International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 4, pp 280-284, April-2024

https://doi.org/10.47001/IRJIET/2024.804043

Smart Waste Management System Using ESP32

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***Abstract* - The Smart Waste Management System (SWMS) is designed to revolutionize traditional waste management practices by integrating Internet of Things (IoT) technology, data analytics, and real-time monitoring capabilities. The system utilizes a network of sensors deployed in waste bins to collect data on fill levels, location, and other relevant parameters. This data is transmitted wirelessly to a central server for analysis using advanced algorithms to optimize waste collection routes, schedule maintenance, and detect anomalies. Through a user-friendly web or mobile interface, stakeholders can access real-time information, receive alerts, and monitor the status of waste bins remotely. SWMS aims to improve operational efficiency, reduce environmental impact, and enhance public health by minimizing waste overflow, optimizing resource allocation, and promoting sustainable waste management practices. This abstract provides an overview of the SWMS's functionality, highlighting its potential to revolutionize waste management practices and contribute to a cleaner, smarter, and more sustainable urban environment.**

Keywords: Iot, sensors, monitoring, waste, location.

I. INTRODUCTION

The management of waste has become a significant concern in modern urban environments, as population growth and urbanization have led to an exponential increase in waste generation. Traditional waste management practices often struggle to cope with the sheer volume and diversity of waste produced, resulting in inefficiencies, environmental degradation, and health hazards. To overcome these challenges, there is a growing interest in deploying smart waste management systems that leverage emerging technologies such as the Internet of Things (IoT), data analytics, and real-time monitoring. These systems offer the promise of revolutionizing waste management by enabling more efficient collection, optimization of resources, and promotion of sustainable practices.

Smart waste management systems integrate sensors, actuators, and communication technologies to monitor waste levels in bins, optimize collection routes, and facilitate timely disposal. By leveraging data analytics and machine learning algorithms, these systems can predict waste generation patterns, optimize resource allocation, and identify areas for improvement. Moreover, real-time monitoring allows for proactive intervention, such as prompt collection of overflowing bins or detection of hazardous materials. Overall, smart waste management systems hold great potential to enhance operational efficiency, reduce costs, minimize environmental impact, and improve the quality of life in urban areas.

II. LITERATURE SURVEY

Smart Waste Management System Using IoT. International Journal of Scientific Research in Engineering & Technology. 04-08. 10.59256/ijsreat.20240403002. Waste collection and management are integrated parts of both city and village life. Lack of an optimized and efficient waste collection system vastly affects public health and costs more. The prevailing traditional waste collection system is neither optimized nor efficient. The Internet of Things (IoT) has been playing a great role in making human life easier by making systems smart, adequate, and self-sufficient. Thus, this paper proposes an IoT-based, efficient waste collection system with smart bins. India generates tons of waste annually. Conventional garbage collection is not efficient since the authorities are not notified until the waste bin is full, and this leads to an overflow of waste material. Efficient waste disposal and collection are essential for a sustainable and clean India. A smart waste management system uses an IoT-based waste bin for collection and monitoring the level of waste inside the bin. The system does real-time monitoring of the waste bins and determines which are to be emptied. The system is implemented using two ultrasonic sensors. One of the ultrasonic sensors detects the level of waste in the bin, and the other detects the person approaching the bin to dispose of the waste. This detection helps with the automatic opening and closing of the lid. A servo motor is connected to the lid, which

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serves the action of closing and opening the lid. In this system, the level of waste in the bin will be sent to the concerned authorities. Thus, it reduces fuel costs and human labor, making the system optimized and efficient by enabling real-time monitoring and enhanced navigation.

Kishore, G. Krishna & Sonali, P. & Divya, K. & Reddy, Vidhisha & Pravalika, P. (2024). Smart Wet and Dry Waste Management System Using IoT. International Journal for Research in Applied Science and Engineering Technology. 12. 5039-5042. 10.22214/ijraset.2024.61200. Waste management is one of the important aspects when it comes to avoiding diseases caused by unsegregated waste. Many people have lesser knowledge about what is wet and dry waste. The escalating global waste generation has led to a pressing need for innovative waste management solutions that are efficient, sustainable, and technologically advanced. This abstract introduces a "Smart Dry and Wet Waste Management System" that leverages the Internet of Things (IoT) to revolutionize waste management practices. Traditional waste management systems often lack real-time monitoring and optimization capabilities, resulting in inefficiencies, environmental concerns, and increased operational costs. The proposed system aims to address these challenges by integrating IoT technologies, sensor networks, and data analytics into waste collection and disposal processes. The main objective is to automate the segregation system thereby removing the human intervention. The hardware components such as Arduino, sensors, LCD are used to build the system. The integration of IoT in waste management contributes to a cleaner environment, reduced operational costs, and increased overall efficiency. By preventing overflows, minimizing unnecessary collection trips, and promoting recycling practices, the system aligns with sustainable waste management goals. Moreover, the collected data can be analyzed over time to identify long term trends, enabling continuous optimization of waste management strategies.

