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A Survey on Automated Waste Segregation System Using Raspberry Pi and Image Processing

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Abstract - This project introduces a novel approach to waste segregation using a Raspberry Pi and a camera-based system. The system uses OpenCV for waste identification and continuously captures images of a designated area, saving them as reference photos. When an object is recognized as waste, a robotic arm is activated for collection. The collected waste is then carefully deposited into a designated trash can with a level sensor monitoring its capacity. When the can reaches its capacity threshold, a notification is generated and sent to a central center, signaling the need for waste removal. This innovative solution combines image processing, automation, and smart monitoring, minimizing human intervention and improving waste segregation efficiency. The use of a Raspberry Pi and camera technology for waste segregation is cost-effective, scalable, and environmentally conscious, making it a valuable step towards a more eco-friendly and efficient waste management system

Keywords-Raspberry Pi, Open-cv, Robotic Arm, Image Processing.

1.INTRODUCTION

Waste management is a pressing issue in today's society, with increasing volumes of waste generated. Proper waste segregation is crucial for recycling and reducing environmental impact. This project introduces an innovative approach to waste segregation using a Raspberry Pi and a camera-based system. The system categorizes waste materials into distinct groups, such as paper, plastic, glass, and organic waste, enabling efficient recycling and proper disposal. Traditional methods often rely on manual labor, which can be time-consuming and labor-intensive. The project focuses on twofold: detection and collection. Using the OpenCV framework, the system identifies waste items within a predefined area, and the Raspberry Pi camera captures images as reference images. As new images are captured, they are compared to the reference images. When an object is recognized as waste, a robotic arm is triggered to collect the waste. The collected waste is then carefully deposited into a designated trash can with a level sensor to monitor its capacity. This innovative and cost-effective solution aims to reduce human intervention, improve waste segregation accuracy, and enhance waste collection processes. The integration of Raspberry Pi and camera technology opens up new possibilities for optimizing waste management practices, contributing to a cleaner and more sustainable environment. This paper delves into the technical details of the waste segregation system, discussing hardware and software components, image processing techniques, and the potential impact of this technology on waste management practices.

2. PROPOSED METHOD

The performance of the proposed technique is systematically evaluated using the waste images received from the public sources. For validating the effectiveness of the modified region growing, the quantity rate parameter has been considered.

