Implementing an Automated Waste Sorting System Using OpenCV: Smart Bin Approach

AN END-SEMESTER PROJECT REPORT ON THE SUBJECT OF ROBOTIC OPERATING SYSTEMS AND ROBOT SIMULATION

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By

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BONAFIDE CERTIFICATE

Certified that this project report **IMPLEMENTING AN AUTOMATED WASTE SORTING SYSYTEM USING OPEN CV:A SMART BIN APPROACH"** is the bonafide work of **"Team_7"** who carried out the project work under my supervision towards his completion of the end semester project for the subject "ROBOT OPERATING SYSTEMS AND ROBOT SIMULATIONS (21AIE213)".

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ABSTRACT

The implementation of a smart bin system using OpenCV, a popular computer vision library, is an innovative approach to automating waste sorting based on materials. The main objective is to effectively develop waste management in airports by automatically segregating the waste. The proposed system utilizes OpenCV to analyze real-time video feed from a camera fixed on the bin. These images are processed using OpenCV to identify the material type, such as plastic, glass, food waste, or metal. Using this information, the system efficiently sorts the waste into the appropriate bins, aiming to improve waste management practices and minimize the amount of recyclable material ending up in landfills. By utilizing machine learning algorithms like CNN, waste items are classified into appropriate categories, and the bin's compartments are intelligently activated to sort the waste accordingly. The system's performance will be evaluated based on accuracy, speed, and reliability. The implementation of this automated waste sorting system has the potential to significantly reduce manual sorting efforts and help in environmentally friendly waste disposal practices.

Keywords: OpenCV, Smart bin system, Sort waste.

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CHAPTER 1

INTRODUCTION

1.1. BACKGROUND

This project focuses on implementing a smart bin approach for waste sorting by leveraging OpenCV, a computer vision library. The system uses web camera to detect and classify various types of waste in real-time. By analyzing visual characteristics, the system automatically sorts the waste into appropriate categories for efficient waste management, reducing manual sorting, and encouraging recycling and environmental sustainability.

Convolutional Neural Networks (CNN) and other machine learning techniques can be used to train the system to accurately classify waste materials. The system can categorise waste items based on their material composition fast and accurately by using these algorithms during the image analysis process. This permits the system to turn on the proper bin chambers or processes, ensuring that the garbage is accurately sorted.

The use of this automated garbage sorting system has the potential to significantly improve waste management procedures, particularly in busy places like airports. Sorting can be automated to cut down on manual labour, eliminate mistakes, and increase productivity. Maximising recycling efforts, reducing contamination, and promoting environmentally acceptable waste disposal practises are all made possible by the system's capacity to precisely identify and separate waste elements.

1.2. RESEARCH MOTIVATION

In today's world airport plays significant role in generating large amount of waste due to continuous flow of passengers and activities. Proper waste management in airports is not only for environmental sustainability but also for health and safety. In many airports the sorting of waste is done manually which is more time-consuming, error-prone and labor work. The problem in manual sorting may lead to inconsistencies, resulting in improper disposal and proper waste segregation. In this regard, the utilization of advanced technology like OpenCV (Open-Source Computer Vision Library) has potential to improve waste segregation procedures in airport facilities. If we are able to build a system, then the biodegradable waste can be properly recycled and reused, while non-biodegradable waste can be appropriately disposed of. By achieving these objectives, the system helps in achieving sustainability targets, decreasing waste sent to landfills, preserving resources, and minimizing the environmental impact of airports. This research acts as base for to create project for high environments such as shopping malls, train station and in public places.

1.3 OUTLINE OF THE REPORT

The structure of this thesis is summarized below.

Chapter1 Briefly explains the history and significant areas of development in waste segregation and smart bin

Chapter 2 (Literature Review) deals with the details of the past literature review of waste management and also how open cv can be used here of sorting the wastes.

Chapter3 (Problem Statements and Methodology) The problem statement of this project is create a smart bin which will sort the waste accordingly . Methodology used here CNN of Machine learning is used of classifing wastes by testing and training with the dataset

Chapter4 (Results and Discussion) Our model is able to classify the waste which is trained and also been tested successfully.

