WASTE SEGREGATION USING ADVANCED TECHNIQUES

ECD416 PROJECT PHASE II

Submitted by

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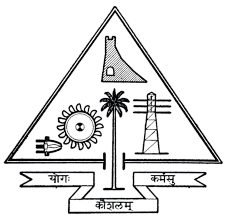
to

The APJ Abdul Kalam Technological University
in partial fulfilment of the requirements for the award of the Degree

of

Bachelor of Technology
In
Electronics and Communication Engineering



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DECLARATION

I undersigned hereby declare that the project report "Waste Segregation using Advanced Techniques", submitted for partial fulfilment of the requirements for the award of degree of Bachelor of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by me under the supervision of Prof. Latha K N. This submission represents my ideas in my own words and where ideas or words of others have been included, I have adequately and accurately cited and referenced the original sources. I also declare that I have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in my submission. I understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

Place : Thrissur — Ananya M

Date : 25.05.23 — Dennis Mathew Jose

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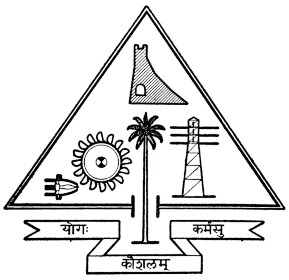

CERTIFICATE

This is to certify that the report entitled '**Waste Segregation using Advanced techniques'** submitted by **Ananya M** and **Dennis Mathew Jose** to the APJ Abdul Kalam Technological University in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in Electronics and Communication Engineering is a bonafide record of the project work carried out by him/her under my/our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

Project Guide **Project Coordinator** **Head of the Department**

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ABSTRACT

The project “WASTE SEGREGATION USING ADVANCED TECHNIQUES” is an innovative approach to categorise waste. Waste segregation is one of the primary challenges to recycling systems in major cities in our country. The waste segregation system presented in this project aims to automate the process of categorizing waste objects into recyclable and organic waste using machine learning techniques. The system consists of various components, including a waste analyzing compartment with a camera for image capture, a Convolutional Neural Network (CNN) for image processing and classification, and a pipe-like structure with servo motors for directing waste to the appropriate bins. The CNN is trained on a dataset obtained from Kaggle, allowing it to learn and recognize patterns in waste object images. When a waste object is detected, its image is processed by the CNN, which determines its category. Based on the classification result, the servo motors rotate the pipe to guide the waste into the correct bin. This automated waste segregation system offers an efficient and reliable solution to promote effective waste management and recycling practices.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL BACKGROUND

Waste management is a universal issue which matters to every single human being on this planet.The garbage and recycling businesses are being overwhelmed by the ever-increasing volume of global garbage. As a result, the demand for smart solutions for environmental monitoring and recycling process improvement is stronger than ever. Human life and the environment are both affected by waste disposal, whether directly or indirectly. The negative consequences of waste materials can be mitigated with the use of a competent waste management system

1.2 PROBLEM STATEMENT

- The traditional method of waste segregation involves collecting waste from households and surroundings and then manual segregation of waste at a station or dumping areas. This method is time-consuming and less efficient.
- The non-segregated waste dumped in landfill discharges poisonous gases and leaches into the air and soil respectively. When this poisonous gas gets mixed with air or water bodies it affects the health, increases the pollution and leads to blockage of drainage systems which increases the chances of flood occurring.

1.3 OBJECTIVE

- To design and implement a fully automated waste segregation system that can categorize recyclable and organic materials.
- To use machine learning to identify the waste material and create a mechanical part to put the waste into the right bin.

1.4 SCOPE

The proposed system in this project has many upcoming applications in our world. It can be used in houses, workplaces and even outdoors. As this reduces human effort and time consumption, this will gain popularity very quickly. This will improve the health of people as it will help prevent pollution. Here, in this project we have used two categories. It can be increased to more categories by changing the dataset accordingly. The system can also be improved by adding an alert system to be used when the waste bin is full.

CHAPTER 2

RELEVANCE

Recycling is rapidly becoming an essential component of a sustainable society. However, the entire recycling process has a high hidden cost. This is caused by the recycling materials' selection, categorization, and processing. Even while many customers nowadays are able to perform their own garbage sorting, they may be puzzled about how to select the correct waste category when disposing of a wide range of items. Finding an automated approach to recycling is currently extremely valuable in today's industrial and information-based world since it offers both environmental and economic benefits.

Dumping organic wastes in landfills is a big concern, not because of the resources lost in the process, but because the organic waste undergoes anaerobic decomposition in the landfill, resulting in methane production. Methane has a greater greenhouse gas effect than carbon dioxide when discharged into the atmosphere. Organic waste, on the other hand, has its own set of issues, since it may be a source of greenhouse gases, methane, and pollution. If organic waste is not properly cleaned or controlled, it can infiltrate water sources and feed bacteria, resulting in the formation of fungus, which can be hazardous to society.

In our proposed system, we are using deep learning algorithms to solve the issues regarding waste segregation. The system is fully automated and highly efficient making human life easier and healthier.

CHAPTER 3

LITERATURE SURVEY

Waste segregation refers to the process of separating different types of waste materials in order to facilitate their proper disposal and recycling. This is an important aspect of waste management, as it helps to reduce the amount of waste that ends up in landfills and reduces the negative environmental impacts of waste disposal. In recent years, there has been growing interest in using machine learning techniques to improve the efficiency and accuracy of waste segregation processes.