Burange, Dr. (2024). Review on Development of E-Waste Management System. International Journal for Research in Applied Science and Engineering Technology. 12. 1171-1175. 10.22214/ijraset.2024.58542. Today, the advancement of technology has the power to change everyone's life. Although this innovation is beneficial, it creates serious effects on human health and environmental health. One of the main reasons for this is "e-waste" resulting from electronic products. With the use of electronic products all over the world, the amount of "e-waste" or e-waste has also increased and this has now become a serious problem. Improper disposal of e-waste has become an environmental and public health problem as it now accounts for the largest portion of water litter in the world's cities. Therefore, correct classification and management of e-waste requires the recovery of important information about waste. These growing wastes are hard in nature and rich in metals such as neodymium, indium, palladium, tantalum, platinum, gold, silver, lead and copper, which can be recovered from discards and brought back to the earth. Production cycle and daily use. In this project, a deep learning model is used to identify e-waste and general waste using image processing. The design model, on the other hand, selects the waste with good accuracy and takes less time. Wastes are divided into two groups according to the amount or value in the waste. By using this model effectively, we can solve e-waste management problems, improve recycling and contribute to environmental sustainability.

Block Diagram:

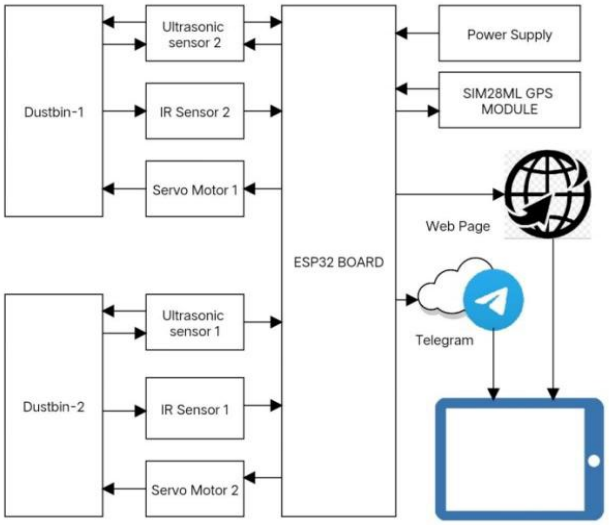

Figure 1: Block Diagram

Circuit Diagram:

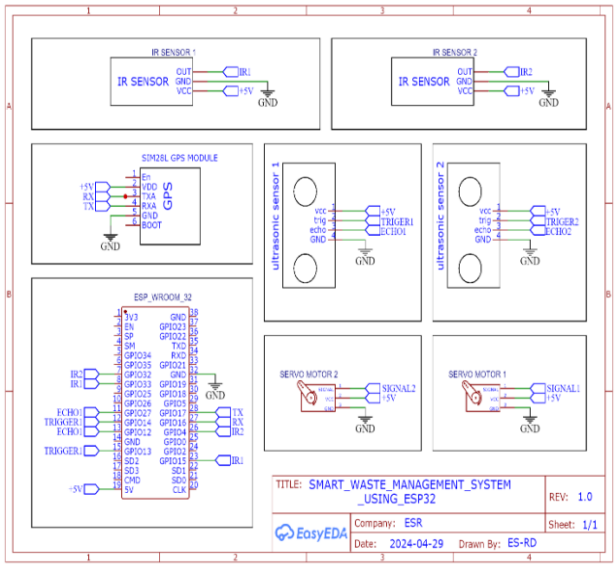

Figure 2: Circuit Diagram

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III. PROPOSED ALGORITHM

A recommended approach for developing a smart waste management system using ESP32 involves several key steps. Firstly, define the requirements and objectives of the system, including the types of waste to be monitored, the level of monitoring granularity needed, and the desired outcomes such as optimizing waste collection routes and minimizing environmental impact. Next, select appropriate sensors and hardware components compatible with the ESP32 platform, considering factors such as sensor accuracy, durability, and power consumption.