Chapter5 (Conclusion and Future Scope) In summary, the implementation of an automated waste sorting system using OpenCV presents a promising solution to enhance waste management practices, improve recycling rates, and minimize environmental impact. With ongoing research and development, this technology can play a pivotal role in achieving sustainable waste management goals and creating a cleaner, greener future

CHAPTER 2

LITERATURE REVIEW

2.1 OVERVIEW

The basic idea behind implementing an automated waste sorting system using open cv is to build a system that uses computer vision and machine learning to sort waste automatically. The aim of this system is to solve the problem of improper waste disposal in Airport and also to reduce the impact of waste on environment .

Our system is made by the camera, stereo meters , Arduino and other things that is needed to be in bin. the camera capture is the images of the waste, these images will processed by the opencv library function or image recognition and a machine algorithm called CNN to identify the type of waste and sort in according.

Our system is trained is such a way that it will be able to sort different types of wastes like plastic, metal, food waste and paper waste so that sorted waste can be sent for recycling or disposal, depending on the type of waste .

2.2 Review your subject (Change your title according to your work)

1. AI Smart Bin
2. Automated Waste Segregation System

2.1 RESEARCH GAP and KEY FINDINGS

S.NO	TITLE	ABSTRACT	YEAR
1	Standalone Frequency Based Automated Trash Bin and Segregator of Plastic Bottles and Tin Cans	"Resonant Frequency Based Automated Waste Material Segregator using MATLAB". The decision process is done by the microcontroller Arduino	**2016**
2	Literature Review of Automated Waste Segregation System using Machine Learning: A Comprehensive Analysis	Machine Learning, image processing, artificial intelligence and a combination of waste segregation was used in searching in the database from two large databases	**2019**
3	Design Of A Monitoring System For Waste Management Using IoT	The proposed systems find the solution for the garbage disposal by designing a smart dust bin by managing the garbage. The garbage is collected, and the garbage collector sent from the control room. The smart dustbin sends the message to the control room through the sensors attached to it.	**2019**

1. Resarch Gap

CHAPTER 3

PROBLEM STATEMENT AND METHODOLOGY

3.1 OVERVIEW

This chapter is dedicated to enumerating the materials required to achieve the proposed objectives of this research work with the help of the involved technologies. The research work envisaged in this research work is investigated in different phases.

3.2 PROBLEM STATEMENT

Traditional waste sorting methods are time-consuming, labor-intensive, and prone to human error, leading to inefficient waste management practices and inadequate recycling rates. There is a need for an automated solution that can accurately and efficiently sort different types of waste to optimize recycling and resource recovery. By leveraging computer vision technology, specifically OpenCV, and incorporating a smart bin approach, this project aims to develop a system that can intelligently classify and sort waste items into appropriate categories, thereby improving waste management processes and promoting sustainable practices.

3.3 OBJECTIVES

Automate garbage Sorting: The main goal is to create a system that uses computer vision and machine learning to automate the garbage sorting process. By minimising or eliminating the need for manual sorting, this method attempts to increase productivity and decrease labor-intensive jobs.

Accurate Material Identification: Using OpenCV's image processing capabilities, the system should be able to correctly identify various waste materials, including plastic, glass, food waste, and metal. To ensure appropriate sorting and reduce errors, the goal is to obtain a high level of accuracy in material recognition.

Effective Waste Segregation: The system must logically group the identified waste items into the correct subcategories or divisions inside the container. The goal is to effectively segregate waste in order to maximise recycling efforts, minimise contamination, and recover as much recyclable material as possible.

Real-Time Processing: The system must quickly process the live video stream from the cameras installed on the bin. The goal is to make sure that waste items are classified promptly and precisely, enabling smooth and speedy waste sorting.

Performance Evaluation: Important measures like accuracy, speed, and dependability should be used to gauge the system's performance. The goal is to evaluate the system's efficacy and efficiency and pinpoint opportunities for development.