One of the main challenges in waste segregation is the wide range of waste materials that must be processed, which can include paper, plastic, metal, glass, food waste, and other types of materials. This requires the use of advanced sensors and imaging systems to accurately identify and classify different types of waste. Machine learning algorithms can be used to analyse the data generated by these sensors and improve the accuracy of waste segregation over time.

One approach to using machine learning for waste segregation is to train a classifier to identify different types of waste materials based on their physical characteristics. This can involve using techniques such as convolutional neural networks (CNNs) to analyse images of waste materials and classify them based on visual features. Other approaches may involve using data from sensors such as spectrometers or infrared cameras to classify waste materials based on their chemical or physical properties.

Another area where machine learning has been applied to waste segregation is in the development of autonomous robots for sorting and processing waste materials. These robots can be equipped with sensors and machine learning algorithms to enable them to navigate through a waste processing facility and identify and classify different types of waste materials. This can improve the efficiency and accuracy of the waste segregation process, as the robots can operate around the clock without the need for human intervention.

Overall, the use of machine learning in waste segregation has the potential to significantly improve the efficiency and accuracy of waste management processes, as well as reduce the environmental impact of waste disposal. While there are still challenges to be addressed in the development and deployment of these systems, the use of machine learning in waste segregation is an active area of research that is likely to continue to grow in importance in the coming years.

To look into the details of the papers referred for the project:

1. **M. G. C. P, S. Yadav, A. Shanmugam, H. V and N. Suresh, "Waste Classification and Segregation: Machine Learning and IOT Approach," *2021 2nd International Conference on Intelligent Engineering and Management (ICIEM)*, 2021, pp. 233-238, doi: 10.1109/ICIEM51511.2021.9445289.**

   The method adopted is computer vision and deep learning paired with an internet of things (IOT) system that is capable of segregating municipal waste into Organic and Recyclable waste. Eliminating manual segregation in the process of waste management significantly reduces the risk to the health of municipal workers by preventing the contraction as well as the spread of transmissible diseases. Automation will also increase

the speed while significantly reducing the cost of the waste segregation process. This study was conducted in order to ideate and bring to life innovative and sustainable ideas for effective waste management systems with little to no human intervention.

2. **S. K. Koganti, G. Purnima, P. Bhavana, Y. V. Raghava and R. R, "Deep Learning based Automated Waste Segregation System based on degradability," 2021 Second International Conference on Electronics and Sustainable Communication Systems (ICESC), 2021, pp. 1953-1956, doi: 10.1109/ICESC51422.2021.9532837.**

   A model is suggested in this paper which focuses on the software portion of an automatic waste segregation system where a camera and Raspberry Pi are mounted to detect and classify the individual waste item placed on a conveyor belt that carries the waste to the respective dustbin based on the classification done by Pi module. The software module consists of a Deep Learning algorithm called Single Shot Detector model with MobileNet as base network to classify the waste into biodegradable and non-biodegradable.

3. **R. Parvin, D. P. C, D. V and A. S. G, "Automatic Segregation of Household Waste using Machine Learning Approaches," 2022 International Conference on Edge Computing and Applications (ICECAA), 2022, pp. 1243-1248, doi: 10.1109/ICECAA55415.2022.9936207.**

   The proposed approach uses an algorithm to categorise biodegradable and non-degradable waste. The signal from the IR sensor is continuously transmitted to detect the existence of obstructions. When the waste is thrown into the bin, the receiver picks up the reflected signal from the waste and begins the process with the Raspberry Pi. In turn,

the DC motor is activated by running a programme that rotates the motor forward. The conveyor belt rotates smoothly because to two DC motors. The garbage is recognised by the sensors connected in series near the conveyor belt because both DC motors operate in the forward direction.

4. **F. Shaikh, N. Kazi, F. Khan and Z. Thakur, "Waste Profiling and Analysis using Machine Learning," 2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA), 2020, pp. 488-492, doi: 10.1109/ICIRCA48905.2020.9183035.**

   This paper has proposed a system which can classify the waste as dry waste or wet waste based solely on the image of the waste taken. Focusing on simplicity, it is intended to propose an application which will only be required by the civic bodies to upload the captured images of garbage bins and send them to the system to analyse whether the garbage is wet, dry or mixed. The detection of contents of the garbage is the crucial aspect which will be done using machine learning. This idea can contribute in the near future to help analyse the waste disposal habits of people in different locations. This analysis can then be used to create awareness in required locations and help improve the waste disposal habits.

CHAPTER 4

THEORY

4.1. PROPOSED SYSTEM

The proposed system is a waste segregation system using advanced techniques. The system uses two sections: A software section and a mechanical section. Raspberry Pi is used to control the system. In the image processing section that uses machine learning algorithm, Raspberry Pi Camera Module is used to capture the image of the object. The mechanical arm that puts the waste into the right bin is a pipe-like structure. The gate of the compartment to which the waste falls is turned using a servo motor. Similarly, another servo motor is used to rotate the pipe towards the correct bin.

