# SORT $MART

## Garbage Segregator


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# TABLE OF CONTENTS


01
Problem Statement

02
Proposed Solution

03
EDA

04
Code & Process Flow

05
Results & Conclusion

06
Future Scope

# 01

# Problem Statement

## Problem Statement

The improper disposal of waste is a major environmental concern, and there is a need to enforce regulations to discourage this behavior. However, monitoring and identifying the type of waste in public bins can be a tedious and time-consuming task.

## OUR AIM

In order to optimize the process of waste management and reduce the need for laborious and time-consuming sorting, we suggest implementing a segregation system at the source of waste production. In addition, this system can also serve as an educational tool, helping to raise awareness and promote responsible waste disposal practices among individuals and communities.

# 02 SOLUTION

## Live Object Detection

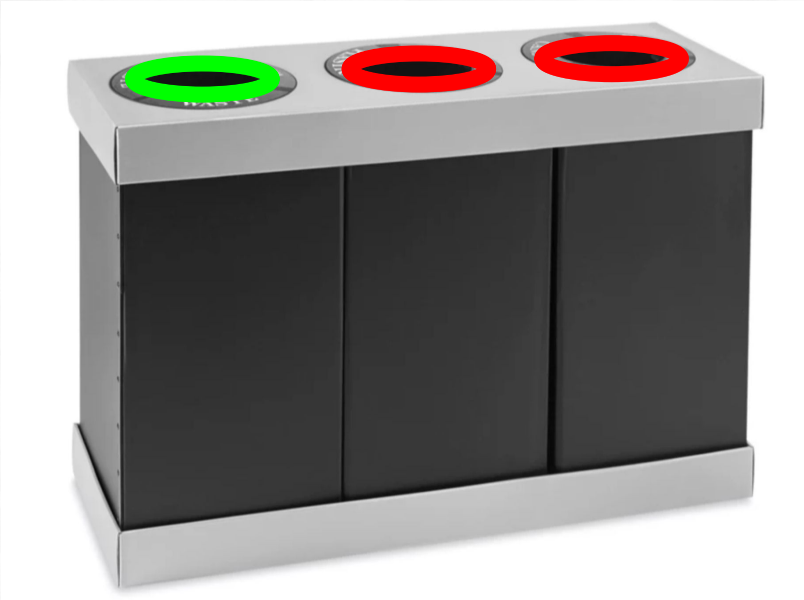
The solution involves the deployment of live object/image detection technology that can accurately identify the type of garbage in each bin. This technology is based on advanced deep learning algorithms that can classify garbage into categories such as organic, recyclable, or waste.

## Customisable Solution

We propose to develop a customized solution that meets your specific requirements and integrates seamlessly with your existing infrastructure. Our team of experienced deep learning experts will work closely with you to understand your needs and deliver a solution that meets your goals.

# Our USP

- Enhances bin functionality.
- Cost-effective and retrofitting.
- Promotes sustainable waste management.
- Customizable to unique needs.



# ML Canvas

## Prediction Task:

- The goal of the model is to accurately classify different types of garbage into their respective categories using a multi-class classification approach.
- The input to the model would be an image of garbage, and the output of the model would be a probability distribution over the possible categories (e.g. paper, plastic, glass, metal, organic).
- The model should predict the most likely category based on the input image, and can be evaluated using metrics such as accuracy, precision, recall, and F1 score.
- The higher the accuracy of the model, the better it is at predicting the correct class labels for unseen garbage images.

## Impact Solution:

- Environmental Impact
- Public Health
- Economic Benefits
- Awareness and Education
- Innovation and technology

## Decisions:

- **Deep Learning Model:** The deep learning model choice is crucial for a garbage classification system. CNNs and other models are used for image classification tasks, and selecting the right model impacts accuracy and efficiency.
- **Data Collection and Preprocessing:** Garbage classification systems need large data for training and testing. Decisions must be made for data collection, variety, and preprocessing, like using augmentation techniques for improving the model's performance.
- **Training and Model Evaluation:** The garbage classification system requires choosing training metrics, such as learning rate, epochs, optimizer, loss function, and evaluation metrics like accuracy, precision, recall, F1 score, and confusion matrix.
- **Deployment and Integration:** Deploying the system may involve integration with waste management infrastructures, UI development, and mobile apps.
- **Cost and Sustainability:** The cost and sustainability of the system need consideration, like using cost-effective hardware and cloud-based services, and renewable energy sources.