Trash Management Optimisation: To analyse trash generation trends, improve collection routes, and find chances for waste management optimisation, the system's acquired data should be used. The goal is to boost resource conservation, reduce environmental impact, and generally improve waste management practises.

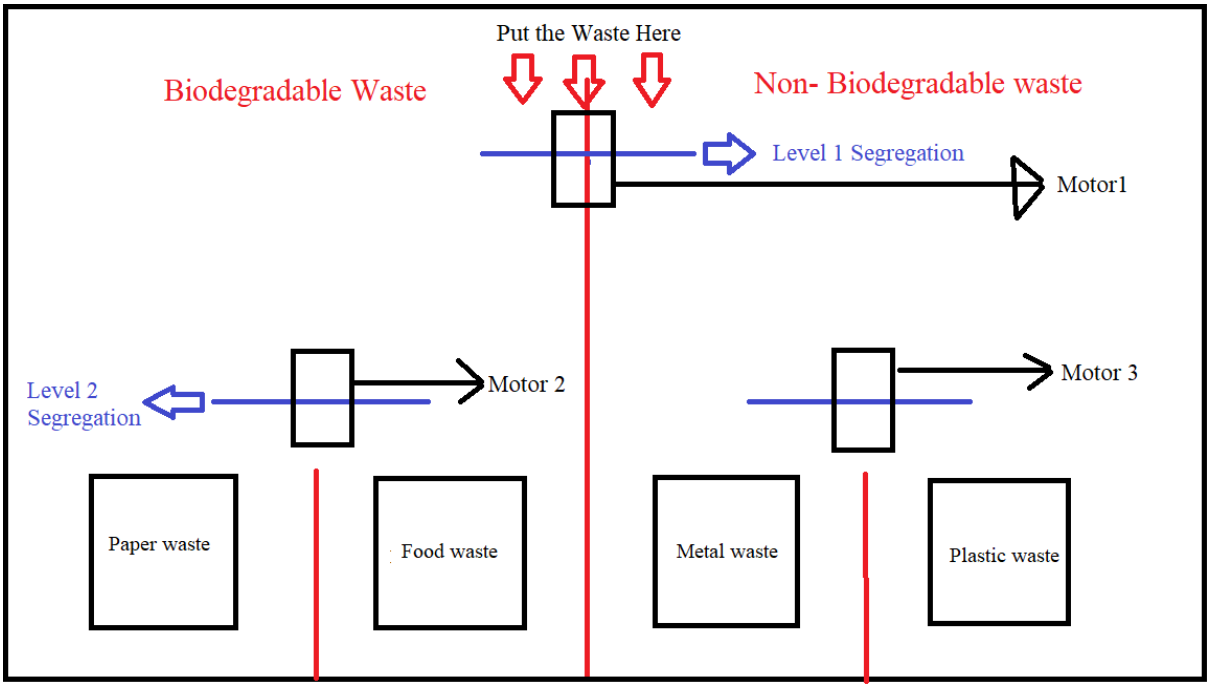
Environmental Sustainability: By minimising the amount of recyclable material that ends up in landfills, the goal is to promote ecologically sustainable trash disposal practises. The system intends to facilitate the transition to a circular economy and make a positive impact on sustainable waste management objectives.

Scalability and Adaptability: The system needs to be made scalable and adjustable so that it may be used in a variety of scenarios outside of airports. The goal is to develop a solution that can be used in many waste management scenarios, hence increasing its impact.

3.4 METHODOLOGY

Developing a smart bin that segregates four classes of waste typically involves a combination of hardware and software components. Here is a general methodology that can be followed:

- Libraries used : cvzone, cv2, tensorflow, keras, pyserial
- Machine learning : In our project we have 2 levels of segregation , and 4 classes – Paper, Plastic, metal and food waste. For all the classes we have trained the CNN model of around 1000 png and jpeg images. We have trained 80% of the data and the 20% for training and ran 30 epochs .
- OpenCV : Converted that CNN based machine learning files into a h5 file .Then did the OpenCV code for initializing the camera and detecting the type of waste from the external web cam connected to the laptop/PC
- Ardiuno: we have 3 servo motors, wrote code for the movement of the level 1 and level 2 segregation .
- Hardware :



Level 1 Segregation – This segregation plate is only used for the direction of the waste where it finds whether the respective wate is biodegradable or non-biodegradable . in the next step the waste is moved to the second level segregation plate.