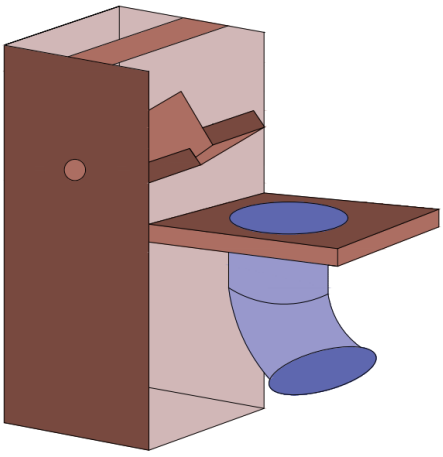

Fig 4.1 : Proposed design of the final system

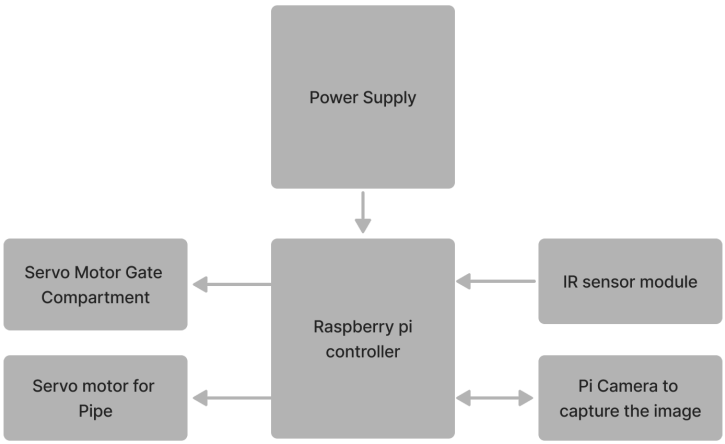

Fig 4.2: Block Diagram of the proposed system

4.2. Hardware Components

4.2.1 Raspberry Pi 4 Model B

Raspberry Pi 4 Model B is the latest product in the popular Raspberry Pi range of computers. It offers ground-breaking increases in processor speed, multimedia performance, memory, and connectivity compared to the prior-generation Raspberry Pi 3 Model B+, while retaining backwards compatibility and similar power consumption. For the end user, Raspberry Pi 4 Model B provides desktop performance comparable to entry-level x86 PC systems. This product's key features include a high-performance 64-bit quad-core processor, dual-display support at resolutions up to 4K via a pair of micro-HDMI ports, hardware video decode at up to 4Kp60, up to 8GB of RAM, dual-band 2.4/5.0 GHz wireless LAN, Bluetooth 5.0, Gigabit Ethernet, USB 3.0, and PoE capability (via a separate PoE HAT add-on).

Specification

Processor:	Broadcom BCM2711, quad-core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
Memory:	1GB, 2GB, 4GB or 8GB LPDDR4 (depending on model) with on-die ECC
Connectivity:	2.4 GHz and 5.0 GHz IEEE 802.11b/g/n/ac wireless LAN, Bluetooth 5.0, BLE Gigabit Ethernet 2 × USB 3.0 ports 2 × USB 2.0 ports.
GPIO:	Standard 40-pin GPIO header (fully backwards-compatible with previous boards)
Video & sound:	2 × micro HDMI ports (up to 4Kp60 supported) 2-lane MIPI DSI display port2-lane MIPI CSI camera port 4-pole

	stereo audio and composite video port
Multimedia:	H.265 (4Kp60 decode); H.264 (1080p60 decode, 1080p30 encode); OpenGL ES, 3.0 graphics
SD card support:	Micro SD card slot for loading operating system and data storage
Input power:	5V DC via USB-C connector (minimum 3A1) 5V DC via GPIO header (minimum 3A1) Power over Ethernet (PoE)–enabled (requires separate PoE HAT)
Environment:	Operating temperature 0–50ºC

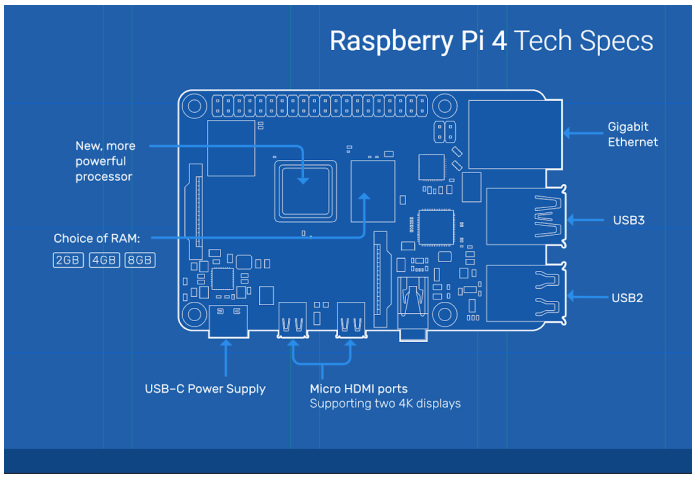

Fig 4.3 Raspberry Pi 4 model B

4.2.2 Pi Camera Module

The Raspberry Pi Camera Module 2 has a Sony IMX219 8-megapixel sensor. The Camera Module 2 can be used to take high-definition video, as well as stills photographs. The camera works with all models of Raspberry Pi 1, 2, 3 and 4. It can be accessed through the MMAL and V4L APIs, and there are numerous third-party libraries built for it, including the Picamera Python library. It supports 1080p30, 720p60 and VGA90 video modes, as well as still capture. It attaches via a 15cm ribbon cable to the CSI port on the Raspberry Pi.