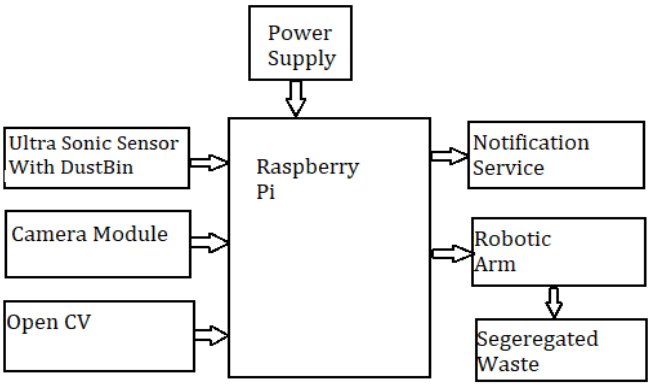


Fig 1. Block Diagram

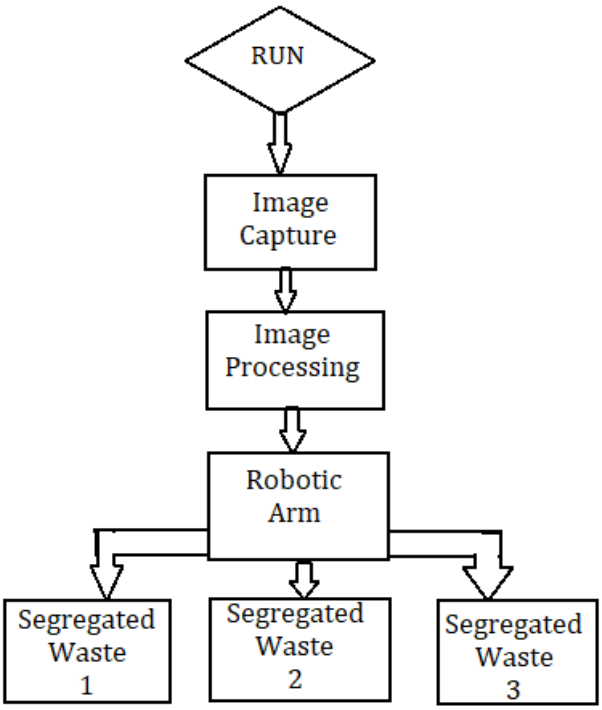


Fig 2. Flow Chart

2.1 Hardware

2.1.1 Raspberry Pi 3 Board

Pi is a credit-card sized computer that connects to a computer monitor TV and uses input devices like keyboard and mouse. It is capable of performing various functionalities such as surveillance system, military applications, surfing internet, playing high-definition videos, live games and to make data bases. Raspberry Pi is the main controller in our project which gathers data from the input modules and transmits it to the output modules.

Specifications:

Microprocessor	Broadcom BCM2837 64bit Quad Core Processor
Processor Operating Voltage	3.3V
Raw Voltage input	5V, 2A power source
Maximum current through each I/O pin	16mA
GPU	Dual Core Video Core IV® Multimedia Co-Processor. Provides Open GLES 2.0, hardware-accelerated Open VG, and 1080p30 H.264 high- profile decode.
Internal RAM	1Gbytes DDR2
Clock Frequency	1.2GHz
Operating Temperature	-40ºC to +85ºC
Wireless Connectivity	BCM43143 (802.11 b/g/n Wireless LAN and Bluetooth 4.1)
Ethernet	10/100 Ethernet

Fig 3. Raspberry Pi

2.1.2 Ultrasonic Sensor

The HC-SR04 ultrasonic sensor to determine distance to an object like bats or dolphins do. It offers excellent range accuracy and stable readings in an easy- to- use package. Its operation is not affected by sunlight or black material like sharp range finder are (although acoustically soft materials like cloth can be difficult to detect). Similar in performance to the SRF005 but with the low-prince of a Sharp infrared sensor.

Specifications:

Power Supply	DC 5V
Working Current	15mA
Working Frequency	40Hz
Ranging Distance	2cm – 400cm/4m
Resolution	0.3 cm
Measuring Angle	15 degree
Trigger Input Pulse width	10uS
Dimension	5mm x 20mm x 15mm

Fig 4. Ultrasonic Sensor

2.1.3 Raspberry Pi Camera

USB Camera are imaging camera that use USB 2.0 or USB 3.0 technology to transfer image data. USB cameras are designed to easily interface with dedicated computer systems by using the same USB technology that is found on most of the computers. The accessibility of USB 2.0 makes USB technology in computer systems as well as the 480 Mb/s transfer rate of USB 2.0 makes USB cameras ideal for many imaging applications. An increasing selection of USB 3.0 Cameras is also available with data transfer rates of up to 5Gb/s.

Specifications:

Resolution	5 MP
Compatibility	Raspberry Pi 3B+/4B
Lens Focus	Fixed Focus
Image Size(Pixels)	2592Ã—1944
Interface Type	CSI(Camera Serial Interface)
Sensors	Omnivision 5647 fixed-focus
Aperture	2.9
Focal Length	3.29