Once the hardware components are selected, proceed to design the system architecture, including sensor placement, data collection points, and communication protocols. Utilize GPIO pins on the ESP32 for interfacing with sensors and actuators, ensuring efficient use of available resources. Implement wireless communication protocols such as Wi-Fi or Bluetooth to enable data transmission from sensors to a centralized hub or cloud-based platform for real-time monitoring and analysis.

Develop software firmware for the ESP32 to handle data acquisition, processing, and decision-making algorithms. Utilize low-power modes and optimization techniques to prolong battery life and reduce energy consumption, especially in remote or off-grid deployment scenarios. Implement intelligent algorithms for waste level monitoring, predictive maintenance, and route optimization to optimize waste collection schedules and reduce operational costs. Finally, conduct thorough testing and validation of the smart waste management system in real-world environments to ensure reliability, accuracy, and scalability before deployment. Regular maintenance and updates should be performed to address any issues and incorporate new features or improvements over time. By following this approach, a robust and efficient smart waste management system can be developed using ESP32, contributing to environmental sustainability and efficient resource utilization.

Project Model:

Figure 3: Final Project

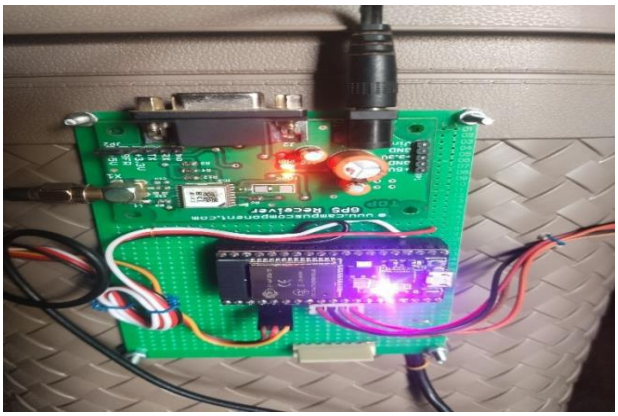

Figure 4: Final Hardware

IV. RESULT

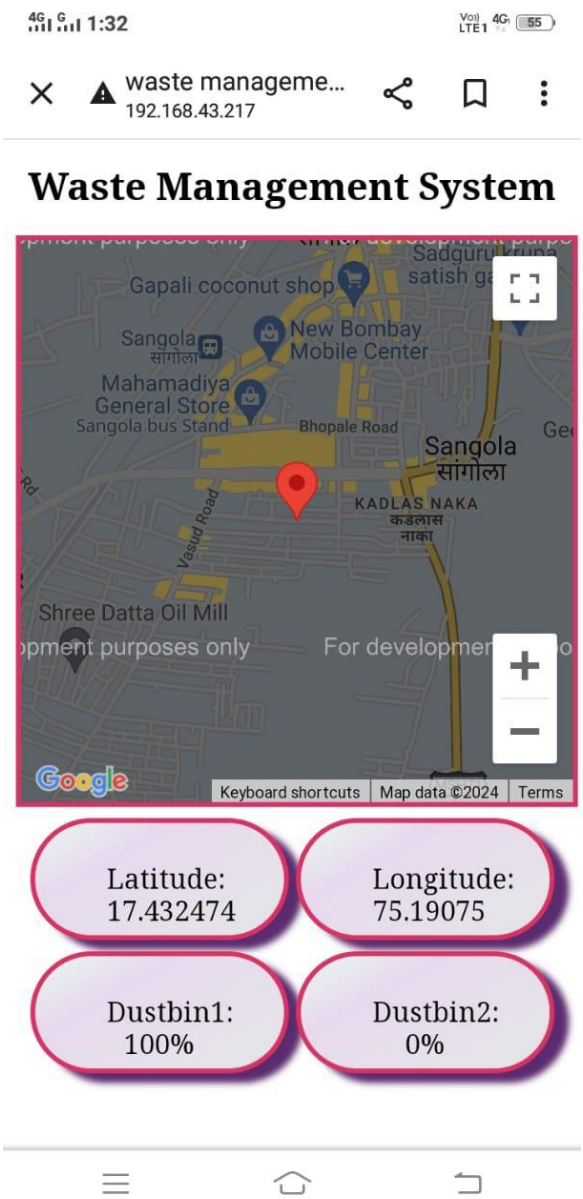

Figure 5: Final Project

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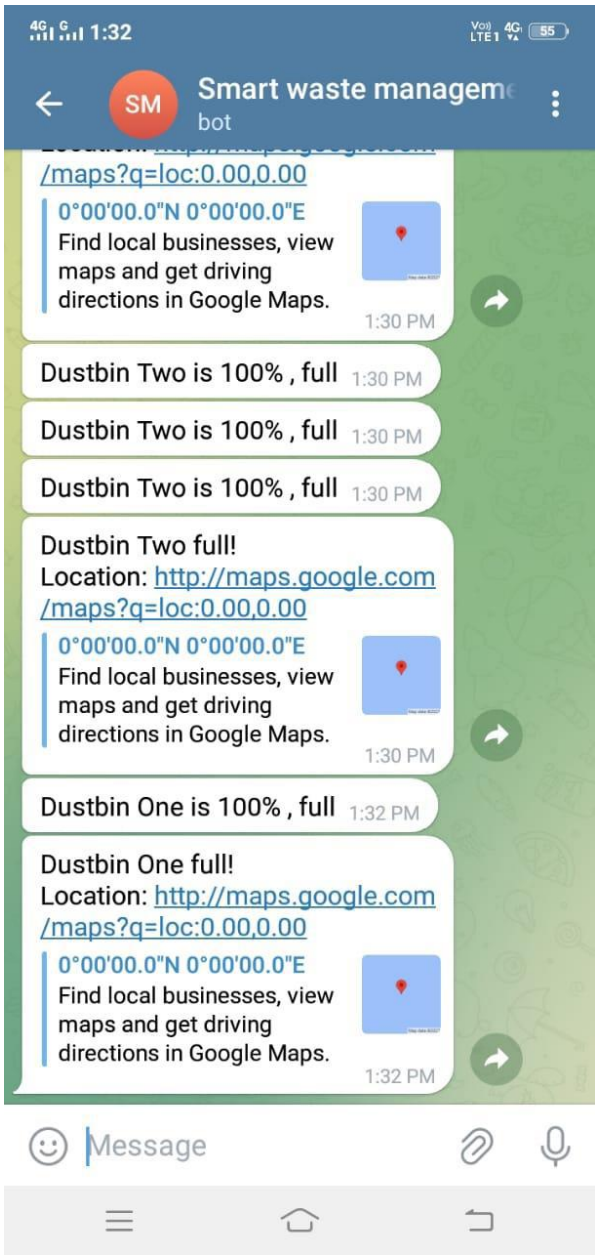

Figure 6: Dustbin Updates on Telegram App

In the proposed waste management system, ultrasonic sensors are deployed for accurate measurement of dustbin levels, allowing for efficient waste collection scheduling. Servo motors are utilized to control the opening and closing of dustbin lids, ensuring seamless operation and preventing overflow. Infrared sensors are employed for detecting human presence, triggering servo movements to avoid obstruction during waste disposal. GPS modules provide real-time location tracking of dustbins, facilitating optimized collection routes and resource allocation. Data collected from these sensors are transmitted to a central web server and Telegram messaging application, enabling remote monitoring and management of waste disposal operations. This integrated approach enables proactive waste management, ensuring timely collection, minimizing environmental impact, and enhancing overall efficiency.

V. CONCLUSION

In conclusion, the integration of ultrasonic sensors, servo motors, infrared sensors, GPS modules, and data transmission technologies presents a comprehensive solution for smart waste management. By leveraging these technologies, the system enables real-time monitoring of dustbin levels, automated lid control, obstruction detection, and precise location tracking. This not only enhances the efficiency of waste collection processes but also facilitates proactive decision-making and resource optimization. The ability to remotely access and manage waste disposal operations through web-based platforms and messaging applications further enhances the system's effectiveness and scalability. Ultimately, the adoption of such smart waste management systems holds great promise in promoting sustainable practices, reducing environmental impact, and improving overall urban hygiene and cleanliness.

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ISSN (online): 2581-3048

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Citation of this Article:

Mulani Mumtaj Raju, Pawar Swapnali Dilip, Sawant Sonali Bandopant, Kadam Akanksha Annaso, Asst. Prof. R.K. Patole, "IoT-Based Non-Invasive Blood Glucose Monitoring System", Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 8, Issue 4, pp 280-284, April 2024. Article DOI https://doi.org/10.47001/IRJIET/2024.804043

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