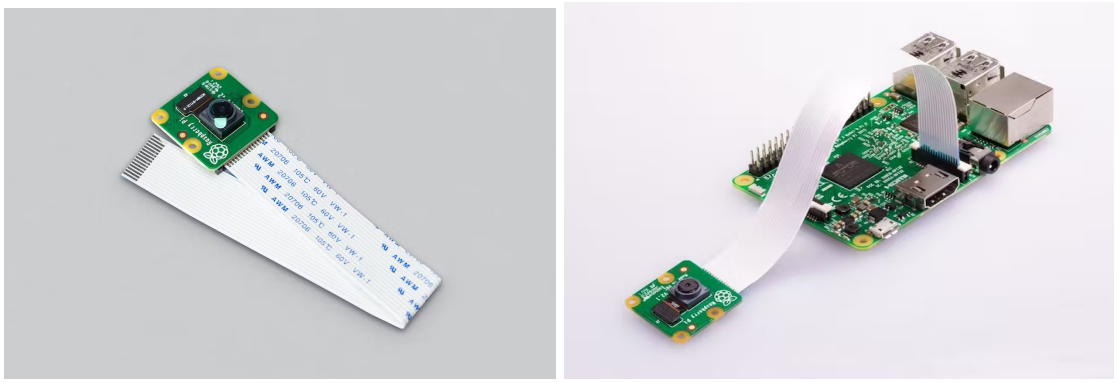

Fig 4.4 Raspberry pi camera module

4.2.3 MG996R Servo Motor

The MG996R servo motor is a high-torque, metal-geared servo motor widely used in robotics, remote-controlled vehicles, aeroplanes, and other projects. It offers a good balance between power and performance. Some of its notable features include:

1. High Torque: The MG996R servo motor is known for its high torque output, which allows it to exert significant rotational force. This makes it suitable for applications that require moving heavy loads or performing tasks that require strength.

2. Metal Gears: It is equipped with metal gears instead of plastic gears found in cheaper servo motors. The metal gears provide durability, improved precision, and increased resistance to wear and tear, making it more reliable for demanding applications.

3. Rotation Range: The MG996R servo motor typically has a rotation range of around 180 degrees. This means it can rotate from 0 degrees (fully clockwise) to 180 degrees (fully counterclockwise), with the ability to stop at any position within that range.

4. Operating Voltage: The operating voltage of the MG996R servo motor is usually between 4.8V and 7.2V, which is compatible with common power sources such as batteries or power supplies used in hobbyist electronics.

5. Control Signal: The servo motor receives control signals in the form of pulse width modulation (PWM). By varying the width of the PWM signal, the motor's shaft position can be controlled precisely. Typically, a pulse width of 1 to 2 milliseconds is used to control the servo motor's position within its operating range.

6. Servo Horn and Mounting: The MG996R servo motor is usually provided with a servo horn, which is a disc-shaped attachment that allows for easy coupling with other mechanical components. It also features mounting holes for secure attachment to a structure or device.

The MG996R servo motor operates based on the principle of a closed-loop feedback control system. It consists of a DC motor, a set of gears, a potentiometer, and a control circuit. The control circuit receives the PWM signal, compares it with the motor's current position obtained from the potentiometer, and adjusts the motor's position accordingly by driving the appropriate voltage to the motor.

Overall, the MG996R servo motor is valued for its high torque, durability, and precision. It provides reliable and accurate angular positioning control, making it a popular choice in various robotics, RC, and automation applications.

Fig 4.5 MG996R Servo motor

4.2.4 IR Sensor

An IR sensor works by detecting and responding to infrared radiation, which is a type of electromagnetic radiation with longer wavelengths than visible light. The sensor consists of two main components: an emitter and a receiver.

1. Emitter: The emitter is an infrared light source that emits infrared radiation. It can be an LED (Light-Emitting Diode) or an IR laser diode.

2. Receiver: The receiver is a sensor that detects the presence or absence of infrared radiation. It is typically a photodiode, phototransistor, or an IR sensor module that includes these components.

When the emitter emits infrared light, it illuminates the surrounding area. If there is an object within the range of the sensor, the object either reflects or emits its own infrared radiation.

The receiver detects the infrared radiation that reaches it. The intensity of the received infrared radiation is then converted into an electrical signal that can be processed and interpreted by a circuit or microcontroller.

The behaviour of the IR sensor depends on its specific type and purpose. Some IR sensors are designed to detect reflected infrared light, while others are used to detect emitted infrared radiation.

Overall, the working principle of an IR sensor involves the emission and detection of infrared radiation. By analysing the received infrared signals, the sensor can provide information about the presence or characteristics of objects, enabling various applications in proximity sensing, temperature measurement, object detection, and more.

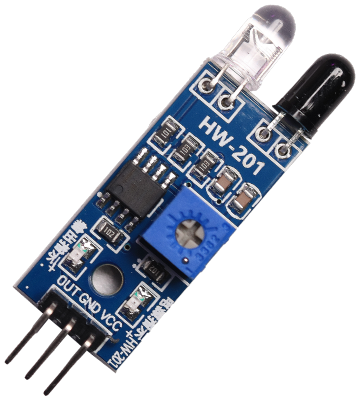

Fig 4.6 IR sensor module

4.3. Software Technologies

4.3.1 PuTTy and VNC viewer for windows

1. PuTTY:

PuTTY is a free and open-source terminal emulator, serial console, and network file transfer application. It is primarily used to establish secure shell (SSH), Telnet, and raw TCP connections to remote servers or devices. PuTTY provides a command-line interface (CLI) where users can execute commands, manage remote systems, and transfer files securely over a network.

Key Features of PuTTY:

- SSH, Telnet, and Serial Connections: PuTTY allows users to establish secure shell (SSH), Telnet, and serial connections to remote servers or devices. This enables remote administration, remote access, and troubleshooting.

- Encryption and Security: PuTTY supports various encryption algorithms, including AES, 3DES, Blowfish, and RSA, ensuring secure data transmission over the network. It also provides features like key generation, public key authentication, and support for SSH tunnelling.

- Flexible Configuration: PuTTY offers a range of configuration options, allowing users to customise the appearance, terminal settings, key mappings, and connection parameters based on their preferences and requirements.

- X11 Forwarding: PuTTY supports X11 forwarding, enabling users to run graphical applications on a remote server and display them on their local machine.

