -
learning_rate: 0.0010
Epoch 32/50
388/388                44s 113ms/step -
accuracy: 0.7461 - loss: 1.0329 - val_accuracy: 0.1682 - val_loss: 7.6776 -
learning_rate: 9.0100e-04
Epoch 33/50
388/388                44s 113ms/step -
accuracy: 0.7690 - loss: 0.9324 - val_accuracy: 0.4956 - val_loss: 3.5357 -
learning_rate: 8.0200e-04
Epoch 34/50
388/388                43s 112ms/step -
accuracy: 0.7922 - loss: 0.8310 - val_accuracy: 0.1424 - val_loss: 7.9129 -
learning_rate: 7.0300e-04
Epoch 35/50
388/388                43s 112ms/step -
accuracy: 0.8012 - loss: 0.7879 - val_accuracy: 0.3497 - val_loss: 5.1748 -
learning_rate: 6.0400e-04
Epoch 36/50
388/388                43s 112ms/step -
accuracy: 0.8325 - loss: 0.6452 - val_accuracy: 0.4992 - val_loss: 4.1824 -
learning_rate: 5.0500e-04
Epoch 36: early stopping
Restoring model weights from the end of the best epoch: 21.
```

[5]:
```python
import matplotlib.pyplot as plt
import numpy as np

# Get predictions for the test data
predictions = model.predict(test_data)

# Convert predictions and true labels from one-hot to class indices
predicted_classes = np.argmax(predictions, axis=1)
true_classes = np.argmax(test_labels, axis=1)

# Calculate overall accuracy
overall_accuracy = np.sum(predicted_classes == true_classes) / len(true_classes)
print(f"Overall Test Accuracy: {overall_accuracy:.2f}")

# Calculate per-class accuracy
num_classes = len(class_names)
class_accuracies = []
for class_index in range(num_classes):
    indices = np.where(true_classes == class_index)[0]
    class_correct = np.sum(predicted_classes[indices] == true_classes[indices])
    class_accuracy = class_correct / len(indices) if len(indices) > 0 else 0
    class_accuracies.append(class_accuracy)
```
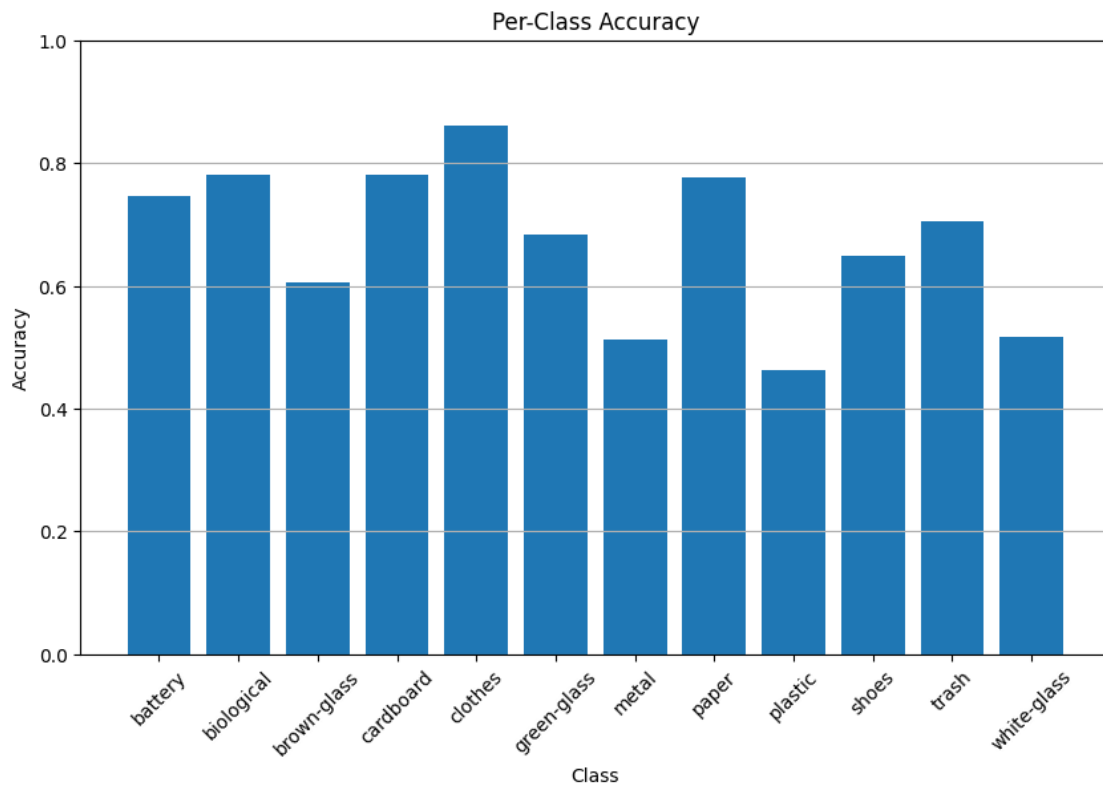
```
# Plot per-class accuracy
plt.figure(figsize=(10, 6))
plt.bar(class_names, class_accuracies)
plt.title("Per-Class Accuracy")
plt.xlabel("Class")
plt.ylabel("Accuracy")
plt.ylim(0, 1)
plt.xticks(rotation=45)
plt.grid(axis="y")
plt.show()
```

97/97   9s 81ms/step
Overall Test Accuracy: 0.73