## Value Proposition:

- **Improved Waste Management:** A garbage classification system using deep learning can help improve waste management by accurately identifying different types of garbage, enabling effective separation and disposal.
- **Environmental Benefits:** Proper waste management can have significant environmental benefits by reducing pollution, conserving natural resources, and promoting sustainable practices.
- **Cost Savings:** Effective garbage classification can result in cost savings for waste management organizations by reducing the amount of material that needs to be sent to landfill or incineration.

- **Enhanced User Experience:** A garbage classification system with a user-friendly interface and mobile applications can provide an enhanced user experience for individuals and organizations involved in waste management.
- **Innovation and Competitive Advantage:** Implementing a garbage classification system using deep learning can provide a competitive advantage by demonstrating innovation and a commitment to sustainable practices.

## Data Collection:

- Balanced datasets prevent model bias towards one category.
- Imbalanced datasets can lead to poor classification performance.
- Equal representation of each category ensures fair assessment.
- Proper data balance leads to improved accuracy and generalization.

## Data Sources:

**Open Images Dataset:** This is a dataset maintained by Google that includes millions of images across a variety of categories, including waste management. You can filter the dataset to only include images of waste and use these images to train your model.

## Building the Model

- VGG16
- Resnet
- VGG16 with transfer learning

## Features:

- Raw pixel values: Using the raw pixel values of the images as features can be computationally expensive, but this approach can also capture a lot of information that may be relevant for classification.
- Color-based features: You can extract color-based features such as color histograms or color moments, which can capture information about the color distribution of the images.
- Texture-based features: Extracting texture-based features such as Local Binary Patterns (LBP) or Gabor filters can capture information about the patterns and texture of the images.
- Shape-based features: Using shape-based features such as edge detection or contour analysis can capture information about the shape of the objects in the images.
- Transfer learning: Transfer learning involves using a pre-trained neural network as a feature extractor. By removing the last layer of the network, you can use the output of the second-to-last layer as features for your garbage classification task.

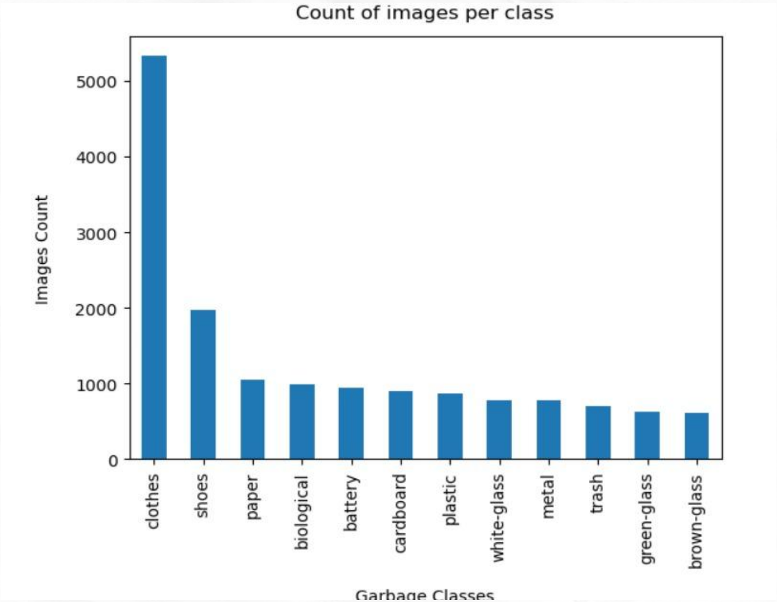
## Monitoring:

- Accuracy measures the percentage of correctly classified images in the test set.
- Precision and recall are useful for imbalanced datasets, where precision measures the percentage of correctly classified positive samples among all samples predicted as positive and recall measures the percentage of correctly classified positive samples among all actual positive samples.
- F1 score combines precision and recall into a single score and is useful for imbalanced datasets.
- The confusion matrix summarizes the number of correctly and incorrectly classified images and can be used to calculate metrics such as accuracy, precision, recall, and F1 score.
- ROC and AUC are useful for binary classifiers, where the ROC curve shows performance at different classification thresholds and the AUC measures overall performance across all possible thresholds.