2. VNC Viewer:

VNC Viewer is a remote desktop application that allows users to connect to and control remote computers over a network. It uses the Virtual Network Computing (VNC) protocol to provide a graphical desktop sharing experience. With VNC Viewer, users can access and interact with a remote computer as if they were sitting in front of it.

Key Features of VNC Viewer:

- Remote Desktop Access: VNC Viewer provides a graphical interface that allows users to connect to and remotely control desktop environments of remote computers. This enables remote troubleshooting, technical support, and collaboration.

- Cross-Platform Compatibility: VNC Viewer is compatible with multiple operating systems, including Windows, macOS, Linux, and mobile platforms. This allows users to access remote computers from different devices.

- Real-Time Screen Updates: VNC Viewer provides real-time screen updates, ensuring that users see changes on the remote desktop as they happen. This allows for seamless interaction and a responsive remote desktop experience.

Both PuTTY and VNC Viewer are popular tools for remote access and management. While PuTTY focuses on providing secure command-line and network connections, VNC Viewer offers a graphical remote desktop experience. These tools are widely used in various scenarios, such as system administration, technical support, remote collaboration, and accessing remote machines securely.

4.3.2 Thonny IDE

Thonny is an Integrated Development Environment (IDE) specifically designed for beginners and educators to learn and teach programming. Here's a brief explanation of Thonny IDE:

Thonny IDE:

Thonny provides a user-friendly and beginner-friendly environment for programming in languages such as Python. It aims to simplify the coding experience and make it easier for beginners to understand and debug their code.

Key Features of Thonny IDE:

1. Simple and Clean Interface: Thonny has a clean and intuitive interface, making it easy for beginners to navigate and use. The layout is designed to minimize distractions and focus on the coding process.

2. Integrated Python Interpreter: Thonny comes with an integrated Python interpreter, allowing users to write and execute Python code within the same environment. This eliminates the need for a separate terminal or console for running code.

3. Code Editor with Syntax Highlighting: Thonny provides a code editor with syntax highlighting, making it easier to read and write code. Syntax highlighting helps highlight different elements of the code, such as keywords, variables, and comments, improving code readability.

4. Variable Explorer and Debugger: Thonny includes a variable explorer that allows users to monitor the values of variables during program execution. It also provides a debugger with features like breakpoints, stepping through code, and inspecting variables, helping users identify and fix errors in their code.

5. Autocompletion and Code Suggestions: Thonny offers autocompletion and code suggestions, providing hints and suggestions as users type their code. This feature assists beginners in writing correct code and encourages good coding practices.

6. Interactive Shell: Thonny includes an interactive shell, allowing users to execute individual Python statements or experiment with code snippets without writing a complete program. This provides a quick and easy way to test code and understand its behaviour.

Thonny IDE is widely used in educational settings, coding bootcamps, and for self-learning purposes. Its beginner-friendly features, integrated debugging capabilities, and simplified interface make it an excellent choice for those starting their programming journey with Python.

4.3.3 Proteus

Proteus is a powerful simulation software that is extensively utilised by engineers, designers, and students for designing and testing electronic circuits and systems. It provides a virtual environment where users can simulate and validate the behaviour of electronic circuits before actually implementing them physically. With a user-friendly interface, Proteus allows for the creation of circuit schematics using an extensive library of electronic components such as resistors, capacitors, microcontrollers, and sensors. It offers the ability to design complex circuits and simulate their functionality.

One of the key features of Proteus is its capability to simulate and analyse circuit performance without the need for physical components. It provides tools for validating circuit behaviour, testing different operating conditions, and performing analysis of important parameters such as voltage, current, and frequency. Proteus also supports the simulation of microcontrollers, including popular ones like Arduino, PIC, and AVR. Users can write and debug embedded software code, simulate the behaviour of the microcontroller, and test its interaction with the rest of the circuitry.

Proteus excels in its ability to handle mixed-signal simulation, allowing the combination of analog and digital components within a single circuit. This capability is particularly valuable for designing and testing mixed-signal circuits that involve both types of signals, such as data acquisition systems and communication interfaces. Additionally, Proteus offers tools for PCB design and layout, enabling users to create custom PCB layouts, place components, define tracks and vias, and generate manufacturing-ready output files.

To enhance the simulation experience, Proteus provides virtual instruments including oscilloscopes, logic analyzers, and function generators that replicate the behaviour of their physical counterparts. These virtual instruments aid in visualising and analysing circuit signals during the simulation process. Furthermore, Proteus supports 3D visualisation and virtual reality (VR) features, allowing users to view and interact with their circuits in a more immersive manner, facilitating the exploration of complex designs from different perspectives.

CHAPTER 5

METHODOLOGY

5.1 WORKING PRINCIPLE

The waste segregation system using advanced techniques follows a specific process to categorise waste objects into recyclable or organic waste.

1. Power Supply: The system is powered by a suitable power supply, providing the necessary electricity to activate its components.

2. Waste Analysis Compartment: A waste object is placed into the waste analysis compartment, which triggers the system's operation.

3. Image Capture: The waste object's image is captured by a camera integrated into the system. This image serves as input for further analysis. The camera is triggered only when the IR sensor detects a waste in the compartment.

4. Image Processing: The captured image undergoes image processing techniques. These techniques extract relevant features and characteristics from the image that can aid in distinguishing between recyclable and organic waste. The purpose is to analyze the image and identify visual patterns that differentiate the waste categories.