Level 2 Segregation - in this plate the waste is send to the separated waste boxes for all the four classes . In this level it has 2 plates.

- Connection of ardiuno and the OpenCv python code using a package from python package called pyserial. The data i.e is whether the object is of what class id send in the form of binary data to the ardiuno in the String format . In the following form

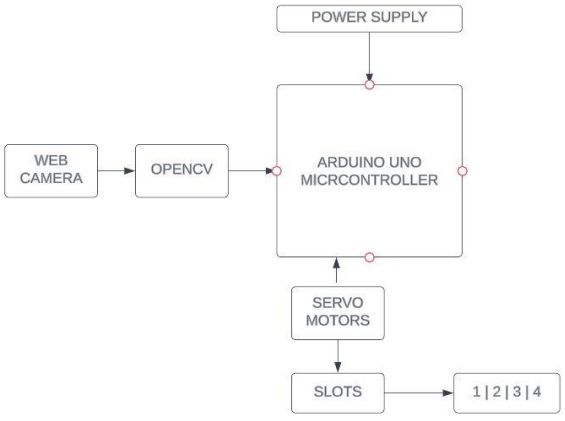
Paper	Food	Metal	Plastic	Nothing	Waste
1	0	0	0	0	Paper
0	1	0	0	0	Food
0	0	1	0	0	Metal
0	0	0	1	0	Plastic
0	0	0	0	1	Nothing

2 SERIAl COMMUNICATION

- In the ardiuno code the data is received and separated into each letter(i.e digit in string format)
- If the camera detects that it is a paper then data = “10000”, if it is food then data = “01000”,if it is metal then data = “00100”, if it is plastic then data = “00010”, if nothing is detected then data = “00001”
- According to the block diagram below the slot 4 is for plastic, slot 3 is for metal, slot 2 for food, slot 1 for paper .

BLOCK

:



Flow chart:

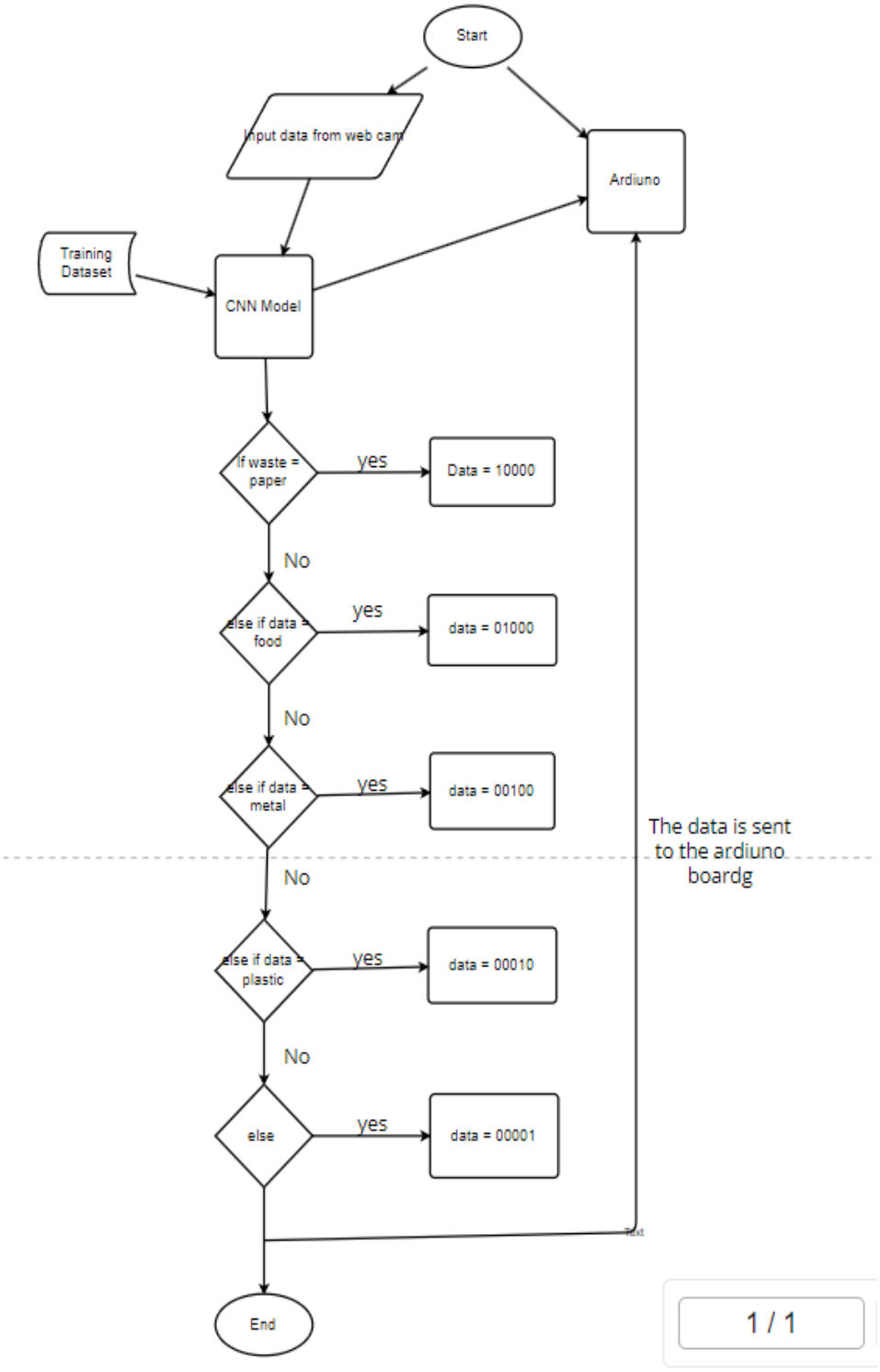


Fig.2

Initially the input data is read from the web cam connected to the computer and sent to the trained CNN model and predicted the appropriate class and displayed in the screen , then that data is sent to ardiuno in the form of binary values. According to the binary values received from the python the servo motor is powered and do the appropriate rotation which makes the waste fall in their respective boxes.

Components Used:

1.Web Camera

Fig.3

2.Connecting Wires

Fi g.4

3. Bread Board

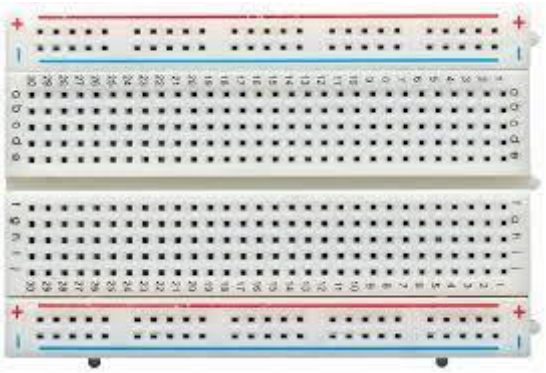


Fig.5

4.Arduino

Fig.6

5.Server Motor

Fig.7

CHAPTER 4

RESULTS AND DISCUSSION

The system is able to differentiate between different types of waste materials, which is a particularly challenging task in waste sorting. The materials like plastics, food waste , metals and also papers wastes.

The smart bin system developed in this project was able to capture images of waste and process them in real-time, making it a practical solution for waste sorting.

Overall, the results of the project demonstrate the potential of computer vision and machine learning to improve waste management practices. The system developed as part of the project has the potential to make a significant positive impact on the environment and promote more sustainable waste management practices.

