# Smart Waste Segregation and Route Planner

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## ABSTRACT

*Internet of Things and Embedded Systems have shown tremendous growth in recent times, and have been used daily in all spheres from health, education to even waste segregation and disposal. In India, the problem of improper waste management is a major environmental issue. Smart waste segregation and route planner is an innovative solution to optimize the waste collection and management process by integrating advanced technology solutions. It involves the development of a smart waste management system with sensors, machine learning algorithms, and route planners to segregate waste and plan efficient collection route.The traditional waste management relies heavily on manual labor, which is time-consuming, expensive, and prone to errors. This system can significantly improve the efficiency and effectiveness of the waste management process. It consists of smart bins, sensors, machine learning algorithms, and a route planner. The smart bins are equipped with sensors that can detect the type and quantity of waste deposited. The sensors use machine learning algorithms to segregate the waste into different categories while machine learning algorithms are trained on waste composition and segregation patterns. They analyze the data, recognize different types of waste based on color, texture, and density. Once the waste is segregated, the smart bins send the data to the route planner, which determines the most efficient collection route based on factors such as traffic, distance, and waste volume. The smart waste segregation and route planner project is a cutting-edge solution that can revolutionize the waste management process. The project uses advanced technology solutions such as sensors, machine learning algorithms, and route planners to optimize waste collection and management. The system can significantly reduce the amount of waste sent to landfills, improve recycling rates, enhance the overall efficiency and effectiveness of the waste management process, and provide real-time data for monitoring and improvement.*

**Keyword : -** *IoT, Sensors, Waste management with Machine Learning and Embedded Systems*.

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## 1. INTRODUCTION

Smart waste segregation and route planner is a cutting-edge technology that combines the principles of waste management and advanced routing algorithms to optimize the process of waste collection and disposal. It utilizes various sensors, data analytics, and machine learning algorithms to intelligently sort and route waste in an efficient and environmentally friendly manner.

With smart waste segregation, waste is categorized into different types, such as recyclables, organic waste, and non-recyclables, using sensors and automated sorting systems. This allows for effective separation of waste at the source, reducing contamination and improving the quality of recyclable materials. The route planner component of the system uses real-time data on waste generation, location of waste bins, and traffic conditions to optimize waste collection routes. The system can dynamically adjust routes based on changing waste generation patterns, traffic conditions, and other factors, resulting in reduced fuel consumption, decreased emissions, and improved overall efficiency of waste collection and disposal operations.Smart waste segregation and route planner systems offer numerous benefits, including increased recycling rates, reduced operational costs, minimized environmental impact, improved waste collection efficiency, and enhanced sustainability. These technologies are being increasingly adopted by waste management agencies and smart cities around the world to tackle the growing challenges of waste management and environmental sustainability.

### 1.1 PROBLEM STATEMENT

To create a system that uses technology to efficiently dispose of different types of waste, while also optimizing waste collection and disposal routes to reduce costs and minimize environmental impact. The goal is to improve waste management practices and promote sustainability in communities.

## 2. LITERATURE SURVEY

A literature survey is a check of scholarly initiators and frequently written as part of a thesis, discussion, or exploration paper, in order to stick to your work in relation to knowledge. A lot of research papers were continuously referred to for idea generation and incorporating innovation. However, these four research papers have been of most use to us over the course of this project. A short summary of the same is put across in the table below.

**Table - 1:** Literature Survey Papers referred

| YEAR OF PUBLICATION | PAPER TITLE | PUBLICATION JOURNAL / CONFERENCE | AUTHOR | WORK DONE |
|---|---|---|---|---|
| 2020 | Waste Segregation Robot - A swachh Bharat Initiative | Most economical robotic arm with Raspberry pi, making collection and training of images easy. Needs work on training models and accuracy | Sunil MP; Shravya Chand; Bhavya Grandhep; Hariprasad | Using Image processing to train ML models which reduce human effort in waste segregation. Part of Swachh Bharat and Smart Cities scheme |
| 2016 | Approach to the garbage collection in “Smart City” project | 4th IEEE International Colloquium on Information Science and Technology (CiSt) | Andrei Borozdukhin, Olga Dolinina, Vitaly Pechenkin | Provides detailed mathematical model to implement Smart GCT system in Smart Cities |
| 2021 | Data collection and detailed analysis of waste on cloud | An International Journal of Environmental Health and Sustainability | Jacob M. Kihila, Kris Wernsted & Mengiseny Kaseva | Researching about waste generation, analysis and nature in the country of Tanzania. Also finding out sustainable waste disposal solutions, techniques for Tanzania |

