Garbage Recycle System using Machine Learning

- Transforming waste into a sustainable future.

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(TASK 0)

1. Prototype Selection

Abstract

Recycling has become an essential practice in today's society to mitigate the environmental impact of waste disposal. This abstract explores the concept of recycling and its **potential for generating profit**. It delves into various recycling methods and **technologies** that can be employed to extract valuable resources from **discarded materials.**

Additionally, it examines the economic benefits associated with recycling, such as reduced production costs, job creation, and the development of a circular economy.

The abstract also highlights the importance of public awareness and participation in recycling initiatives to maximize profit and ensure the long-term sustainability of recycling efforts.Overall, this abstract emphasizes the potential for recycling to not only protect the environment but also serve as a **profitable business venture**.

2. Problem Statement

The improper disposal of waste is a major environmental concern, leading to pollution, greenhouse gas emissions, and depletion of natural resources. Recycling is one of the most effective ways to mitigate the environmental impact of waste disposal, but the process can be time-consuming and expensive.

Furthermore, the lack of a standardized system for classifying waste makes ”it difficult to identify and extract valuable resources from discarded materials. This problem can be addressed by leveraging machine learning algorithms to classify garbage into categories, allowing for more efficient and cost-effective recycling practices.”

3. Market/Customer Need Assessment

1. Environmental Impact: Customers are increasingly seeking solutions that leverage machine learning algorithms to reduce the environmental impact of waste disposal. Machine learning can help identify and sort waste more efficiently, reducing pollution and resource depletion.

2. Cost and Efficiency: Machine learning can streamline the recycling process, making it more efficient and cost-effective. Customers require solutions that can automate waste classification and extraction, minimizing labor costs and maximizing resource recovery.
3. Resource Recovery: Machine learning can accurately identify and extract valuable resources from discarded materials, enhancing resource recovery and reducing reliance on raw materials. Customers are interested in recycling solutions that can optimize resource recovery.

4. Economic Benefits: Machine learning can help reduce production costs, create jobs, and contribute to the development of a circular economy. Customers seek recycling solutions that not only protect the environment but also offer economic benefits through the use of machine learning.

Based on this assessment, there is a clear market need for recycling solutions that leverage machine learning algorithms to address the challenges of waste disposal, improve resource recovery, and provide economic benefits. Additionally, solutions that emphasize public awareness and participation will be highly valued by customers.

4. Target Specification and characterization

The target segment for the recycling solution that incorporates machine learning algorithms would primarily include waste management companies**, recycling facilities**, and organizations involved in sustainable waste management practices. These entities are actively seeking innovative solutions to improve their recycling processes, enhance resource recovery, and reduce environmental impact.

The solution can also cater to **municipalities and local governments** that are responsible for waste management and recycling programs. These entities are interested in efficient and cost-effective recycling solutions that can help them achieve their sustainability goals.

Incorporating local NGOs as a target segment can strengthen the impact and reach of the recycling solution, fostering community involvement, and ensuring long-term sustainability.

Furthermore, **manufacturers and industries** that generate significant amounts of waste can be another target segment. They are looking for recycling solutions that not only comply with environmental regulations but also offer economic benefits through resource recovery and cost reduction.
Overall, the target segment for the recycling solution with machine learning capabilities would encompass **waste management companies, recycling facilities, municipalities, manufacturers, industries, and environmentally conscious consumers.**

5. External Search(information sources)

We aim on classifying the recycling of materials such as glass, paper, cardboard, and metal. The dataset was used for training the models.

The dataset mentioned, "Garbage Detections," is a collection of images labeled with different types of garbage. It includes categories such as plastic, metal, paper, glass, and cardboard.

This dataset is valuable for training machine learning algorithms to classify and detect different types of waste materials accurately.

By utilizing this dataset, the recycling solution can leverage machine learning algorithms to analyze and classify waste materials based on their visual characteristics.

The images on this dataset consist of photographs of garbage taken on a white background. The different exposure and lighting selected for each photo include the variations in the dataset. Each image was resized to 512 × 384 pixels and the original dataset is nearly 250 MB in size.
http://Dataset/Kaggle
The Dataset can be found on the kaggle.