```
[6]: from sklearn.metrics import classification_report, accuracy_score
     import numpy as np

     # Get predictions for the test data
     predictions = model.predict(test_data)

     # Convert predictions and true labels from one-hot encoding to class indices
```

```
predicted_classes = np.argmax(predictions, axis=1)
true_classes = np.argmax(test_labels, axis=1)

# Compute overall accuracy
accuracy = accuracy_score(true_classes, predicted_classes)
print(f"Overall Accuracy: {accuracy:.2f}")

# Compute classification report (includes Precision, Recall, F1-Score)
report = classification_report(true_classes, predicted_classes,␣
 ↪target_names=class_names)
print("Classification Report:")
print(report)
```

```
97/97                7s 67ms/step
Overall Accuracy: 0.73
Classification Report:
              precision    recall  f1-score   support

     battery       0.75      0.75      0.75       189
  biological       0.77      0.78      0.78       197
 brown-glass       0.65      0.61      0.63       122
   cardboard       0.58      0.78      0.67       178
     clothes       0.96      0.86      0.91      1065
 green-glass       0.74      0.68      0.71       126
       metal       0.43      0.51      0.47       154
       paper       0.62      0.78      0.69       210
     plastic       0.41      0.46      0.43       173
       shoes       0.79      0.65      0.71       395
       trash       0.62      0.71      0.66       139
 white-glass       0.48      0.52      0.50       155

    accuracy                           0.73      3103
   macro avg       0.65      0.67      0.66      3103
weighted avg       0.75      0.73      0.74      3103
```

[7]:
```
model.save("saved_models/garbage_classification_model_rsnet_73_h5.h5")
model.save("saved_models/garbage_classification_model_rsnet_73_tf_keras.keras")
```

```
WARNING:absl:You are saving your model as an HDF5 file via `model.save()` or
`keras.saving.save_model(model)`. This file format is considered legacy. We
recommend using instead the native Keras format, e.g.
`model.save('my_model.keras')` or `keras.saving.save_model(model,
'my_model.keras')`.
```

[8]:
```
# Initialize an empty list to store misclassified images and details
misclassified_images = []
```

```
# Iterate through the test data to find misclassified samples
for i in range(len(test_data)):
    if predicted_classes[i] != true_classes[i]:
        misclassified_images.append({
            "expected": class_names[true_classes[i]],  # The correct label
            "predicted": class_names[predicted_classes[i]],  # The predicted
  ↪label
            "image": test_data[i]  # The misclassified image
        })

# Check how many misclassifications were found
print(f"Total Misclassified Images: {len(misclassified_images)}")
```

Total Misclassified Images: 847

```
[11]: # Print all misclassified details
for idx, misclassified in enumerate(misclassified_images):
    print(f"Index: {idx}, Expected: {misclassified['expected']}, Predicted:
  ↪{misclassified['predicted']}")

# Display up to 25 misclassified images (or all if fewer)
num_to_display = min(len(misclassified_images), 25)  # Adjust this to show more
  ↪if needed
rows = int(np.ceil(num_to_display / 5))  # Calculate number of rows for a
  ↪5-column grid

plt.figure(figsize=(15, rows * 3))
for idx, misclassified in enumerate(misclassified_images[:num_to_display]):
    plt.subplot(rows, 5, idx + 1)
    plt.imshow(misclassified["image"])
    plt.title(f"Expected: {misclassified['expected']}\nPredicted:
  ↪{misclassified['predicted']}")
    plt.axis("off")