# 03 Exploratory Data Analysis

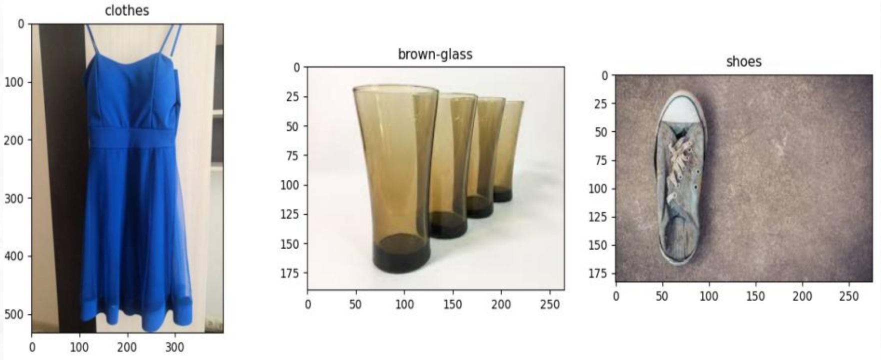
## Dataset Used

- This dataset is generated from images which are classified or labeled into total of 12 different types of waste materials which are use for recycling
- I.E., 'cardboard', 'compost', 'glass', 'metal', 'paper', 'plastic', 'trash', 'shoes', 'batteries', 'biological', 'White Glass', 'Brown Glass'.
- The dataset contains a total of 2187 images.



# About the dataset

| | filename | category |
|---|---|---|
| 0 | metal/metal389.jpg | 3 |
| 1 | clothes/clothes2482.jpg | 12 |
| 2 | green-glass/green-glass378.jpg | 14 |
| 3 | paper/paper797.jpg | 6 |
| 4 | metal/metal268.jpg | 3 |

# Pre-Processing

- Segregated different images and classified them; putting them into different folders.
- Creating df to create categories to define classes.

| | filename | category |
|---|---|---|
| **0** | metal/metal389.jpg | 3 |
| **1** | clothes/clothes2482.jpg | 12 |
| **2** | green-glass/green-glass378.jpg | 14 |
| **3** | paper/paper797.jpg | 6 |
| **4** | metal/metal268.jpg | 3 |

# 04 Code and Process Flow

- Data Augmentation
- EDA
- Pre-processing
- Training
- Testing
- Model Deployment
- Results

# Building Model

```
# Create the base model from the pre-trained model MobileNet V2
IMG_SHAPE = (IMAGE_HEIGHT, IMAGE_WIDTH, 3)
base_model = tf.keras.applications.VGG16(input_shape = IMG_SHAPE,
                                          include_top = False,
                                          weights = 'imagenet')
#base_model.trainable = False
base_model.summary()
```

- Using VGG16 and ResNet50 pre-trained CNN model

- Created an VGG16 model without the last layer and load the ImageNet pretrained weights
- Added a pre-processing layer
- Adde a pooling layer followed by a softmax layer at the end

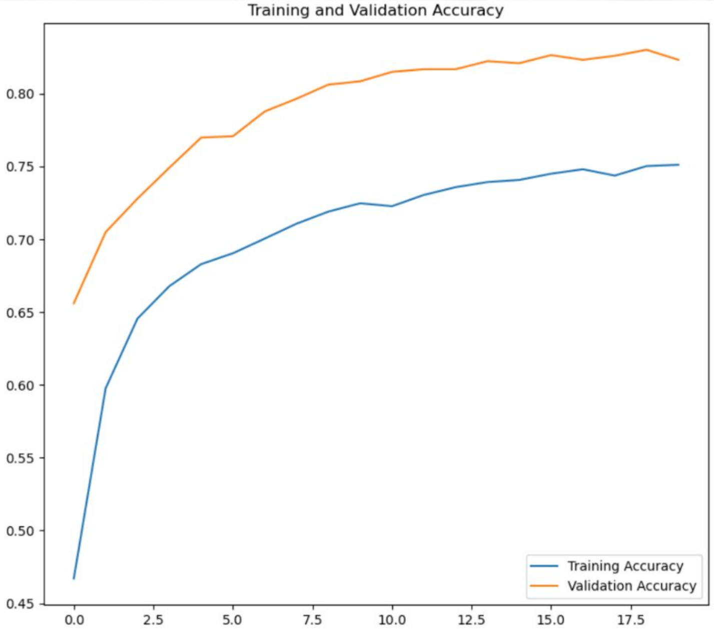
```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 sequential (Sequential)     (None, 224, 224, 3)       0

 rescaling_1 (Rescaling)     (None, 224, 224, 3)       0

 vgg16 (Functional)          (None, 7, 7, 512)         14714688

 global_average_pooling2d_1   (None, 512)              0
 (GlobalAveragePooling2D)

 dense_2 (Dense)             (None, 128)               65664

 dropout_1 (Dropout)         (None, 128)               0

 dense_3 (Dense)             (None, 12)                1548

=================================================================
Total params: 14,781,900
Trainable params: 13,046,412
Non-trainable params: 1,735,488
_________________________________________________________________
```