It contains 2513 images in total. The content of the dataset is as follows: 594 paper, 501 glass, 137 trash, 410 metal, 482 plastic, 403 cardboard. For this work, 70% of all images were used for training, 17% for testing, and 13% for validation

WASTE CLASSIFICATION USING CNN

IMAGE PREPROCESSING

IMPORTING REQUIRED LIBRARIES

In [1]:

```
import os
import time
import cv2
import numpy as np
import pandas as pd
import tensorflow as tf
import matplotlib.pyplot as plt
from PIL import Image, ImageOps
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Flatten, Conv2D, MaxPooling2D, Dropout, BatchNormalization
from tensorflow.keras.callbacks import EarlyStopping, ModelCheckpoint, ReduceLROnPlateau
from tensorflow.keras.preprocessing.image import ImageDataGenerator

import warnings
```

Here is some information about the dataset

SETTING UP DATA FILE PATHS

In [2]:

```python
img_train_path = os.path.join("/kaggle/input/waste-classification-data/","DATASET","TRAIN")
img_test_path = os.path.join("/kaggle/input/waste-classification-data/","DATASET","TEST")
```

DATA GENERATORS FOR IMAGE CLASSIFICATION

In [3]:

```python
data_gen = ImageDataGenerator(rescale=1./255, fill_mode='reflect')
val_gen = ImageDataGenerator(rescale=1./255)

train_gen = data_gen.flow_from_directory(img_train_path, target_size=(256,256), batch_size=128)
validation_gen = val_gen.flow_from_directory(img_test_path, target_size=(256,256), batch_size=128)
```

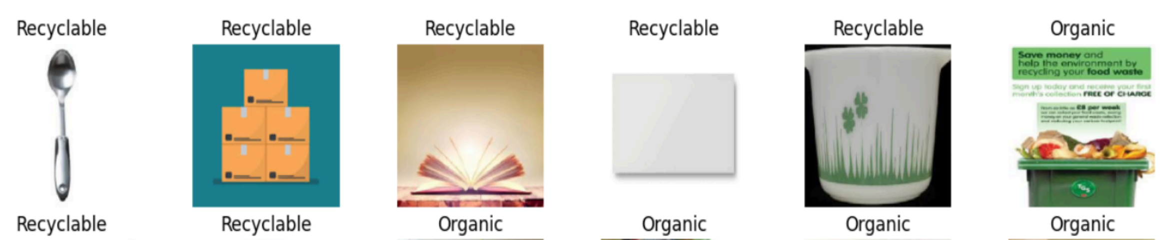
```
Found 22564 images belonging to 2 classes.
Found 2513 images belonging to 2 classes.
```

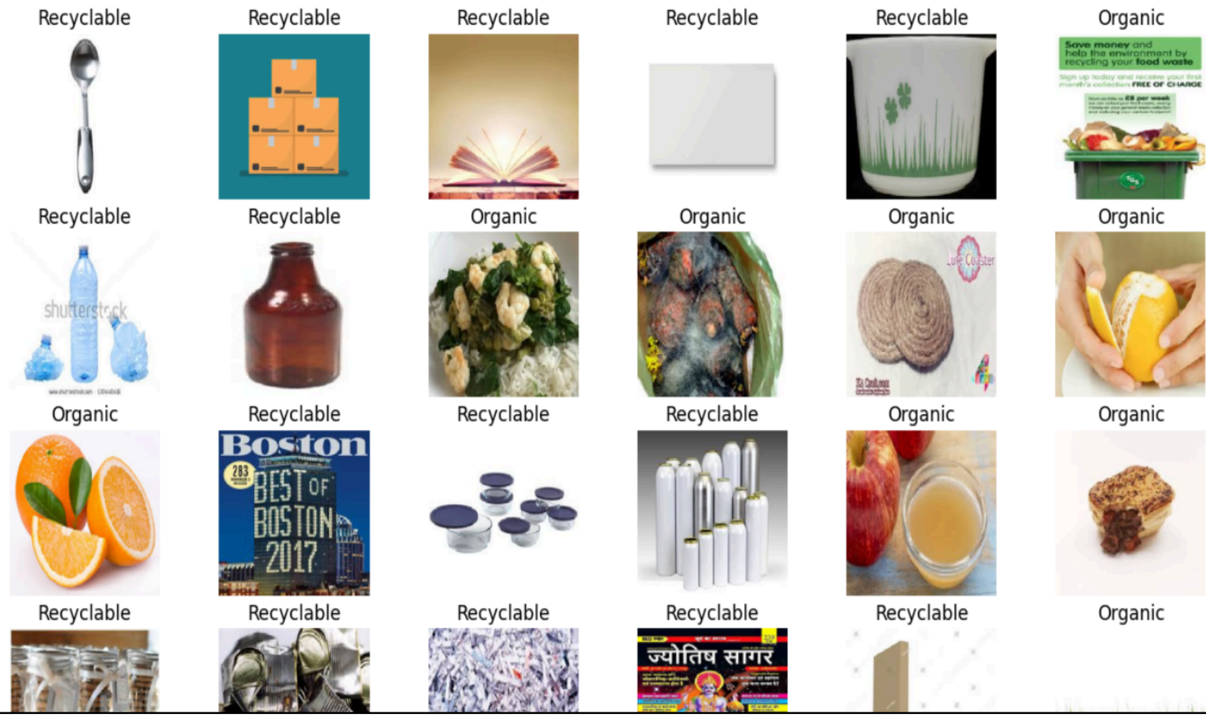
CLASS INDICES AND LABELS

SAMPLE IMAGES WITH LABELS

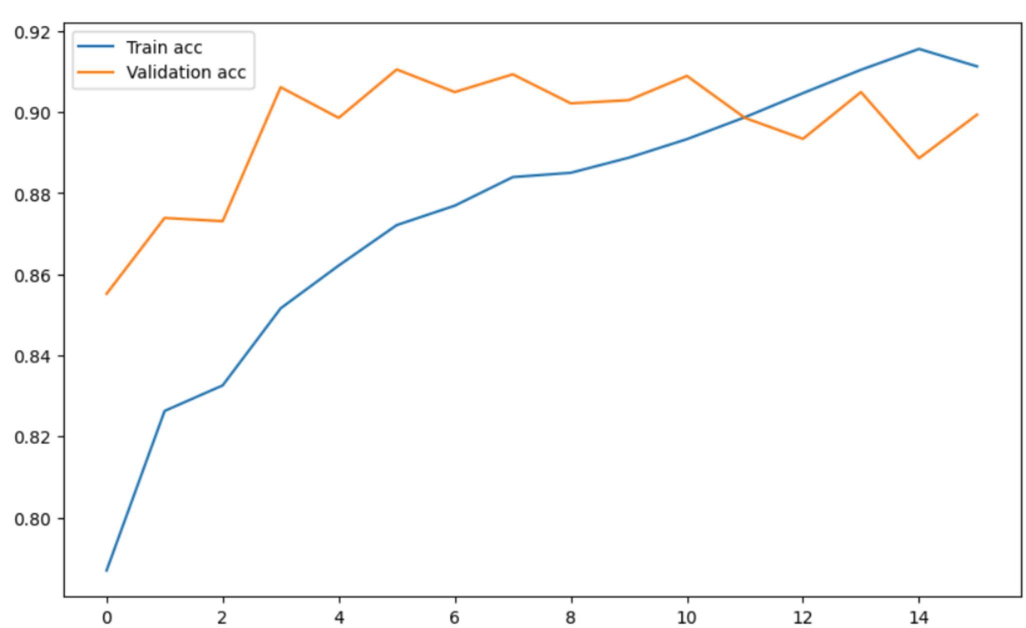
In [5]:

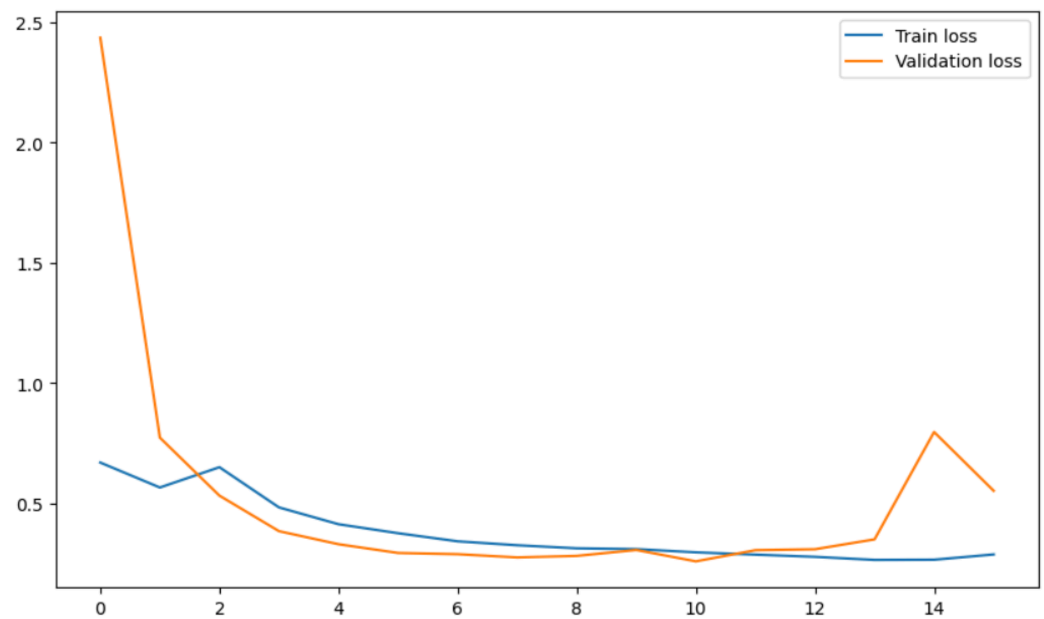
```python
img, _= next(train_gen)
plt.figure(figsize=(15, 13))
for i in range(30):
    ax = plt.subplot(6, 6, i + 1)
    plt.imshow(img[i])
    if _[i][1] == 0:
        plt.title("Organic")
    else:
        plt.title("Recyclable")
    plt.axis("off")
del img
del _
```

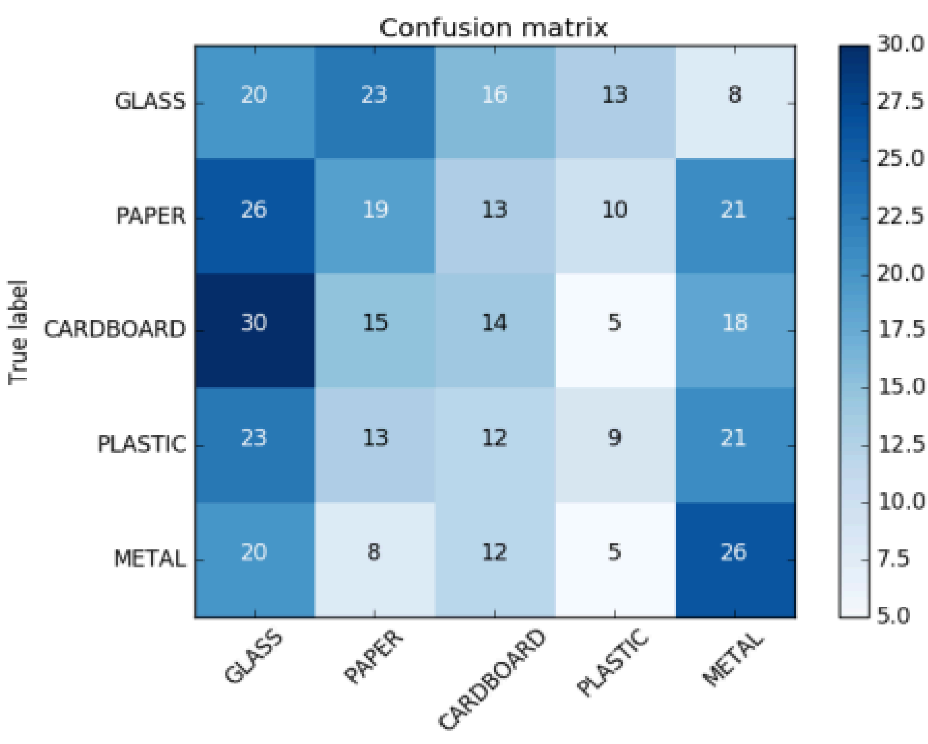




6. Benchmarking




Train loss
Validation loss
2.5
2.0
1.5
1.0
0.5
0
2
4
6
8
10
12
14


Confusion matrix
GLASS
PAPER
CARDBOARD
PLASTIC
METAL
True label
20 23 16 13 8
26 19 13 10 21
30 15 14 5 18
23 13 12 9 21
20 8 12 5 26
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
GLASS
PAPER
CARDBOARD
PLASTIC
METAL
Predicted label

7. Applicable Regulations:

The Bureau of Indian Standards has issued standards/guidelines on how to recover and recycle plastic waste and what kind of products could be manufactured from recycled plastics.

IS 14534: 1998: Guidelines for the recovery and recycling of plastic waste. This standard prescribes guidelines for the selection, segregation and processing of plastics waste/ scrap.

This standard also prescribes guidelines to the manufacturers of plastic products with regard to the marking to be used on the finished product in order to facilitate identification of the basic raw material. It will also help in identifying whether the material used on the end product is virgin, recyclate or a blend of virgin and recyclate.
IS 14535: 1998: Indian Standard for Recycled plastics for the manufacturing of products – Designation. This lays out the guidelines for identification and classification of recycled plastics materials (that are ready for normal use without any further modifications)on the basis of its basic properties and applications.

8. Business Opportunity:

Here are some specific business opportunities in recycling using machine learning:

1. Image recognition for material identification: Machine learning algorithms can be used to analyze images of waste materials and identify their composition. This can help recycling companies automate the sorting process and ensure accurate segregation of recyclable materials.
2. Predictive maintenance for recycling machinery: Machine learning can be utilized to predict when recycling equipment is likely to fail or require maintenance. By analyzing sensor data and historical maintenance records, businesses can optimize maintenance schedules, minimize downtime, and reduce costs.

3. Quality control in recycling processes: Machine learning algorithms can be trained to analyze data from sensors and cameras to detect defects, impurities, or contaminants in recycled materials. This can help ensure that the recycled products meet quality standards and improve overall product consistency.

Demand forecasting for recycled products: Machine learning can analyze historical sales data, market trends, and other factors to forecast the demand for specific recycled products. This information can assist businesses in optimizing production, inventory management, and pricing strategies.

4. Optimization of recycling collection routes: Machine learning algorithms can analyze historical data on waste generation, collection points, and transportation infrastructure to optimize collection routes. This can help reduce fuel consumption, minimize travel time, and improve overall efficiency in waste collection.

5. Personalized recycling recommendations: Machine learning can analyze individual recycling behavior, preferences, and consumption patterns to provide personalized recycling recommendations. This can encourage individuals to recycle more effectively and adopt sustainable waste management practices.

These opportunities highlight how machine learning can enhance various aspects of recycling, from sorting and maintenance to quality control and demand forecasting. Implementing machine learning technologies in these areas can lead to improved efficiency, cost savings, and a more sustainable recycling industry

9. Concept Generation:

9.1 Waste classification efficiency, we present a **multi-layered cloud supported architecture**, depicted in the Figure.

The proposed system consists of several embedded devices distributed in different waste collection facilities that capture photos of waste in real time and send them to a **cloud server for classification.**
The goal of our work is to instruct in real time a distributed number of robotic systems to extract and sort the materials in proper bins.

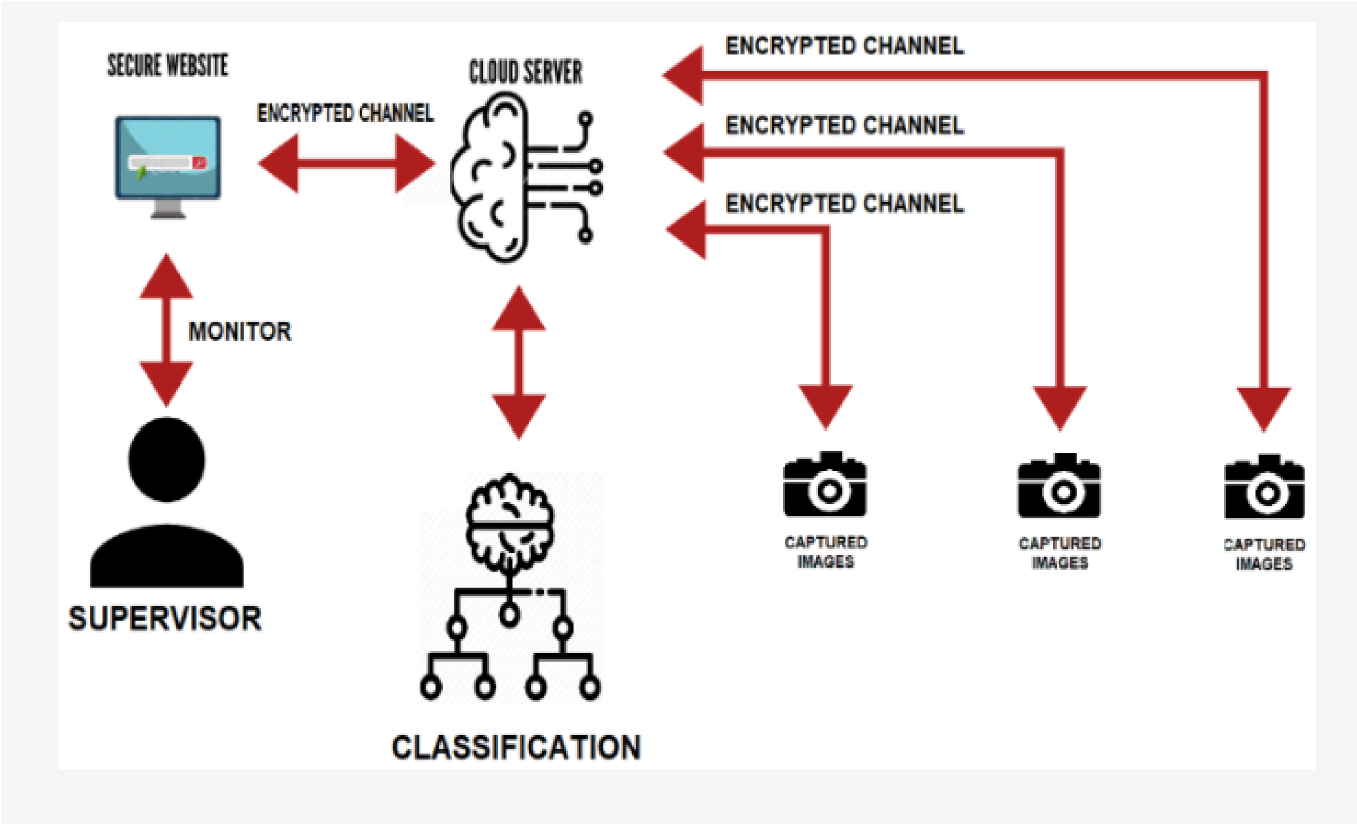


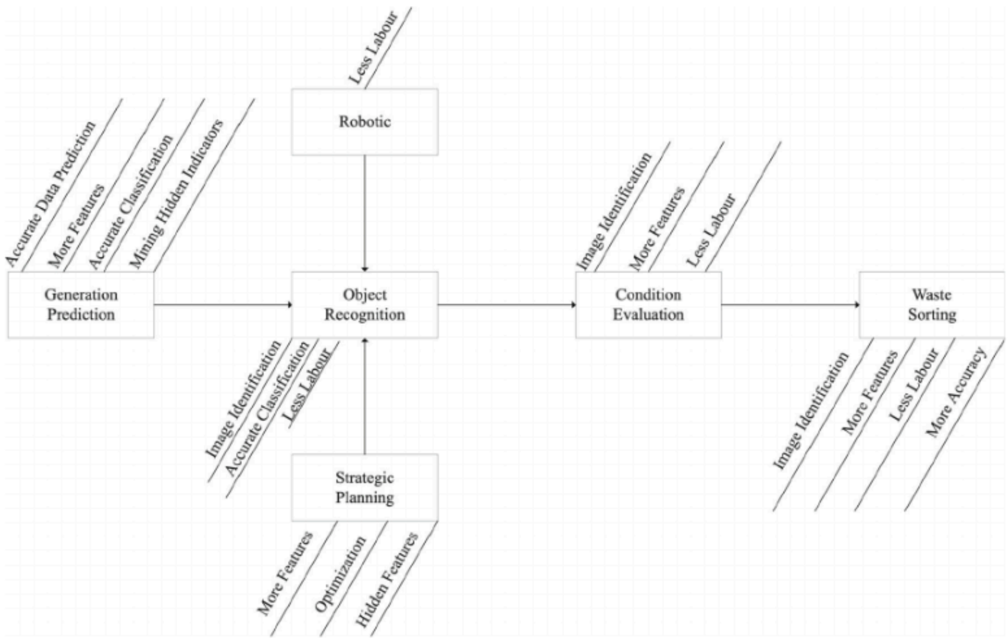
Figure 1. In the proposed system architecture, captured images are being offloaded to the cloud for the classification process.

9.2 For Large Scale integration:

The results suggest that ML has been applied to a few domains within recycling busi-ness and has been a proved irreplaceable interpretation tool of large data sets like municipal recycling data, but thefindings obtained in this paper also indicate that the MLapplications in recycling business are still a niche area.

Therefore, a large research space is out there for further exploration by more researchers and practitioners out of more countries, who may obtain inspirations from the leading authors and journals listed in this paper.

for example, on more recycling materials than that have been dealt with in the 51 studies, and on potential applications of ML into more domains of recycling business by making a statistical reference to the frequently used ML algorithms discussed in the paper, which would surely be able to provide an explicit guidance map for them. In order to present the guidance map in more detail, the 6 recycling domains and three of their top benefits are depicted in Figure for a quick view of what domains ML can be applied to and their possible benefits for the applications.



9.3 Team required to develop:

1. Machine Learning Engineer
2. Business Analyst
3. Software Developer
4. Cloud Engineer
5. Data Researcher
6. Data Engineer

10. Code Implementation:

[small scale integration]

11. Final Report Prototype:

Frontend
Frontend technology used is the camera that captures images.To build a secure website, you can consider using the following frameworks: **React, Angular,Vue.js, Django** etc.

Backend
The backend technology involves cloud deployment and a machine learning model.
The cloud deployment could be implemented using cloud services such as **Amazon Web Services (AWS)**, **Microsoft Azure**, or **Google Cloud Platform (GCP**). These cloud services provide a range of tools and services for deploying and managing applications and data in the cloud.

As for the machine learning framework, it is likely that a deep learning framework such as **TensorFlow, PyTorch**, or **Keras** is used in the backend for training and inference of the machine learning model. These frameworks provide a range of tools and libraries for building and deploying deep learning models, which can be used to analyze and classify the images captured by the camera.

Step 4: Financial Modeling

It can be directly launched into the retail market.
Let's consider our price of product = 250 for getting our graph.
if we take m = 250 (pricing of your product), x(t) = 50 (total sales), and c = 50 (production, maintenance etc. costs), then the linear equation becomes:

y = 250*50 + 50

So, y = 12500 + 50 = 12550

This means that the total profit (y) would be 12550 for these given values.

12 Conclusion:

Over the last few years, the generation of **municipal solid waste (MSW)** has constantly increased. According to the **World Bank's review report[1]**, it is expected that MSW will reach **2.2 billion tons** per year by 2025. It is evident that recycling is the only viable solution to this problem. The process of recycling, however, requires that the waste materials are separated.

The separation of waste materials is a time consuming process that is currently being performed by the hands of workers. As an attempt to solve this issue, in this paper we present an innovative solution for waste classification in waste collection facilities.

By utilizing computation offloading to the cloud, we can achieve low on-site implementation cost and complexity. Our work utilizes computer vision technologies along with a **Convolutional Neural Network (CNN)** in order to detect the recycled materials on a moving trash belt. The CNN classifies the waste materials in five categories: Paper, glass, plastic, metal, cardboard. The main purpose of this project is to solve the problem of non-segregated waste, which exists more in developing and developed countries.

13 References:

1. Rada, E.C.; Zatelli, C.; Cioca, L.I.; Torretta, V. Selective Collection Quality Index for Municipal Solid Waste Management. *Sustainability* 2018, *10*, 257. [Google Scholar][CrossRef][Green Version].

2. Waste Recycling—European Environment Agency. 2019. Available online: https://www.eea.europa.eu/data-and-maps/indicators/waste-recycling-1

3. https://www.mdpi.com/1999-5903/12/9/141

4.https://www.researchgate.net/Machine_learning_in_recycling_business_an_investigation_of_its_practicality_benefits_and_future_trends