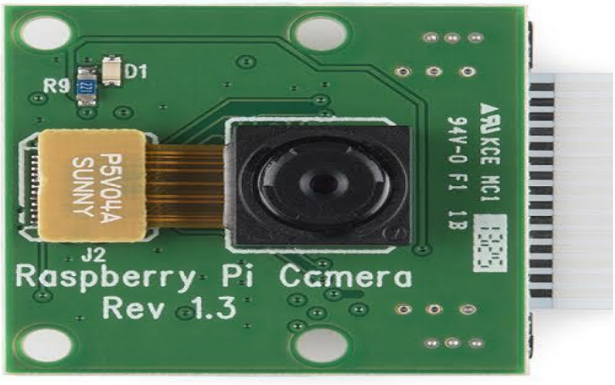


Fig 4. Raspberry Pi Camera

2.1.4 DC Motor

A DC Motor is an electric motor that runs on direct current power. In any electric motor, operation is dependent upon simple electromagnetism. A current carrying conductor generates a magnetic field, when this then placed in an external magnetic field it will encounter a force proportional to current in the conductor and to strength of external magnetic field. A DC Motor provide excellent speed control for acceleration and deceleration. It is easy to understand, simple and has cheap drive design.

Specifications:

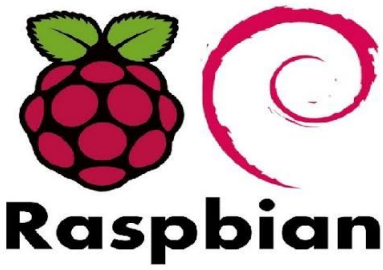
Standard	130 Type DC motor
Operating Voltage	4.5V to 9V
Recommended/Rated Voltage	6V
Current at No load	70mA (max)
No-load Speed	9000 rpm
Loaded current	250mA
Motor Size	27.5mm x 20mm x 15mm
Weight	17 grams

Fig 5.DC Motor

2.2 Software Components

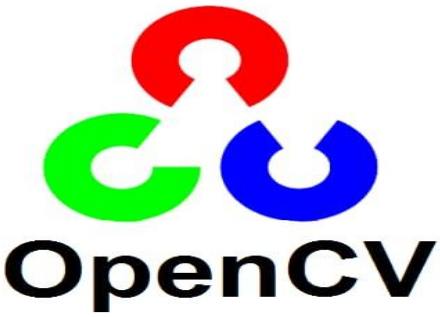
2.2.1 Raspbian OS

This provides significantly faster performance for applications that make heavy use of floating-point arithmetic operations. All other applications will also gain some performance through the use of advanced instructions of the ARMv6 CPU in Raspberry Pi. Although Raspbian is primarily the efforts of Mike Thompson (MP Thompson) and Peter Green (plug wash), it has also benefited greatly from the enthusiastic support of Raspberry Pi.



2.2.2 Open CV

Open CV (Open-Source Computer Vision) is a library of programming functions mainly aimed at real- time computer vision originally developed by Intel. The library is cross platform and free for use under the open-source BSD license OpenCV supports deep learning frameworks TensorFlow, Torch/PyTorch and Cafe.



3.METHODOLOGY

1. **Image Capture**: The Raspberry Pi is equipped with a camera module that continuously captures images of a designated area where waste items are expected to be placed. These initial images serve as reference photos.

2. **Image Comparison**: As new images are captured, the system uses the OpenCV (Open Source Computer Vision) framework to compare these images with the reference photos. The image processing algorithms identify waste items within the images based on predefined characteristics, such as shape, color, or patterns.

3. **Waste Detection**: When the system recognizes an object in the images as waste, it triggers the waste detection process. The recognition algorithms identify the type of waste, such as paper, plastic, glass, or organic waste.

4. **Robotic Arm Activation**: Upon successful detection and classification, the system activates a robotic arm. This robotic arm is responsible for collecting the identified waste item.

5. **Waste Collection**: The robotic arm carefully scoops up the waste item and deposits it into the corresponding waste bin, ensuring proper segregation. Different bins are designated for different waste types.

6. **Capacity Monitoring**: Each waste bin is equipped with a level sensor that continuously monitors the amount of waste inside the bin. When a bin reaches its predefined capacity threshold, the sensor sends a signal to the system.