# Improve VGG16 using Transfer Learning

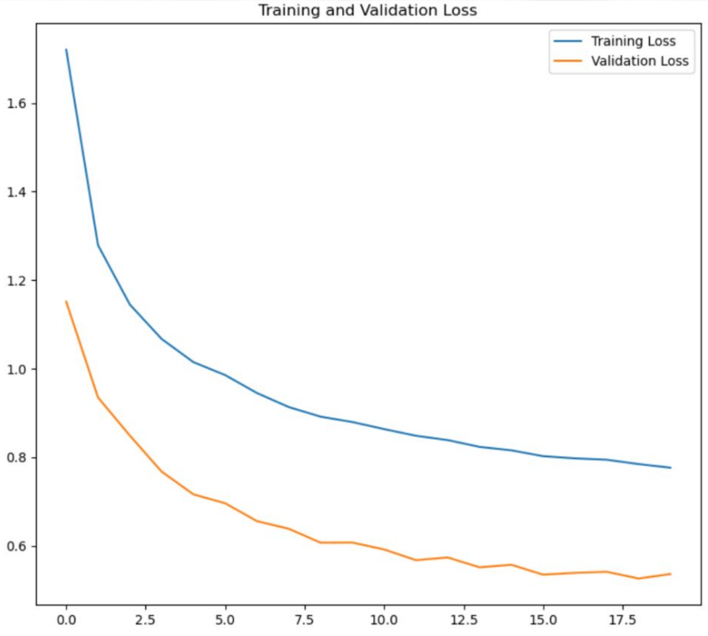
- VGG16 architecture will be loaded and the pre-trained weights will be frozen.
- The last few layers of VGG16 model will be replaced with classification task for segregating of garbage.
- The final layer is a fully connected layer with a softmax activation function that produces a probability distribution over the output classes.

# Base Model Evaluation

## Training Phase




## Testing Phase



# Model Deployment

To deploy our model on a Streamlit app, we used the Streamlit API to load your model.

```
!streamlit run score3.py & npx localtunnel --port 8501

npx: installed 22 in 3.645s

Collecting usage statistics. To deactivate, set browser.gatherUsageStats to False.

your url is: https://curvy-carrots-shop-34-148-170-76.loca.lt

  You can now view your Streamlit app in your browser.

  Network URL: http://172.28.0.12:8501
  External URL: http://34.148.170.76:8501

2023-04-22 00:49:01.855702: I tensorflow/core/platform/cpu_feature_guard.cc:182] This TensorFlow binary is optimized to use available CPU instru
To enable the following instructions: AVX2 FMA, in other operations, rebuild TensorFlow with the appropriate compiler flags.
2023-04-22 00:49:03.258978: W tensorflow/compiler/tf2tensorrt/utils/py_utils.cc:38] TF-TRT Warning: Could not find TensorRT
2023-04-22 00:49:05.574 `label` got an empty value. This is discouraged for accessibility reasons and may be disallowed in the future by raising
2023-04-22 00:49:10.661 `label` got an empty value. This is discouraged for accessibility reasons and may be disallowed in the future by raising
1/1 [==============================] - 1s 843ms/step
  Stopping...
^C
```

# 05

# Results & Conclusion

# Results

```
filenames = test_generator.filenames
nb_samples = len(filenames)

_, accuracy = model.evaluate_generator(test_generator, nb_samples)

print('Accuracy on test set = ',  round((accuracy * 100),2 ), '%')
```

```
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:4: UserW
n a future version. Please use `Model.evaluate`, which supports gener
  after removing the cwd from sys.path.
Accuracy on test set =   82.06 %
```

Accuracy on Test Set

| | precision | recall | f1-score | support |
|---|---|---|---|---|
| battery | 0.82 | 0.95 | 0.88 | 58 |
| biological | 0.98 | 0.82 | 0.90 | 74 |
| brown-glass | 0.61 | 0.74 | 0.67 | 23 |
| cardboard | 0.84 | 0.71 | 0.77 | 58 |
| clothes | 0.88 | 0.97 | 0.92 | 326 |
| green-glass | 0.93 | 0.74 | 0.82 | 34 |
| metal | 0.54 | 0.68 | 0.60 | 37 |
| paper | 0.80 | 0.68 | 0.73 | 59 |
| plastic | 0.72 | 0.52 | 0.60 | 54 |
| shoes | 0.87 | 0.93 | 0.90 | 119 |
| trash | 0.86 | 0.68 | 0.76 | 47 |
| white-glass | 0.59 | 0.57 | 0.58 | 42 |
| accuracy | | | 0.83 | 931 |
| macro avg | 0.79 | 0.75 | 0.76 | 931 |
| weighted avg | 0.83 | 0.83 | 0.83 | 931 |

Classification Report

# Conclusion

Our proposal involves utilizing the existing infrastructure for garbage disposal at its origin to minimize the risks to manual scavengers and reduce health hazards. By leveraging the existing setup, our solution is cost-effective, easily adoptable, and sustainable in the long run. Additionally, our solution aims to increase the recycling-to-energy ratio and mitigate the errors caused by manual segregation. Overall, our solution ensures a safer and healthier environment while promoting sustainable practices.

# Future of Sort$mart

- Launch our own SmartBin
- Minimize Waste to Energy
- Improve Monetary Penalty System
- Launch Subscription based models for cloud services

# References

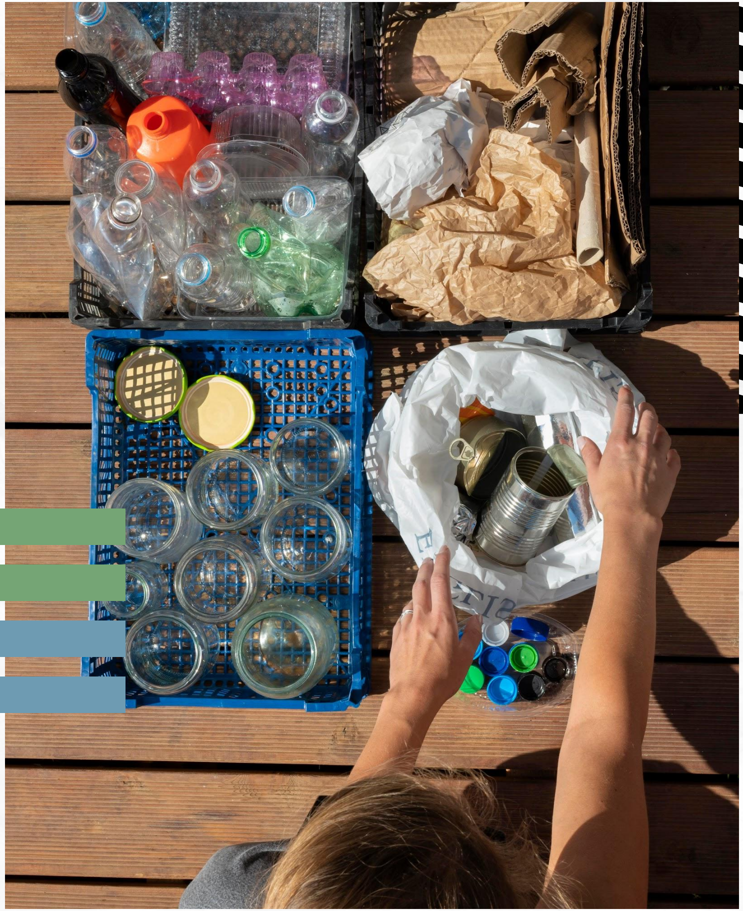

- https://www.toronto.ca/services-payments/recycling-organics-garbage/ 2)

- https://www.sciencedirect.com/science/article/pii/S2351978919307231

- https://www.researchgate.net/publication/346937517_Trash_Classification_Classifying_garbage_using_Deep_Learning
- https://www.ibisworld.com/canada/market-size/waste-collection-services/

# THANKS!

## DO YOU HAVE ANY QUESTIONS?



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