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|---|---|---|---|---|
| 2021 | Dry and Wet Waste Segregation and Management System | European Journal of Engineering | MdAbdullah Al Rakib, Md. Sohel Rana, Md. Moklesur Rahman, and Fysol Ibna Abbas. | Waste Segregation into different sections and how better methods can be put to use, study is majorly based in Russia and Europe. |

## 3. PROPOSED SYSTEM

The entire system consists of two sub-systems. One is mobile hardware, and the second part is system software running with backend algorithms. Hardware contains a microcontroller interfaced with a sensor (ultrasonic) which detects if garbage is being placed in the view. It contains a camera which will be triggered when the user places trash in front of the sensor and it'll capture the image and send it to the backend server for waste classification.

The frontend of a smart waste segregation project is the user interface that allows the user to interact with the system. In this context, the frontend could include a map that displays the waste collection route or the location of waste bins. It could also show the unclassified labels of waste that were not recognized by the system, allowing the user to identify and classify them correctly.

For example, suppose a user notices that the system has classified some waste incorrectly, or the system was unable to identify certain items. In that case, the user could use the frontend to provide feedback to the system by reporting misclassified items or adding new labels to the system. The frontend is a web application accessible via a browser. It typically includes a graphical user interface that displays relevant information. Overall, the frontend plays a crucial role in facilitating user interaction with the smart waste segregation project, ensuring accurate waste classification and efficient waste collection. The backend of a smart waste segregation project is the server-side component of the system responsible for processing the data collected from the hardware sensors, applying machine learning algorithms to classify the waste, and storing the results.

In the context of the project described, the backend could receive images captured by the camera mounted on the hardware and use image recognition algorithms to classify the waste into different categories, such as plastic, paper, metal, or glass. The backend could also integrate with a database to store the waste classification data and retrieve the information when necessary. This information could be useful for waste management authorities to optimize collection routes, allocate resources more efficiently, and reduce the environmental impact of waste disposal.

The backend is implemented using a variety of technologies, such as cloud computing services, database management systems, and programming languages like Python. It would typically include a set of APIs to enable communication with the frontend and the hardware components of the system. Overall, the backend is a crucial component of a smart waste segregation project, enabling efficient waste classification and management based on accurate data analysis.

### 3.1 BLOCK DIAGRAM

**The description block diagram illustration is as follows:**

On the extreme left a user is shown, throwing the trash near the hardware system. The hardware consists of an ultrasonic sensor interfaced with it, which will detect the trash monitored by the controlling unit. The controlling unit will sense the trash object and take necessary actions to detect the waste classification and provide it to the user. After knowing the waste classification, now waste can be dropped into its respective waste classified bin.

Block diagram components are listed below**:**

- User: Person using the project.
- Trash: Trash Object to be classified for waste disposal and segregation.

- Controlling Unit: A microcontroller board to manage the functioning of the system, all the sensors and other modules are interfaced with this unit.
- Publisher: This component will interact with the backend server to transfer information to and fro between the hardware and other components using the backend server.
- Sensor and Camera: These components are used to detect human interaction with the system and signal the microcontroller to take appropriate action.
- Cloud Server (Backend)
  - Hosted Machines: Virtual machines running on the public cloud to access the backend server.
  - Database: One of the cloud components to store and retrieve information regarding the waste label classes, Garbage Bin locations, Users and their privileges.
  - Route Mapper Algorithm: The main algorithm used to calculate the optimal route between the garbage bin locations and send it back to the user on frontend.
- End User Application (Frontend)
  - Classless Labels List: Provides a list of labels whose waste isn't classified.
  - Route Mapper Viewer: makes a call to the backend server to get the optimal route and displays it to the user.

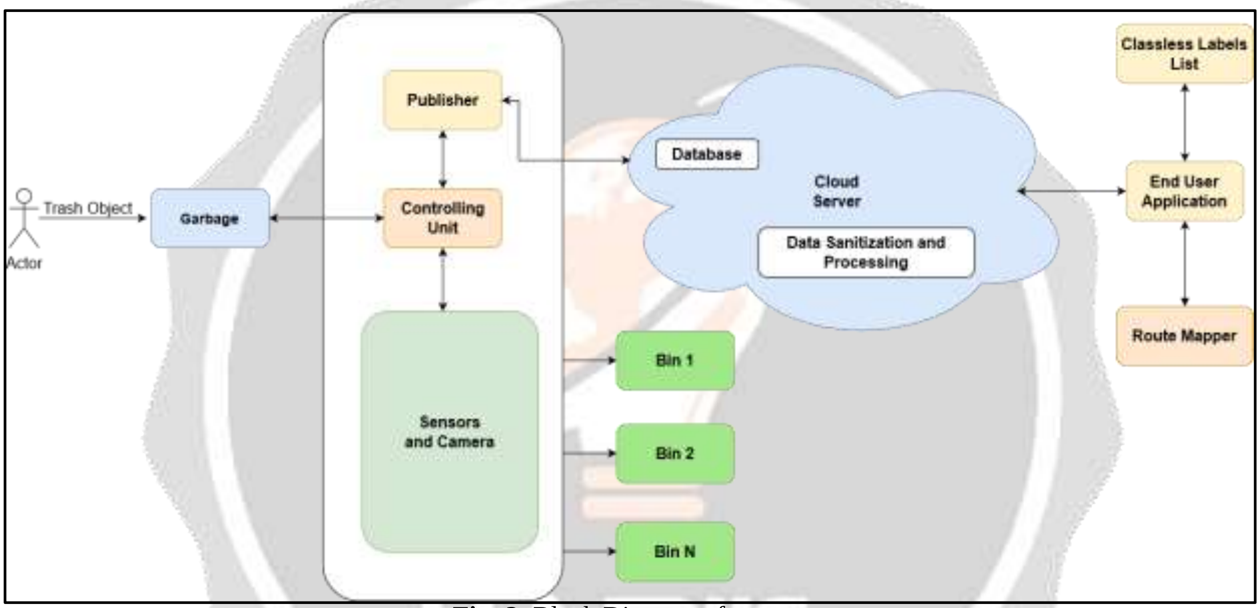


**Fig -2**: Block Diagram of system

### 3.2 CIRCUIT DIAGRAM

The ESP32-CAM is connected to the ultrasonic sensor and the servo motor. The lithium battery is used to power the ESP32-CAM and the servo motor. Here's an explanation of each component:

**ESP32-CAM**: This is the main microcontroller that controls the entire circuit. It communicates with the ultrasonic sensor to measure the distance and the servo motor to control its position. It also receives power from the lithium battery.

**Ultrasonic sensor**: This is used to measure the distance of an object in front of it. The ultrasonic sensor has two pins - Trigger (Trig) and Echo. The Trig pin sends a short pulse to the sensor, which then sends out an ultrasonic wave. When the wave hits an object and bounces back, it is detected by the Echo pin. The time taken for the wave to bounce back is used to calculate the distance.

**Servo motor**: This is used to control the position of a mechanical arm or any other application that requires precise rotational control. The servo motor has three pins - Signal, VCC, and GND. The Signal pin is used to send a PWM (Pulse Width Modulation) signal from the ESP32-CAM to control the position of the servo motor. The VCC and GND pins are used to power the motor.

**Lithium battery**: This is used to power the ESP32-CAM and the servo motor. The positive (+) and negative (-) terminals of the battery are connected to the VCC and GND pins of the ESP32-CAM and the servo motor.

The ESP32-CAM is connected to an ultrasonic sensor and a servo motor, which are powered by a lithium battery. The ultrasonic sensor is used to measure the distance, and the servo motor is used to control the position. The ESP32-CAM controls both components and receives power from the battery.

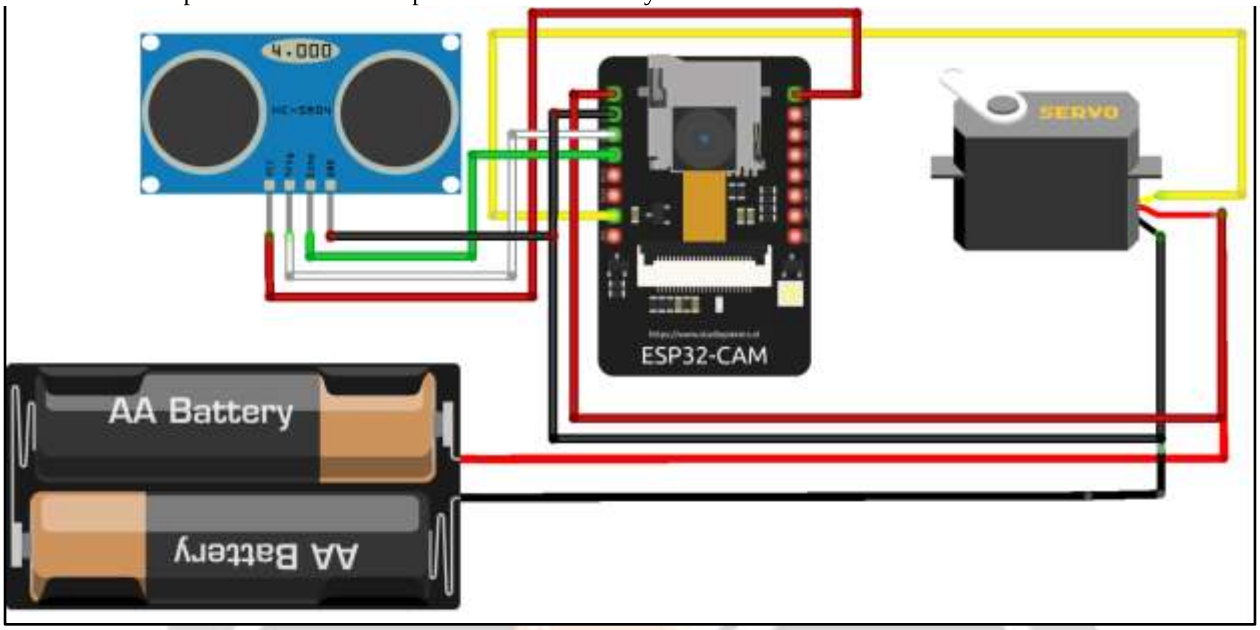


**Fig 3 -** Circuit Diagram of the system

### 3.3 BACKEND-BASED SOFTWARE ALGORITHMS

Backend Server Starts on specified port and environment configurations: This step involves starting the backend server on a specific port and loading the necessary configuration settings for the environment in which it will be deployed. This could include setting up a database connection, loading API keys or other credentials, configuring middleware, or any other necessary setup tasks.

Starts receiving data from the node: Once the backend server is running, it starts listening for incoming data from the node. This could be in the form of HTTP requests, messages sent over a messaging system like MQTT, or any other protocol that the node is using to communicate with the backend.

If data from a node hits the classification endpoint with image data then trigger the classification process and return waste class with messages and errors back to the node: If the backend server receives a request from the node to classify an image of waste, it will trigger the classification process. This could involve using machine learning algorithms to analyze the image and determine the waste class. Once the classification is complete, the backend will send the waste class along with any relevant messages or errors back to the node.

If the frontend requests to generate a route, then load garbage bin locations from the database, generate routes and cache the route's details for further usage. Find the optimal route between the locations and return data back to the node: If the backend server receives a request from the frontend to generate a waste collection route, it will first load garbage bin locations from the database. Then, it will use a routing algorithm to find the optimal route between the locations, taking into account factors such as traffic, distance, and collection schedules. Once the route is generated, the backend will cache the route's details for further usage and send the route data back to the node. Return error message if something goes wrong or request is invalid: Finally, if any errors occur during any of the above steps, or if the backend server receives an invalid request, it will return an appropriate error message back to the node. This could include messages such as "invalid request," "database connection failed," or "classification error." The error message will help the node to identify and resolve any issues that occur during the interaction with the backend server.

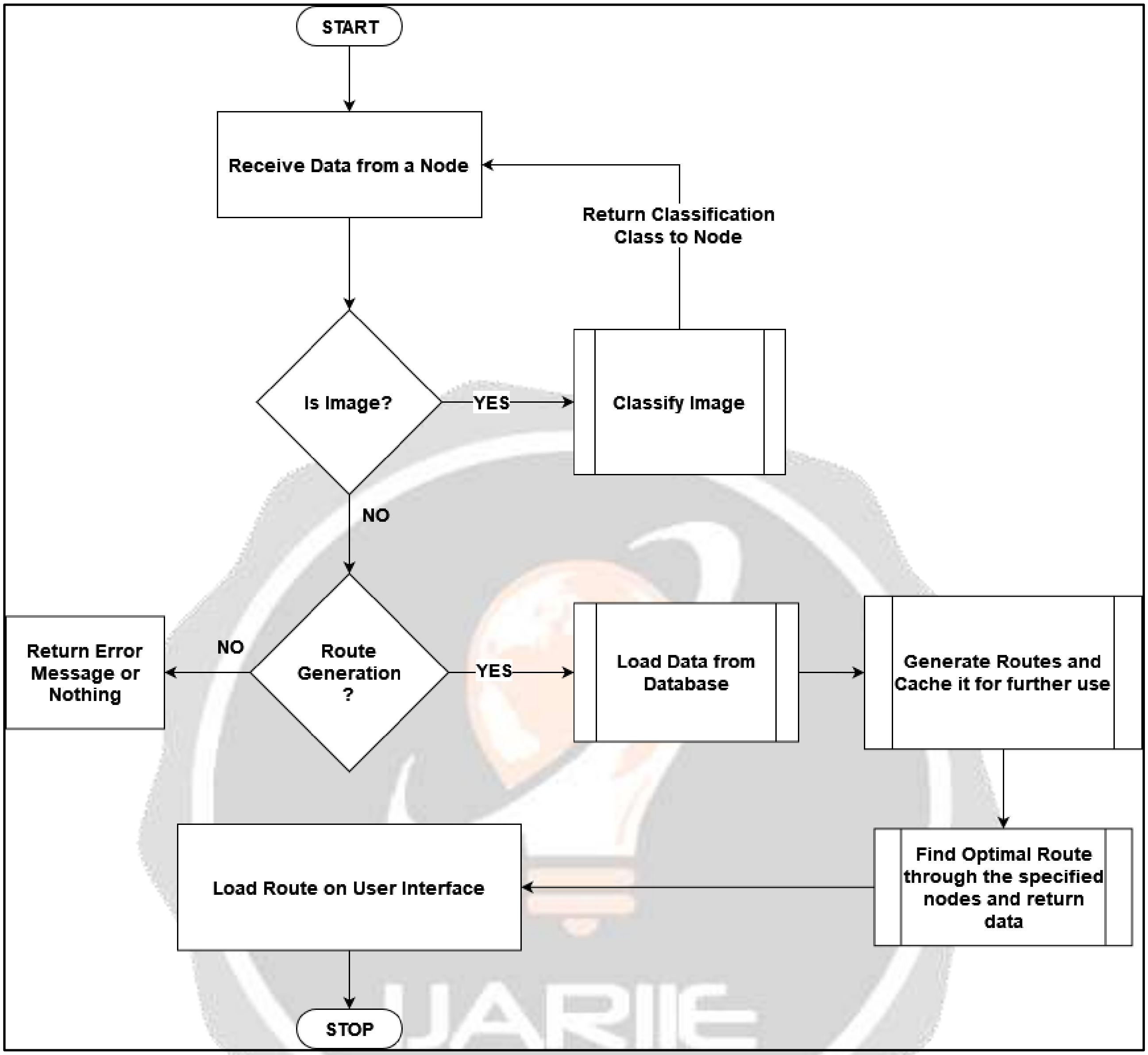


**Fig. 4 -** Backend software algorithm flowchart

## 4. CONCLUSIONS

In conclusion, smart waste segregation and route planner systems offer an innovative and efficient solution for waste management in urban areas. These systems utilize various technologies such as IoT sensors, machine learning algorithms, and geographic information systems to optimize waste collection and disposal processes. Smart waste segregation and route planner systems offer several benefits, including reduced fuel consumption, improved environmental sustainability, and optimized route planning. Additionally, these systems can lead to improved public health and hygiene by ensuring that waste is collected and disposed of in a timely and efficient manner.

Furthermore, smart waste segregation and route planner systems can be customized to meet the specific needs of different cities and municipalities. These systems can be designed to handle different types of waste, such as recyclables, hazardous waste, and organic waste, and can be integrated with existing waste management infrastructure. In summary, smart waste segregation and route planner systems offer a promising solution for improving waste management in urban areas. With continued advancements in technology and increasing awareness of the importance of sustainable waste management, it is likely that these systems will become increasingly common in cities around the world.

## 5. REFERENCES

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