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

```
Index: 0, Expected: plastic, Predicted: paper
Index: 1, Expected: white-glass, Predicted: biological
Index: 2, Expected: shoes, Predicted: clothes
Index: 3, Expected: shoes, Predicted: brown-glass
Index: 4, Expected: white-glass, Predicted: plastic
Index: 5, Expected: clothes, Predicted: white-glass
Index: 6, Expected: battery, Predicted: biological
Index: 7, Expected: battery, Predicted: cardboard
Index: 8, Expected: cardboard, Predicted: paper
Index: 9, Expected: shoes, Predicted: battery
Index: 10, Expected: shoes, Predicted: white-glass
```

```
Index: 11, Expected: plastic, Predicted: trash
Index: 12, Expected: green-glass, Predicted: metal
Index: 13, Expected: paper, Predicted: plastic
Index: 14, Expected: green-glass, Predicted: brown-glass
Index: 15, Expected: plastic, Predicted: metal
Index: 16, Expected: cardboard, Predicted: plastic
Index: 17, Expected: cardboard, Predicted: clothes
Index: 18, Expected: shoes, Predicted: clothes
Index: 19, Expected: clothes, Predicted: white-glass
Index: 20, Expected: battery, Predicted: cardboard
Index: 21, Expected: metal, Predicted: battery
Index: 22, Expected: battery, Predicted: metal
Index: 23, Expected: biological, Predicted: metal
Index: 24, Expected: green-glass, Predicted: plastic
Index: 25, Expected: battery, Predicted: biological
Index: 26, Expected: clothes, Predicted: trash
Index: 27, Expected: brown-glass, Predicted: cardboard
Index: 28, Expected: metal, Predicted: plastic
Index: 29, Expected: clothes, Predicted: cardboard
Index: 30, Expected: green-glass, Predicted: plastic
Index: 31, Expected: cardboard, Predicted: plastic
Index: 32, Expected: battery, Predicted: green-glass
Index: 33, Expected: paper, Predicted: battery
Index: 34, Expected: metal, Predicted: cardboard
Index: 35, Expected: clothes, Predicted: biological
Index: 36, Expected: biological, Predicted: brown-glass
Index: 37, Expected: clothes, Predicted: battery
Index: 38, Expected: biological, Predicted: brown-glass
Index: 39, Expected: clothes, Predicted: cardboard
Index: 40, Expected: green-glass, Predicted: white-glass
Index: 41, Expected: clothes, Predicted: cardboard
Index: 42, Expected: paper, Predicted: green-glass
Index: 43, Expected: metal, Predicted: white-glass
Index: 44, Expected: white-glass, Predicted: plastic
Index: 45, Expected: battery, Predicted: brown-glass
Index: 46, Expected: plastic, Predicted: trash
Index: 47, Expected: shoes, Predicted: clothes
Index: 48, Expected: paper, Predicted: plastic
Index: 49, Expected: clothes, Predicted: battery
Index: 50, Expected: plastic, Predicted: trash
Index: 51, Expected: plastic, Predicted: paper
Index: 52, Expected: plastic, Predicted: brown-glass
Index: 53, Expected: white-glass, Predicted: metal
Index: 54, Expected: trash, Predicted: white-glass
Index: 55, Expected: clothes, Predicted: plastic
Index: 56, Expected: clothes, Predicted: white-glass
Index: 57, Expected: battery, Predicted: clothes
Index: 58, Expected: shoes, Predicted: battery
```

```
Index: 59, Expected: plastic, Predicted: metal
Index: 60, Expected: plastic, Predicted: shoes
Index: 61, Expected: metal, Predicted: plastic
Index: 62, Expected: shoes, Predicted: trash
Index: 63, Expected: clothes, Predicted: cardboard
Index: 64, Expected: plastic, Predicted: brown-glass
Index: 65, Expected: clothes, Predicted: biological
Index: 66, Expected: white-glass, Predicted: cardboard
Index: 67, Expected: cardboard, Predicted: white-glass
Index: 68, Expected: clothes, Predicted: plastic
Index: 69, Expected: paper, Predicted: metal
Index: 70, Expected: metal, Predicted: brown-glass
Index: 71, Expected: paper, Predicted: plastic
Index: 72, Expected: white-glass, Predicted: battery
Index: 73, Expected: clothes, Predicted: shoes
Index: 74, Expected: metal, Predicted: shoes
Index: 75, Expected: shoes, Predicted: cardboard
Index: 76, Expected: clothes, Predicted: brown-glass
Index: 77, Expected: clothes, Predicted: shoes
Index: 78, Expected: white-glass, Predicted: plastic
Index: 79, Expected: green-glass, Predicted: paper
Index: 80, Expected: shoes, Predicted: biological
Index: 81, Expected: trash, Predicted: white-glass
Index: 82, Expected: clothes, Predicted: plastic
Index: 83, Expected: plastic, Predicted: white-glass
Index: 84, Expected: clothes, Predicted: biological
Index: 85, Expected: metal, Predicted: plastic
Index: 86, Expected: metal, Predicted: trash
Index: 87, Expected: shoes, Predicted: clothes
Index: 88, Expected: cardboard, Predicted: paper
Index: 89, Expected: paper, Predicted: metal
Index: 90, Expected: clothes, Predicted: white-glass
Index: 91, Expected: plastic, Predicted: cardboard
Index: 92, Expected: trash, Predicted: plastic
Index: 93, Expected: plastic, Predicted: metal
Index: 94, Expected: brown-glass, Predicted: trash
Index: 95, Expected: shoes, Predicted: clothes
Index: 96, Expected: green-glass, Predicted: shoes
Index: 97, Expected: plastic, Predicted: shoes
Index: 98, Expected: clothes, Predicted: cardboard
Index: 99, Expected: shoes, Predicted: biological
Index: 100, Expected: clothes, Predicted: biological
Index: 101, Expected: green-glass, Predicted: white-glass
Index: 102, Expected: clothes, Predicted: paper
Index: 103, Expected: battery, Predicted: brown-glass
Index: 104, Expected: battery, Predicted: metal
Index: 105, Expected: shoes, Predicted: clothes
Index: 106, Expected: green-glass, Predicted: paper
```

```
Index: 107, Expected: paper, Predicted: white-glass
Index: 108, Expected: shoes, Predicted: trash
Index: 109, Expected: cardboard, Predicted: metal
Index: 110, Expected: brown-glass, Predicted: battery
Index: 111, Expected: metal, Predicted: biological
Index: 112, Expected: plastic, Predicted: green-glass
Index: 113, Expected: paper, Predicted: metal
Index: 114, Expected: brown-glass, Predicted: trash
Index: 115, Expected: trash, Predicted: plastic
Index: 116, Expected: clothes, Predicted: plastic
Index: 117, Expected: white-glass, Predicted: plastic
Index: 118, Expected: battery, Predicted: shoes
Index: 119, Expected: clothes, Predicted: plastic
Index: 120, Expected: paper, Predicted: metal
Index: 121, Expected: clothes, Predicted: shoes
Index: 122, Expected: shoes, Predicted: metal
Index: 123, Expected: clothes, Predicted: shoes
Index: 124, Expected: paper, Predicted: white-glass
Index: 125, Expected: shoes, Predicted: battery
Index: 126, Expected: green-glass, Predicted: brown-glass
Index: 127, Expected: clothes, Predicted: white-glass
Index: 128, Expected: shoes, Predicted: white-glass
Index: 129, Expected: cardboard, Predicted: green-glass
Index: 130, Expected: clothes, Predicted: plastic
Index: 131, Expected: cardboard, Predicted: metal
Index: 132, Expected: battery, Predicted: paper
Index: 133, Expected: green-glass, Predicted: metal
Index: 134, Expected: paper, Predicted: battery
Index: 135, Expected: biological, Predicted: shoes
Index: 136, Expected: trash, Predicted: white-glass
Index: 137, Expected: battery, Predicted: trash
Index: 138, Expected: paper, Predicted: plastic
Index: 139, Expected: plastic, Predicted: paper
Index: 140, Expected: cardboard, Predicted: plastic
Index: 141, Expected: shoes, Predicted: battery
Index: 142, Expected: metal, Predicted: shoes
Index: 143, Expected: cardboard, Predicted: paper
Index: 144, Expected: battery, Predicted: metal
Index: 145, Expected: white-glass, Predicted: brown-glass
Index: 146, Expected: metal, Predicted: shoes
Index: 147, Expected: plastic, Predicted: battery
Index: 148, Expected: battery, Predicted: shoes
Index: 149, Expected: white-glass, Predicted: trash
Index: 150, Expected: shoes, Predicted: cardboard
Index: 151, Expected: shoes, Predicted: battery
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Index: 154, Expected: shoes, Predicted: biological
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Index: 155, Expected: brown-glass, Predicted: metal
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Index: 202, Expected: white-glass, Predicted: metal
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Index: 656, Expected: shoes, Predicted: trash
Index: 657, Expected: white-glass, Predicted: metal
Index: 658, Expected: metal, Predicted: brown-glass
Index: 659, Expected: cardboard, Predicted: battery
Index: 660, Expected: shoes, Predicted: brown-glass
Index: 661, Expected: shoes, Predicted: paper
Index: 662, Expected: white-glass, Predicted: paper
Index: 663, Expected: brown-glass, Predicted: battery
Index: 664, Expected: plastic, Predicted: brown-glass
Index: 665, Expected: white-glass, Predicted: plastic
Index: 666, Expected: brown-glass, Predicted: shoes
Index: 667, Expected: plastic, Predicted: white-glass
Index: 668, Expected: white-glass, Predicted: green-glass
Index: 669, Expected: clothes, Predicted: cardboard
Index: 670, Expected: shoes, Predicted: biological
Index: 671, Expected: paper, Predicted: brown-glass
Index: 672, Expected: clothes, Predicted: shoes
Index: 673, Expected: plastic, Predicted: trash
Index: 674, Expected: cardboard, Predicted: paper
Index: 675, Expected: cardboard, Predicted: trash
Index: 676, Expected: trash, Predicted: white-glass
Index: 677, Expected: plastic, Predicted: trash
Index: 678, Expected: biological, Predicted: paper
Index: 679, Expected: plastic, Predicted: green-glass
Index: 680, Expected: cardboard, Predicted: trash
Index: 681, Expected: battery, Predicted: green-glass
Index: 682, Expected: clothes, Predicted: white-glass
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Index: 683, Expected: shoes, Predicted: paper
Index: 684, Expected: plastic, Predicted: trash
Index: 685, Expected: metal, Predicted: cardboard
Index: 686, Expected: clothes, Predicted: plastic
Index: 687, Expected: white-glass, Predicted: shoes
Index: 688, Expected: white-glass, Predicted: plastic
Index: 689, Expected: clothes, Predicted: shoes
Index: 690, Expected: plastic, Predicted: green-glass
Index: 691, Expected: metal, Predicted: plastic
Index: 692, Expected: battery, Predicted: shoes
Index: 693, Expected: battery, Predicted: shoes
Index: 694, Expected: trash, Predicted: white-glass
Index: 695, Expected: plastic, Predicted: paper
Index: 696, Expected: metal, Predicted: paper
Index: 697, Expected: cardboard, Predicted: plastic
Index: 698, Expected: shoes, Predicted: clothes
Index: 699, Expected: cardboard, Predicted: plastic
Index: 700, Expected: clothes, Predicted: metal
Index: 701, Expected: battery, Predicted: trash
Index: 702, Expected: shoes, Predicted: paper
Index: 703, Expected: brown-glass, Predicted: metal
Index: 704, Expected: brown-glass, Predicted: green-glass
Index: 705, Expected: clothes, Predicted: metal
Index: 706, Expected: cardboard, Predicted: metal
Index: 707, Expected: clothes, Predicted: cardboard
Index: 708, Expected: paper, Predicted: metal
Index: 709, Expected: white-glass, Predicted: green-glass
Index: 710, Expected: plastic, Predicted: white-glass
Index: 711, Expected: white-glass, Predicted: trash
Index: 712, Expected: clothes, Predicted: plastic
Index: 713, Expected: clothes, Predicted: trash
Index: 714, Expected: white-glass, Predicted: plastic
Index: 715, Expected: clothes, Predicted: shoes
Index: 716, Expected: cardboard, Predicted: plastic
Index: 717, Expected: shoes, Predicted: clothes
Index: 718, Expected: battery, Predicted: shoes
Index: 719, Expected: shoes, Predicted: cardboard
Index: 720, Expected: biological, Predicted: plastic
Index: 721, Expected: clothes, Predicted: brown-glass
Index: 722, Expected: clothes, Predicted: paper
Index: 723, Expected: white-glass, Predicted: plastic
Index: 724, Expected: clothes, Predicted: brown-glass
Index: 725, Expected: green-glass, Predicted: shoes
Index: 726, Expected: battery, Predicted: white-glass
Index: 727, Expected: trash, Predicted: white-glass
Index: 728, Expected: plastic, Predicted: white-glass
Index: 729, Expected: cardboard, Predicted: white-glass
Index: 730, Expected: shoes, Predicted: clothes
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Index: 731, Expected: cardboard, Predicted: paper
Index: 732, Expected: metal, Predicted: clothes
Index: 733, Expected: clothes, Predicted: biological
Index: 734, Expected: green-glass, Predicted: biological
Index: 735, Expected: plastic, Predicted: cardboard
Index: 736, Expected: white-glass, Predicted: plastic
Index: 737, Expected: shoes, Predicted: trash
Index: 738, Expected: shoes, Predicted: paper
Index: 739, Expected: plastic, Predicted: trash
Index: 740, Expected: plastic, Predicted: paper
Index: 741, Expected: clothes, Predicted: green-glass
Index: 742, Expected: plastic, Predicted: trash
Index: 743, Expected: clothes, Predicted: plastic
Index: 744, Expected: white-glass, Predicted: metal
Index: 745, Expected: metal, Predicted: plastic
Index: 746, Expected: shoes, Predicted: brown-glass
Index: 747, Expected: trash, Predicted: plastic
Index: 748, Expected: battery, Predicted: paper
Index: 749, Expected: paper, Predicted: plastic
Index: 750, Expected: battery, Predicted: trash
Index: 751, Expected: plastic, Predicted: cardboard
Index: 752, Expected: metal, Predicted: battery
Index: 753, Expected: battery, Predicted: clothes
Index: 754, Expected: trash, Predicted: plastic
Index: 755, Expected: plastic, Predicted: cardboard
Index: 756, Expected: white-glass, Predicted: metal
Index: 757, Expected: cardboard, Predicted: trash
Index: 758, Expected: shoes, Predicted: trash
Index: 759, Expected: cardboard, Predicted: white-glass
Index: 760, Expected: clothes, Predicted: shoes
Index: 761, Expected: paper, Predicted: trash
Index: 762, Expected: white-glass, Predicted: trash
Index: 763, Expected: shoes, Predicted: plastic
Index: 764, Expected: shoes, Predicted: trash
Index: 765, Expected: metal, Predicted: plastic
Index: 766, Expected: shoes, Predicted: trash
Index: 767, Expected: paper, Predicted: white-glass
Index: 768, Expected: clothes, Predicted: shoes
Index: 769, Expected: clothes, Predicted: shoes
Index: 770, Expected: metal, Predicted: trash
Index: 771, Expected: clothes, Predicted: shoes
Index: 772, Expected: biological, Predicted: green-glass
Index: 773, Expected: plastic, Predicted: white-glass
Index: 774, Expected: shoes, Predicted: cardboard
Index: 775, Expected: metal, Predicted: battery
Index: 776, Expected: brown-glass, Predicted: biological
Index: 777, Expected: metal, Predicted: plastic
Index: 778, Expected: brown-glass, Predicted: metal
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Index: 779, Expected: shoes, Predicted: battery
Index: 780, Expected: shoes, Predicted: battery
Index: 781, Expected: trash, Predicted: plastic
Index: 782, Expected: paper, Predicted: plastic
Index: 783, Expected: green-glass, Predicted: trash
Index: 784, Expected: shoes, Predicted: biological
Index: 785, Expected: shoes, Predicted: paper
Index: 786, Expected: metal, Predicted: green-glass
Index: 787, Expected: paper, Predicted: clothes
Index: 788, Expected: biological, Predicted: brown-glass
Index: 789, Expected: clothes, Predicted: biological
Index: 790, Expected: biological, Predicted: brown-glass
Index: 791, Expected: cardboard, Predicted: white-glass
Index: 792, Expected: brown-glass, Predicted: metal
Index: 793, Expected: white-glass, Predicted: cardboard
Index: 794, Expected: battery, Predicted: green-glass
Index: 795, Expected: white-glass, Predicted: cardboard
Index: 796, Expected: shoes, Predicted: clothes
Index: 797, Expected: battery, Predicted: paper
Index: 798, Expected: clothes, Predicted: biological
Index: 799, Expected: shoes, Predicted: paper
Index: 800, Expected: plastic, Predicted: paper
Index: 801, Expected: shoes, Predicted: brown-glass
Index: 802, Expected: plastic, Predicted: white-glass
Index: 803, Expected: shoes, Predicted: cardboard
Index: 804, Expected: biological, Predicted: cardboard
Index: 805, Expected: biological, Predicted: metal
Index: 806, Expected: paper, Predicted: plastic
Index: 807, Expected: shoes, Predicted: brown-glass
Index: 808, Expected: paper, Predicted: biological
Index: 809, Expected: plastic, Predicted: white-glass
Index: 810, Expected: brown-glass, Predicted: plastic
Index: 811, Expected: shoes, Predicted: metal
Index: 812, Expected: cardboard, Predicted: paper
Index: 813, Expected: clothes, Predicted: cardboard
Index: 814, Expected: metal, Predicted: plastic
Index: 815, Expected: metal, Predicted: plastic
Index: 816, Expected: clothes, Predicted: cardboard
Index: 817, Expected: trash, Predicted: clothes
Index: 818, Expected: metal, Predicted: brown-glass
Index: 819, Expected: metal, Predicted: paper
Index: 820, Expected: plastic, Predicted: metal
Index: 821, Expected: white-glass, Predicted: biological
Index: 822, Expected: green-glass, Predicted: plastic
Index: 823, Expected: clothes, Predicted: biological
Index: 824, Expected: paper, Predicted: clothes
Index: 825, Expected: trash, Predicted: metal
Index: 826, Expected: metal, Predicted: shoes
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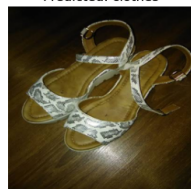
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Index: 827, Expected: green-glass, Predicted: paper
Index: 828, Expected: clothes, Predicted: cardboard
Index: 829, Expected: plastic, Predicted: trash
Index: 830, Expected: clothes, Predicted: battery
Index: 831, Expected: clothes, Predicted: biological
Index: 832, Expected: cardboard, Predicted: paper
Index: 833, Expected: shoes, Predicted: clothes
Index: 834, Expected: shoes, Predicted: brown-glass
Index: 835, Expected: shoes, Predicted: metal
Index: 836, Expected: clothes, Predicted: biological
Index: 837, Expected: metal, Predicted: plastic
Index: 838, Expected: paper, Predicted: clothes
Index: 839, Expected: biological, Predicted: plastic
Index: 840, Expected: trash, Predicted: plastic
Index: 841, Expected: shoes, Predicted: brown-glass
Index: 842, Expected: clothes, Predicted: shoes
Index: 843, Expected: brown-glass, Predicted: battery
Index: 844, Expected: battery, Predicted: paper
Index: 845, Expected: cardboard, Predicted: paper
Index: 846, Expected: shoes, Predicted: clothes
```

Expected: plastic
Predicted: paper

Expected: white-glass
Predicted: biological

Expected: shoes
Predicted: clothes

Expected: shoes
Predicted: brown-glass

Expected: white-glass
Predicted: plastic

Expected: clothes
Predicted: white-glass

Expected: battery
Predicted: biological

Expected: battery
Predicted: cardboard

Expected: cardboard
Predicted: paper
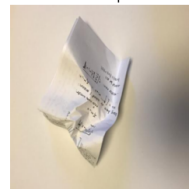
Expected: shoes
Predicted: battery

Expected: shoes
Predicted: white-glass

Expected: plastic
Predicted: trash

Expected: green-glass
Predicted: metal

Expected: paper
Predicted: plastic

Expected: green-glass
Predicted: brown-glass

Expected: plastic
Predicted: metal

Expected: cardboard
Predicted: plastic

Expected: cardboard
Predicted: clothes

Expected: shoes
Predicted: clothes

Expected: clothes
Predicted: white-glass

Expected: battery
Predicted: cardboard

Expected: metal
Predicted: battery

Expected: battery
Predicted: metal

Expected: biological
Predicted: metal

Expected: green-glass
Predicted: plastic

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