4. Literature Review

Title	Author	Methodology
SMART WASTE SEGREGATION USING MACHINE LEARNING AND IOT TECHNIQUES (2022) [1]	Rahul Shivaji Dattawade, Poornesh Havlakar, Vandhan PR, Uzma Khanum, Dr. Ram Gopal Segu	This project utilizes OpenCV for waste detection. A Raspberry Pi camera continuously captures images of a specific area, saving them as default. It compares new images to the default to identify waste. When detected, a robotic arm collects the garbage, placing it in a trash can with a level sensor. When full, a notification is sent to the center
WASTE SEGREGATION USING IMAGE PROCESSING (2020) [2]	Prof. Yuvaraj, Likhith N Gowda, Manavi, Priya P Rao, Shivani Pati	This waste segregation system uses image processing to automatically sort waste. It involves two phases: training and operating/testing. Components include a conveyor belt, Raspberry Pi/Microcontroller, web camera, and motors/drivers. In the training phase, the Raspberry Pi processes input images through segmentation, classification, and object detection. In the operating phase, images are captured at 60 frames per second, pre-processed for clarity, and fed into a trained model for waste recognition.

		The Raspberry Pi then directs waste objects to respective bins
Title	**Author**	**Methodology**
RASPBERRY PI BASED AUTOMATED WASTE SEGREGATION SYSTEM [4]	Gaurav Pawar, Abhishek Pisal, Ganesh Jakhad, Godson Koithodathu, Prof. Piyush G.Kale	The project's primary objective is to create an automated waste sorting system that categorizes waste into metal, wet, and dry types. The system employs a Raspberry Pi 3, inductive proximity sensor, ultrasonic sensor, moisture sensor, and servo motors
Application Research of Automatic Garbage Sorting Based on TensorFlow and OpenCV [5]	Jing Hu , Bo Zha	The study focuses on establishing a comprehensive dataset for garbage classification, encompassing recyclable, kitchen, hazardous, and other waste categories. Manual collection and categorization were necessary due to the absence of a public dataset. The dataset underwent thorough preprocessing, including image enhancement techniques like rotation, brightness adjustment, and scaling
A Garbage Detection and Classification Method Based on Visual Scene Understanding in the Home Environment	Yuezhong W ,Xuehao Shen, Qiang Liu, Falong Xiao and Changyun Li	The proposed methodology employs a YOLOv5m-Attention detection algorithm for real-time identification of household garbage items, providing precise location and category details. A multimodal knowledge graph is constructed to store and organize attribute and interrelated information of the items, enhancing decision-making capabilities. Deep learning, specifically convolutional neural networks (CNNs), is utilized to automatically extract features from a dedicated garbage classification dataset, enabling accurate categorization.

4.APPLICATIONS

1. **Municipal Waste Management:** Implementing the system in municipal waste management operations can streamline the collection and segregation of household waste, reducing the environmental impact and promoting recycling.

2. **Recycling Facilities**: Recycling centers and facilities can use the technology to automate the sorting of recyclable materials, such as paper, plastic, glass, and metal, improving the quality and quantity of recycled items.

3. **Commercial and Industrial Settings**: Businesses and industrial sites that generate substantial waste can benefit from automated waste segregation to enhance recycling efforts and reduce disposal costs.

4. **Public Spaces:** Deploying the system in public spaces, parks, and tourist areas can maintain cleanliness and prevent overflowing trash bins, contributing to a cleaner environment.

5. CONCLUSIONS

In conclusion, this survey paper delves into a diverse array of research endeavors focused on smart waste management systems, integrating cutting-edge technologies like machine learning, IoT, and computer vision. The studies reviewed collectively underscore the pressing need for innovative solutions to cope with the escalating challenges posed by mounting waste volumes in modern societies. The utilization of Raspberry Pi, OpenCV, and robotic arms demonstrates significant strides in automating waste segregation processes, reducing human intervention, and optimizing collection efficiency.

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