Smart Garbage Segregation & Monitoring System using Internet of Things (IoT)

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***Abstract*—** The Smart Garbage Monitoring System using IoT is an innovative solution designed to address the growing problem of waste management. The system integrates a camera connected to a laptop to identify and classify waste into wet, dry, and other categories. Once classified, an ESP8266 microcontroller controls a 3D-printed linear actuator powered by MG995 servos, which segregates the waste into respective bins. Each bin is equipped with an ultrasonic sensor to monitor the garbage level. This data is relayed to a Flask-based web application, where users can track the fill levels of the bins in real-time and generate service requests for garbage collection. The system also allows garbage collectors to close requests once the waste is picked up. By automating waste segregation and monitoring, this system promotes efficient waste management, reduces human intervention, and supports environmental sustainability.

***Keywords*—** Waste Segregation, Monitoring, Image processing, Internet of Things, Environmental Sustainability.

I. Introduction

With urbanization on the rise, waste management has become a significant challenge for municipalities worldwide. Improper waste disposal leads to environmental pollution, health hazards, and an overall decline in the quality of urban life. Traditional waste management systems rely heavily on manual labor, which is not only inefficient but also prone to errors and delays. The advent of IoT (Internet of Things) offers a promising solution to these challenges by enabling smart and automated waste management systems. The Smart Garbage Monitoring System is designed to automate the process of waste segregation and monitoring using advanced technologies such as image processing, IoT, and servo-controlled mechanisms. This system aims to streamline waste management operations, reduce the workload on sanitation workers, and ensure timely disposal of waste, thereby contributing to a cleaner and healthier environment. By integrating real-time data collection and remote monitoring, the system also provides valuable insights for optimizing waste collection routes and schedules, making it a comprehensive solution for modern waste management threats.

I.

II. Related Work

In today's world, there are trash cans on the side of the road, and we see trash bins overflowing. This bin overflow is due to population growth and waste from hotels, industries, etc. When this garbage bin overflows, our environment becomes ugly and causes many diseases to the public. In order to avoid such a situation, we planned to develop a "waste management system utilizing the IoT system". This is implemented in smart cities. In the system proposed this time, multiple trash cans in various parts of the city are connected using IOT technology. The trash can is equipped with an inexpensive built-in device that senses the level inside the trash can and sends it to city officials. The information is then sent to truck drivers who are supposed to pick up the waste. An ultrasonic sensor detects trash in the trash can. Additionally, the presence of toxic gases in the container is indicated by an audible alarm. This document shows effective ways to keep the environment clean and green. Companies with garbage trucks need a platform to organize and optimize their business processes. Garbage truck drivers need a navigation system and a problem reporting system. The public wants better service, lower costs, and easily accessible reports. In these days of overflowing trash bins, the proposed system helps prevent trash bins from overflowing. Provides real-time information about bin filling levels. Messages are sent as soon as the Trash is full. We will provide trash cans according to your actual needs. The cost of this system is minimal.

III. Architecture of the Smart Garbage monitoring system

The architecture of the Smart Garbage Monitoring System is composed of several interconnected components that work together to ensure effective operation and user interaction. Each component plays a crucial role:

➢ **User Interface:**

The user interface (UI) for the Smart Garbage Monitoring System features a web dashboard that displays real-time and historical garbage levels. Admins receive notifications when garbage levels exceed predefined thresholds and can manually trigger actions, such as notifying the garbage pickers, directly from the dashboard. Additionally, the system can include a mobile app for enhanced accessibility, providing similar functionalities and instant push notifications for alerts. This intuitive interface empowers users to efficiently monitor and manage waste levels in real time.

➢ **Processing Layer:**

The architecture of the Smart Garbage Monitoring System centers around the NodeMCU v3 microcontroller, which acts as the core control unit with built-in Wi-Fi for remote connectivity. The system includes an HC-SR04 ultrasonic sensor that measures garbage levels by emitting ultrasonic waves and calculating the time it takes for the echo to return. This data is processed by the NodeMCU, which also controls two servo motors to automate actions such as opening a lid when garbage levels are high. All components are powered by the NodeMCU's 3.3V output, with a shared ground for stable operation. The system enables real-time monitoring and response to waste levels, optimizing waste management processes through automated alerts and control.

➢ **Hardware Implementation:**

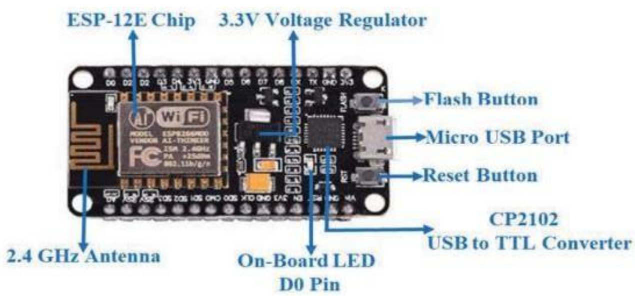

Fig. 01 NodeMCU

The NodeMCU (Node Micro Controller Unit) is an opensource environment for the development of software and hardware designed around a cheap System-on-a-Chip (SoC) called ESP8266. The ESP8266, developed and manufactured by Espressif systems, as shown in Fig. 4, comprises the key components of a computer: CPU, RAM, Wi-Fi, and even a modern operating system and SDK, making it an outstanding option for all sorts of Internet of Things (IOT) applications.

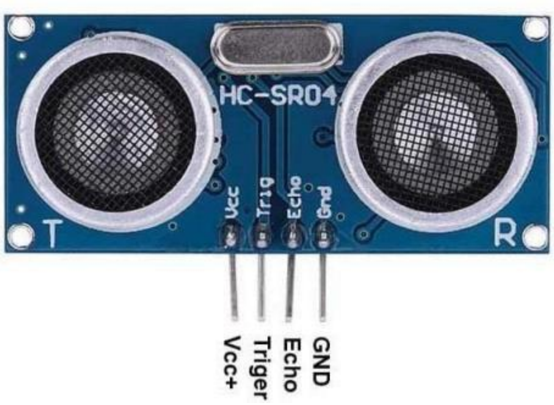

Fig. 02 Ultrasonic Sensor (HC-SR04)

The ultrasonic (or transducer) as shown in Fig. 02 operates on the same radar system concept. Electrical energy can be converted into acoustic waves by an ultrasonic sensor and vice versa. An ultrasonic wave travelling at frequency above 18KHz is the acoustic wave signal. Ultrasonic waves are produced at the 40KHz frequency by the popular HCSR04 ultrasonic sensor.

➢ **Software Implementation:**

The software implementation of the Smart Garbage Monitoring System involves a Flask-based web application that serves as the central interface for monitoring and managing waste. The application processes real-time data from a camera connected to a laptop, performing image classification to categorize garbage into wet, dry, and other types. Control commands are sent to a 3D-printed linear actuator powered by MG995 servos, which sorts the waste into designated bins. Each bin is equipped with an ultrasonic sensor to monitor fill levels, and this data is transmitted to the web application for real-time updates. The system automatically generates service requests when a bin reaches a specified threshold, facilitating timely garbage collection. Once the collection is complete, the garbage collector can close the request through the web interface, ensuring efficient waste segregation and management.

IV. OBJECTIVES

Real-Time Monitoring: Continuously measures the garbage level using the ultrasonic sensor, providing up-to-date information on waste levels.
Automated Waste Management: Automatically triggers actions (e.g., opening a lid) based on the detected garbage level, reducing manual intervention.
User Alerts: Sends notifications or alerts to users when garbage levels exceed predefined thresholds, facilitating timely waste collection.
Data Logging: Can store historical data on waste levels, allowing for analysis and optimization of waste collection routes and schedules.

V. ADVANTAGES

Efficient Waste Segregation: Real-time waste identification & classification using a camera for better recycling and waste management.

Reduced Human Intervention: Automated segregation with ESP8266 and 3D-printed actuator, minimizing labor and exposure to hazards.

Real-time Monitoring: Ultrasonic sensors track garbage levels, with data relayed to a web app for instant status updates.

On-demand Waste Collection: Automated service requests ensure timely garbage disposal, preventing overflows.

Sustainability & Scalability: Supports eco-friendly waste management and smart city integration for broader implementation.

VI. Applications

1. Municipal Waste Management Systems
2. Waste Management in Large Residential Complexes
3. Industrial and Commercial Waste Management
4. Public places like parks and stadiums
5. Hospitals and healthcare facilities
6. Educational Institutions
7. Smart city initiatives

VII. Implementation

Developing the Smart Garbage Monitoring System involves several essential steps that bring the conceptual framework to life.

1. Smart bin Module:

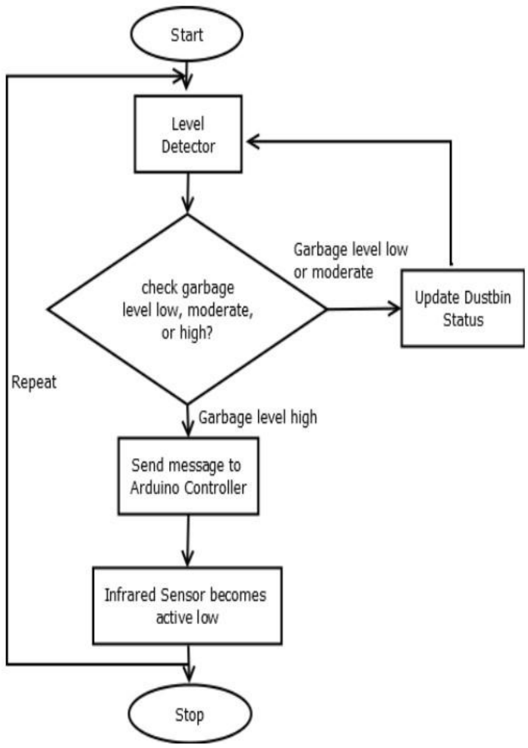

Fig. 03 - Smart bin Module process

- Level detector comprises of infrared sensors which are present in the bins to sense the level of the garbage.
- If the garbage levels pass a threshold value, a message to collect the garbage and empty the bins is sent via the microcontroller to the IoT dashboard where the admin is present.
- If the garbage levels have not yet passed the threshold value, only the status of the dustbin is updated.

2. IoT Dashboard Module:

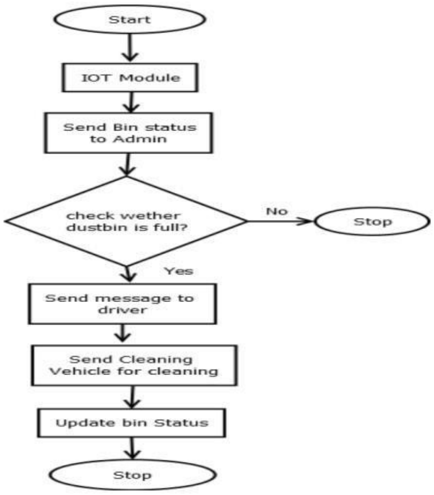

Fig. 04 – IoT Dashboard Module process

The IoT dashboard module receives information from the microcontroller regarding the dustbin full alert and generates service request to collect garbage and close requests.

3. Admin Module:

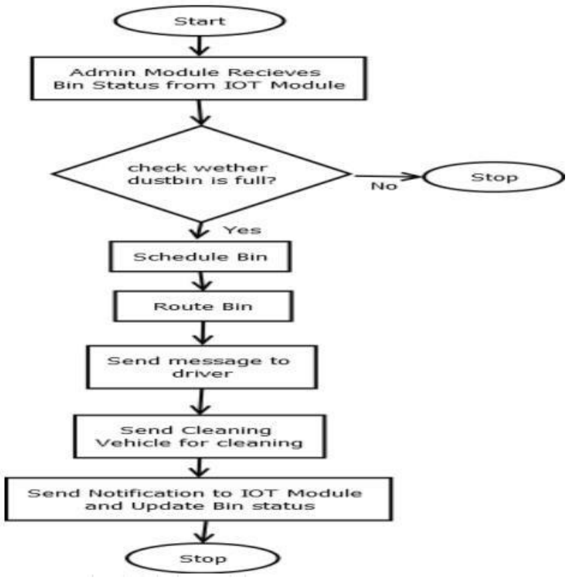

Fig. 05 – Admin Module process

The admin module is the center of the system. It performs tasks of scheduling & routing requests, updating the dashboard, and sending notifications.

VIII. Evaluation

The Smart Garbage Monitoring System's effectiveness is evaluated through user testing and comparative benchmarking against existing solutions. In order to detect & classify waste into the dry category, image processing has been used. While, wet waste detection is being done through sensors present on the linear actuators used to push the garbage in respective dustbins.

➢ Image Processing:

The YOLO (You Only Look Once) object detection algorithm has been used for providing real-time garbage detection and waste classification due to its speed and accuracy. YOLO uses a single convolutional neural network (CNN) to predict both the bounding boxes and class probabilities for objects in the image. By training YOLO on a dataset containing images of various waste categories such as plastic, paper, metal, and organic waste, the model can efficiently identify and classify garbage in real-world environments. This enables automated waste segregation systems, reducing manual effort and improving recycling efficiency. The model processes images in a single pass through the neural network, making it highly suitable for deployment in smart bins and IoT-based monitoring systems. With its ability to perform detection on edge devices like Raspberry Pi and Jetson Nano, YOLO facilitates real-time waste management solutions, contributing to smart city initiatives and sustainable waste disposal practices.

➢ Performance Metrics:

Fig. 06 – Image Detection

II. Future Scope

- Integration with AI for advanced waste classification.
- Scalability for Smart City Deployment.
- Energy Efficiency and Solar Power Integration.
- Integration with Blockchain for Waste tracking.
- Mobile App Development for Enhanced User Interaction.

IX. Conclusion

The Smart Garbage Monitoring System using IoT offers a cutting-edge solution to the growing challenges of waste management by incorporating automation and real-time monitoring. Traditional waste segregation often involves manual effort, leading to inefficiencies and high labor costs. This system eliminates those issues by using a camera to classify waste into categories and automating the process with an ESP8266-controlled 3D-printed linear actuator. It efficiently segregates waste into respective bins, minimizing human intervention and potential exposure to harmful materials.
The use of ultrasonic sensors in each bin ensures that the waste levels are continuously monitored, providing real-time data to users via a Flask-based web application. This allows for timely service requests for waste collection, reducing the chances of garbage overflow and promoting better hygiene in public spaces. Waste collectors can easily track and close requests once the garbage is picked up, streamlining the entire process. By making waste management more efficient and eco-friendly, this system contributes significantly to sustainability. It can easily be adapted to larger systems, making it suitable for smart city applications. With growing urban populations and increasing waste production, innovative solutions like this system are critical for addressing future waste management challenges in a sustainable and scalable manner.

X. References

- IoT based Waste Collection System using Infrared Sensors H. Poddar, R. Paul, S. Mukherjee, and B. Bhattacharyya, in 2017 Innovations in Power and Advanced Computing Technologies (i-PACT). IEEE, 2019, pp. 1–6

- Adaptive and Interactive Modelling System (AIMS) D. D. Vu and G. Kaddoum, “A waste city management system for smart cities applications,” in 2019 Advances in Wireless and Optical Communications (RTUWO). IEEE, 2019, pp. 225–229.

- Waste Segregation System Using Artificial Neural Networks in G. K. Shyam, S. S. Manvi 2020 2nd International Conference on Computing and Communications Technologies (ICCCT). IEEE, 2020, pp. 199– 203.

- Automatic Waste Segregator and Monitoring System S. Murugaanandam, V. Ganapathy, and R. Balaji, “Efficient IoT based smart bin for clean environment,” in 2021 nternational Conference on Communication and Signal Processing (ICCSP). IEEE, 2018, pp. 0715–0720

- Waste Segregator and Monitoring System using SVM ” M. Talha, A. Upadhyayin 2021 International Conference on Multimedia, Signal Processing and Communication Technologies (IMPACT). IEEE, 2021, pp. 175–179.

- Andrea Zanella, Nicola Bui, Angelo Castellani, Lorenzo Vangelista, Michele Zorzi, “Internet of Things for Smart Cities”, IEEE INTERNET OF THINGS JOURNAL, VOL. 1, NO. 1, FEBRUARY 2014.

- Krishna Nirde 1, Prashant S. Mulay 2 , Uttam M.Chaskar , “IoT based solid waste management system for smart city”. International Conference on Intelligent Computing and

Control Systems ICICCS 2017. 978-1-5386-2745-7/17/$31.00 ©2017 IEEE

- Monika Kashyap, Vidushi Sharma, Neeti Guptam, "Taking MQTT and NodeMcu to IOT: Communication in Internet of Things", International Conference on Computational Intelligence and Data Science (ICCIDS 2018), Procedia Computer Science 132 (2018) 1611–1618.
- Shashika Lokuliyana, Anuradha Jayakody, G.S.B.Dabarera, R.K.R.Ranaweera, P.G.D.M.Perera, P.A.D.V.R.Panangala, "Location based Garbage Management System with IOT for Smart City", 13th International Conference on Computer Science & Education, August 2018, pp. 699-703.
- Jetendra Joshi, Joshitha, Praneeth, Akshay Agarwal, Rahul Agarwal, Amrit Bagga, Abhinandan Bhargava, "Cloud Computing based Smart Garbage Monitoring System", IEEE 2016 3rd International Conference on Electronic Design, August 2016, pp. 70-75.
- M. W. Rahman, R. Islam, A. Hasan, N. Islam Bithi, Md. Mahmodul Hasan, Mohammad Motiur Rahman, "Intelligent Waste Management System using Deep learning with IOT", Journal of King Saud University-Computer and Information Sciences, 2020, pp.1-16.
- Ade Geovania Azwar, Riffa Haviani Laluma, Ronny Permana Halim, Nurwathi, Gunawansyah, Gunawan, "Smart Trash Monitoring System Design using NodeMCU-based IOT", 2019 IEEE 13th International Conference on Telecommunication Systems, Services and Applications, October 2019, pp. 67-7
- M. Srilatha, D. Nagajyothi, V. Jyothi, "Smart Garbage Collection and Dumping system using NI myRIO and Arduino", International Journal of Engineering and Advanced Technology, Vol.9, Issue 2, December 2019, pp.2934-2939.
- Namakambo Muyunda, Muhammad Ibrahim, "Arduino-based Smart Garbage Monitoring system: Analysis Requirement and Implementation", 2017 International Conference on Computer and Drone Applications, November 2017, pp. 28-32.
- K. Silpa, L.Yao, P. Bhada-Tata and Frank Van Woerden, "What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2015", Urban Development Series, Washington, DC: World Bank, 2018.
- Minhaz Uddin Sohag, Amit Kumer Podder, "Smart Garbage Management System for a Sustainable Urban Life: An IOT Based Application", Internet of Things (2020).
- Ruhin Mary Saji, Drishya Gopakumar, Harish Kumar S, K N Mohammed Sayed, Lakshmi s, 'A Survey on Smart Garbage Management in Cities using IoT', International Journal Of Engineering And Computer Science ISSN: 2319-7242 Volume 5 Issue 11 Nov. 2016, Page No. 18749-1875.