5. Convolutional Neural Network (CNN): A Convolutional Neural Network, a type of deep learning algorithm specifically designed for image classification, is employed. This CNN has

been trained on a dataset obtained from sources like Kaggle, which contains labelled examples of waste objects along with their corresponding categories (recyclable or organic waste). During training, the CNN learns to recognize patterns and features in the images that correlate with each waste category.

6. Classification: The trained CNN receives the processed image as input and performs classification based on the learned patterns. It predicts whether the waste object is recyclable or organic waste.

7. Pipe-like Structure and Servo Motor: The waste segregation system includes a pipe-like structure with multiple openings or outlets, each corresponding to a specific waste bin. A servo motor controls the rotation of this pipe-like structure.

8. Rotating the Pipe: Depending on the classification output from the CNN, the servo motor rotates the pipe-like structure. This rotation aligns the appropriate opening or outlet of the pipe with the corresponding waste bin. If the waste object is classified as recyclable, the pipe will rotate to direct the waste into the recyclable waste bin. Similarly, if it is classified as organic waste, the pipe will align with the organic waste bin.

9. Servo Motor for the Compartment Gate: Once the pipe is positioned correctly, another servo motor controls the opening of the gate in the waste analysis compartment.

10. Waste Disposal: As the gate opens, the waste object falls into the opening of the pipe. It follows the path determined by the pipe's alignment and falls into the designated bin accordingly.

This ensures that recyclable waste goes into the recyclable waste bin and organic waste goes into the organic waste bin.

By combining image processing, machine learning (CNN), and mechanical components, the waste segregation system automates the identification and sorting of waste objects, facilitating effective waste management practices.

5.2 FLOWCHART

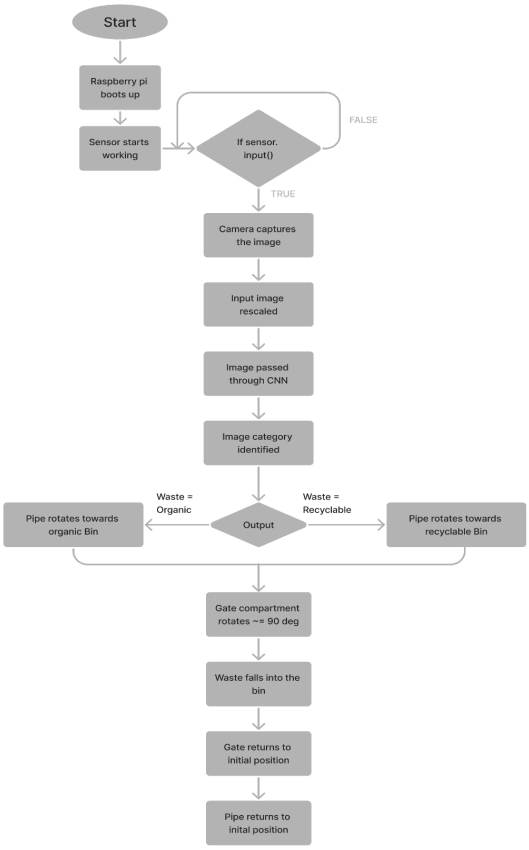

Fig 5.1: FlowChart for the proposed system

5.3 CIRCUIT DIAGRAM

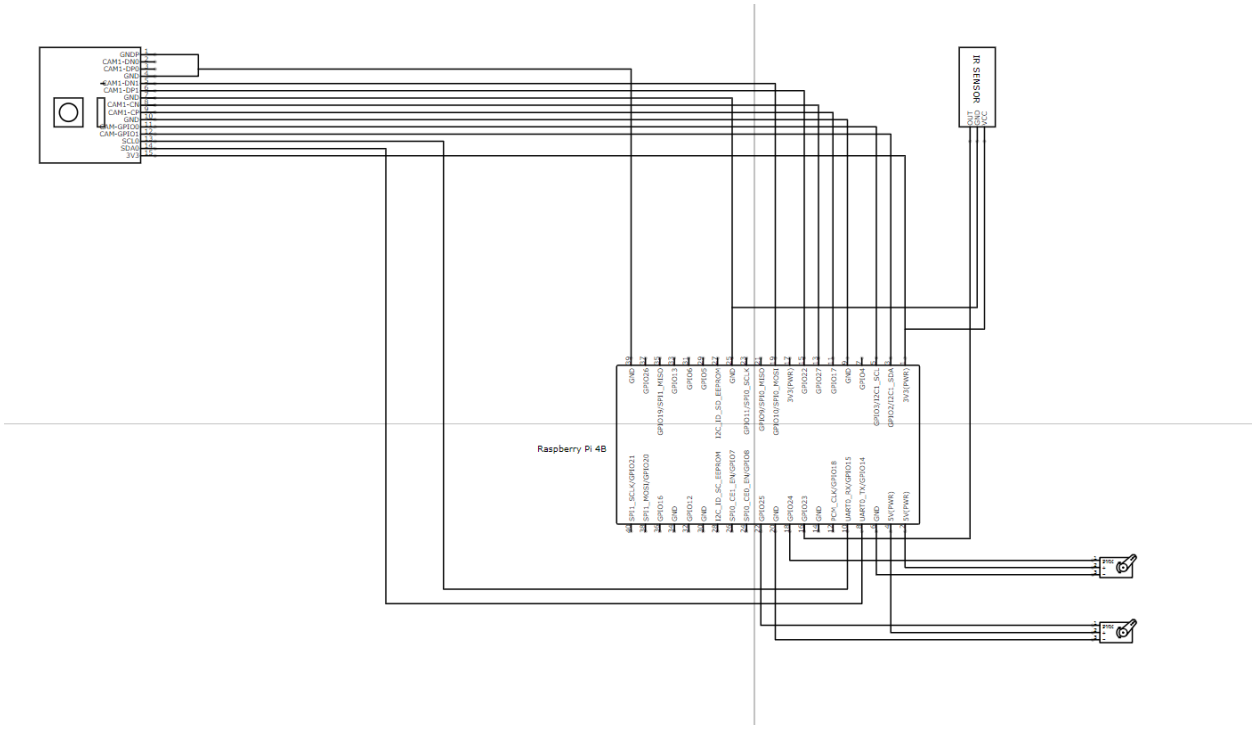

Fig 5.2: Circuit Diagram of the system

CHAPTER 6

MACHINE LEARNING ALGORITHM

The machine learning model used in the project is a Convolutional Neural Network (CNN) implemented as a Sequential model using the Keras library with TensorFlow backend.

The model architecture consists of several layers that perform different operations on the input data, which are images in this case. Here's a breakdown of the layers and their functions:

The model starts with the input layer, which expects input images of size 224x224 pixels with three colour channels (RGB). This input shape is specified as (224, 224, 3).

1. Conv2D Layers:

The first Conv2D layer has 32 filters with a kernel size of (3, 3). It applies convolutional operations to the input image, extracting 32 different features using small filter windows. The ReLU activation function is applied to introduce non-linearity, allowing the model to learn complex patterns and representations.

2. MaxPooling2D Layers:

After each Conv2D layer, a MaxPooling2D layer is added. Max pooling reduces the spatial dimensions of the previous layer's output by selecting the maximum value within a defined window size. It helps in downsampling the feature maps while retaining the most important information.

3. Flatten Layer:

The Flatten layer transforms the multi-dimensional output from the previous layer into a one-dimensional vector. It takes the output from the last MaxPooling2D layer and converts it into a flat representation, which can then be fed into the subsequent dense layers.

4. Dense Layers:

The first Dense layer consists of 256 neurons, which are fully connected to the flattened output. It applies the ReLU activation function, enabling the model to learn complex representations based on the extracted features.

A Dropout layer is added after the first Dense layer with a dropout rate of 0.5. Dropout randomly sets a fraction of input units to 0 at each update during training, reducing overfitting by introducing noise and preventing reliance on specific features.

The second Dense layer consists of 64 neurons with ReLU activation, followed by another Dropout layer with the same dropout rate of 0.5. These layers further refine the learned representations and help prevent overfitting.

5. Output Layer:

The final Dense layer has 2 neurons, representing the two classes: recyclable and organic waste. The activation function used is sigmoid, which produces a value between 0 and 1 for each class. These values can be interpreted as the probabilities of the input belonging to each class.

In summary, the Conv2D layers extract features from the input images, while the MaxPooling2D layers reduce spatial dimensions. The Flatten layer prepares the data for the fully connected Dense layers, which learn complex representations. Dropout layers are added to prevent overfitting. The output layer provides probabilities for each class using sigmoid activation. This architecture enables the model to learn and classify waste objects as either recyclable or organic based on the extracted features.

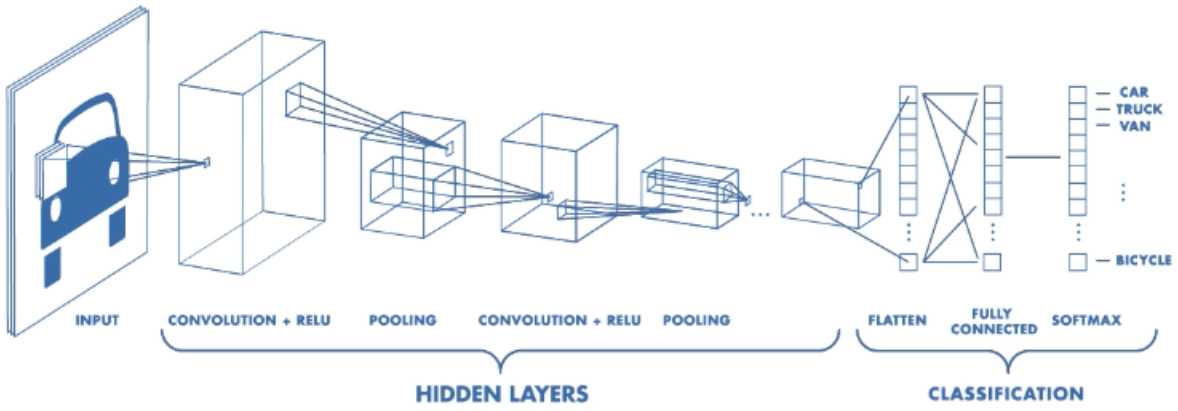

Fig 6.1 Architecture of a CNN

CHAPTER 7

PROGRAMMING IN PYTHON

Main.py

```
import time
import RPi.GPIO as GPIO
import camfinal
from gpiozero import Servo
servoPipe = Servo(25)
servoGate = Servo(24)
servoPipe.detach()
servoGate.detach()
count = 0
def gate():
    servoGate.max()
    time.sleep(0.5)
    servoGate.detach()
    time.sleep(4)
    servoGate.min()
    time.sleep(0.6 )
    servoGate.detach()
while True:
    k = camfinal.camera()
```

```
print(k)
while k == 1:
    servoPipe.max()
    time.sleep(0.7)
    servoPipe.detach()
    time.sleep(2)
    gate()
    time.sleep(2)
    servoPipe.min()
    time.sleep(0.7)
    servoPipe.detach()
    break

while k == 0:
    servoPipe.min()
    time.sleep(0.7)
    servoPipe.detach()
    time.sleep(2)
    gate()
    time.sleep(2)
    servoPipe.max()
    time.sleep(0.7)
    servoPipe.detach()
    break
```

Trials.py

```
def cnn():
    import pandas as pd
    import numpy as np
    import cv2
    from tqdm import tqdm
    from glob import glob
    import tensorflow as tf
    from tensorflow.keras import layers
    train_path = "/home/ananya/Desktop/Dataset/TRAIN"
    test_path = "/home/ananya/Desktop/Dataset/TEST"
    x_data = []
    y_data = []
    for category in glob(train_path+'/*'):
        for file in tqdm(glob(category+'/*')):
            img_array = cv2.imread(file)
            img_array = cv2.cvtColor(img_array, cv2.COLOR_BGR2RGB)
            x_data.append(img_array)
            y_data.append(category.split("/")[-1])
    data=pd.DataFrame({'image': x_data,'label': y_data})
    model = tf.keras.models.Sequential([
      layers.Conv2D(filters = 32,kernel_size = (3,3),activation = 'relu',input_shape = (224,224,3)),
       layers.MaxPooling2D(),
```

```
        layers.Conv2D(filters = 64,kernel_size = (3,3),activation = 'relu'),
        layers.MaxPooling2D(),
        layers.Conv2D(filters = 128,kernel_size = (3,3), activation = 'relu'),
        layers.MaxPooling2D(),
        layers.Flatten(),
        layers.Dense(256,activation = 'relu'),
        layers.Dropout(0.5),
        layers.Dense(64, activation = 'relu'),
        layers.Dropout(0.5),
        layers.Dense(2,activation = 'sigmoid')
    ])
    print(model)
    return model
```

Camfinal.py

```
from picamera import PiCamera
import time
import predictest
import cv2
import RPi.GPIO as GPIO
sensor = 23
GPIO.setmode(GPIO.BCM)
GPIO.setup(sensor,GPIO.IN)
def camera():
```

```
    print(GPIO.input(sensor))
    try:
        while True:
            if GPIO.input(sensor):
                print("Code reached here")
                time.sleep(5)
                camera = PiCamera()
                camera.capture("/home/ananya/Desktop/wastebasket/img.jpg")
                print("Done.")
                camera.close()
                test_img = cv2.imread("/home/ananya/Desktop/wastebasket/img.jpg")
                result = predictest.prediction(test_img)
                return result
            else:
                print(GPIO.input(sensor))
    except KeyboardInterrupt:
        GPIO.cleanup()
```

Predictest.py

```
import cv2
import numpy as np
import trials
model = trials.cnn()
def prediction(img):
```

```
img = cv2.resize(img, (224,224),3)
img = np.reshape(img, [-1,224,224,3])
result = np.argmax(model.predict(img))
return result
```

CHAPTER 8

RESULTS

We were able to create a system very close to the proposed design in the first phase. The final working of the product is shown below:

i) First, the waste is put into the gate compartment.

Fig 8.1: Putting waste into the compartment

ii) This triggers the IR sensor and inturn turns on the camera to capture the image.

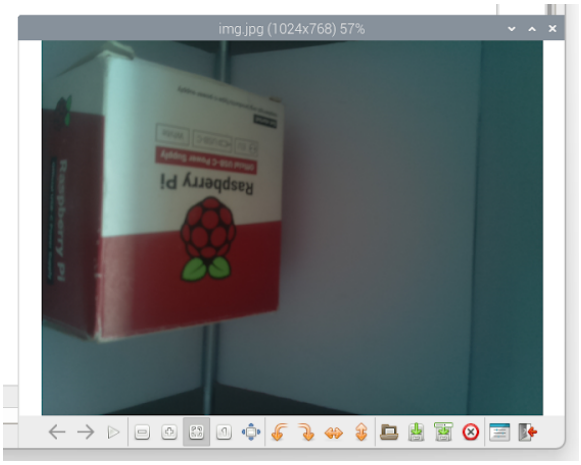

Fig 8.2: Image captured by the Pi camera

iii) Then, the pipe rotates according to the category of waste.

Fig 8.3: Pipe rotates to the recyclable bin

iv) After this, the gate compartment rotates to let the waste fall into the pipe.

Fig 8.4: Waste falls to the bin through the pipe

v) Both the gate compartment and pipe come back to its initial positions.

Fig 8.5: Pipe returned to initial position

vi) When an organic waste is put into the compartment, the pipe rotates to the position of the organic bin.

Fig 8.6: Pipe rotates to the organic bin

CHAPTER 9

CONCLUSION

In conclusion, the waste segregation project presents an automated solution for classifying and disposing of waste using machine learning techniques. The system leverages a combination of components, including a waste analysing compartment, a camera, a Convolutional Neural Network (CNN) model, servo motors, and separate bins for recyclable and organic waste. By capturing images of waste objects and processing them through the CNN model, the system accurately classifies the waste into the respective categories. This classification is then used to guide the rotation of a pipe-like structure, ensuring that the waste is directed into the appropriate bin for proper disposal.

The project demonstrates the potential of machine learning and automation in streamlining waste management processes. It offers a time-efficient and accurate approach to waste segregation, reducing the burden on human efforts and promoting sustainability. The future scope of the project involves expanding the system to handle additional waste categories, incorporating advanced sensors for enhanced waste detection, and integrating real-time monitoring and analysis using IoT technologies. These advancements would enable the system to adapt to evolving waste management needs and contribute to more efficient waste disposal practices in a rapidly changing world.

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