Model Images

Fig.8

Fig.9

Fig.10

Model Accuracy:

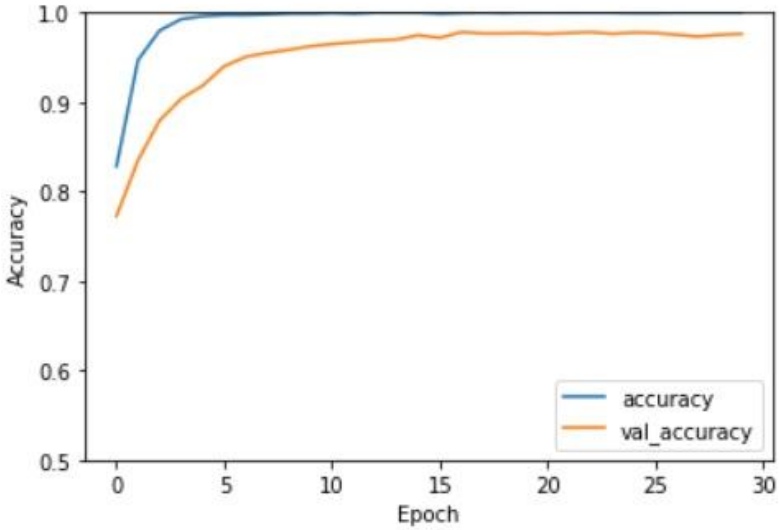


Fig.11

CHAPTER 5

FUTURE SCOPE AND CONCLUSION

In this chapter, a summary of the thesis is presented. Furthermore, the advantages and drawbacks of the proposed approaches are discussed. Finally, a potential future direction is presented.

5.1 Future Scope

Waste sorting into several classes: Enlarge the system to separate waste into different classes such recyclables (plastic, paper, and glass), organic waste, hazardous garbage, etc. This would necessitate expanding the model's classification skills and training the system on a larger and more varied dataset.

Integration with robotic arm: To automate the physical sorting process, pair a robotic arm with the garbage sorting system. The robotic arm can pick up the rubbish and place it into the proper containers when the system recognises its type. The garbage sorting process would be more accurate and efficient as a result of this.

Implement a monitoring system that keeps tabs on the quantity and types of waste being sorted in real time. Analytics and insights about garbage generation patterns, recycling rates, and opportunities for development can be produced using this data. It can aid in the optimisation of waste management plans and the detection of chances for recycling and trash minimization.

Remote monitoring, control, and management via the cloud are possible if you enable the system's connection to the cloud. Administrators would thus be able to monitor the functioning of numerous smart bins, receive alerts about the status of the bins, and remotely modify the sorting model or parameters.

Collaboration with recycling facilities: To make the waste sorting process more efficient, establish collaborations with recycling facilities. This may entail integrating the system with their processes, giving them access to data

on the garbage that has been sorted, or simplifying the direct transfer of waste to recycling facilities.

Integrate mobile and Internet of Things (IoT) devices into the system. Applications for mobile devices can offer details about nearby smart bins, recycling advice, and financial incentives for eco-friendly garbage management. By combining with sensors for weight measurement, odour detection, or bin fill level monitoring, IoT devices can improve the system's functionality.

5.2 Conclusion

Implementing an Automated Waste Sorting System Using OpenCV: A Smart Bin Approach is an innovative and practical solution to the problem of waste management. The project combines computer vision and machine learning techniques to develop a smart bin system that can sort different types of waste automatically. The system is designed to address the growing problem of improper waste disposal and to promote more sustainable waste management practices. The results of the project demonstrate the potential of computer vision and machine learning to improve waste sorting accuracy, reduce the negative impact of waste on the environment, and promote more efficient waste management practices.

Overall, the project showcases the potential of technology to solve real-world problems and promote a cleaner and more sustainable future. The system developed as part of the project has the potential to make a significant positive impact on the environment, and it provides a roadmap for future developments in waste management technology.

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Appendix 1:Relevant mathematics, code etc.

Arduino Code:

```
#include <Servo.h>
//int strlen = 6;
int paper = 0;
int food = 0;
int metal = 0;
int plastic = 0;
int nothing = 0;

Servo servo1;
Servo servo2;
Servo servo3;

const int servoPin1 = 9;
const int servoPin2 = 10;
const int servoPin3 = 11;

void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600);
  servo1.attach(servoPin1);
  servo2.attach(servoPin2);
  servo3.attach(servoPin3);
}
void getdata() {
while (Serial.available()) {
String c = Serial.readStringUntil('\r');

       paper = c.substring(0, 1).toInt();
       metal = c.substring(1, 2).toInt();
       food = c.substring(2, 3).toInt();
       plastic = c.substring(3, 4).toInt();
       nothing = c.substring(4, 5).toInt();
       c = "";
    }
}
void food1(){
```

```
servo1.write(90);
servo3.write(90);
delay(1500); // Wait for 1 second
servo1.write(35);
  servo3.write(150);
  delay(1500); // Wait for 1 second
  servo1.write(90);
  servo3.write(90);
  delay(1500);
  }

 void paper1(){
  // Rotate the servo motor to 0 degrees
  servo1.write(90);
  servo2.write(90);
  delay(1500); // Wait for 1 second
  servo1.write(150);
  servo2.write(150);
  delay(1500); // Wait for 1 second
  servo1.write(90);
  servo2.write(90);
  delay(1500);
  }

  void metal1(){
  // Rotate the servo motor to 0 degrees
  servo1.write(90);
  servo2.write(90);
  delay(1500); // Wait for 1 second
  servo1.write(150);
  servo2.write(35);
  delay(1500); // Wait for 1 second
  servo1.write(90);
  servo2.write(90);
  delay(1500);
  }

  void plastic1(){
  servo1.write(90);
  servo3.write(90);
  delay(1500); // Wait for 1 second
```

```
  servo1.write(35);
  servo3.write(35);
  delay(1500); // Wait for 1 second
  servo1.write(90);
  servo3.write(90);
  delay(1500);
  }
  void nothing1(){
  servo1.write(90);
  servo3.write(90);
  }
void loop() {
  // put your main code here, to run repeatedly:
getdata();
if (paper==1){paper1();}
if (food==1){food1();}
if (metal==1){metal1();}
if (plastic==1){plastic1();}
if (nothing==1){nothing1();}
//delay(3000);
    }
```

OpenCV code:

```
from cvzone.ClassificationModule import Classifier
import cv2
import serial

d = serial.Serial('com18', 9600)
cap = cv2.VideoCapture(1)
Classifier = Classifier('keras_model.h5', 'labels.txt')
waste = [0,1]
string=""
while True:

    success, img = cap.read()

    predection = Classifier.getPrediction(img)
    if predection[1] ==0:
        string = "00001"
```

```
        if predection[1] == 1:
            string = "10000"
        if predection[1] == 2:
            string = "01000"
        if predection[1] == 3:
            string = "00100"
        if predection[1] == 4:
            string = "00010"
        print(string)
        if predection:
    #       hand1 = str(predection[1])
    #               string = str(fingers1[0]) + str(fingers1[1]) + str(fingers1[2]) +
         str(fingers1[3]) + str(fingers1[4])
            string = string + '\r'
            print(string)
            print(string.encode())
            d.write(string.encode())

        cv2.imshow("Image", img)
        if cv2.waitKey(3000) == ord('q'):
            break

    cap.release()
cv2.destroyAllWindows()
```

Appendix 2: Individual Contribution to this project work

Balaji M - literature review, CNN based Machine learning model development, PPT
Logeshwar BS - Hardware, PPT, Report, Integrsting CNN Model and OpenCV code
Mithilesh - Software(Ardiuno Code), Report , PPT, creating own dataset
Sameer - Hardware, Report, lierarture review
Sriram S - Software(OpenCV), CNN model Training , report
Surya-- Hardware model building , Report, Integrating Ardiuno and OpenCV

Photo: