IntelliBin – A smart way to segregate the waste

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***Abstract*— Effective waste management has become a pressing global challenge, with improper disposal contributing to environmental hazards and public health concerns. Conventional waste segregation techniques often involve manual labor, making them inefficient and prone to errors. Furthermore, the absence of awareness and structured disposal mechanisms worsens the issue, leading to increased landfill accumulation and pollution. IntelliBin is designed to address these concerns by incorporating a camera module, Raspberry Pi, and Teachable Machine to automate the categorization of waste. A servo motor responds to the classification result by opening the appropriate bin, ensuring precise and systematic waste separation. This automation significantly reduces human error and enhances the efficiency of waste management compared to traditional methods.**

***Index Terms*—smart waste segregation, raspberry-Pi, machine learning, classification, sorting**

I. INTRODUCTION

waste management lacked organization, resulting in pollution and improper disposal. As urbanization expanded, the necessity for improved segregation methods became apparent. The introduction of separate bins for wet and dry waste helped distinguish organic from inorganic materials. This advancement facilitated composting of organic waste while enabling the recycling of dry waste, ultimately reducing landfill accumulation and promoting a more sustainable approach to waste management.

To tackle the issues in waste segregation, we propose IntelliBin, a sophisticated waste management system utilizing machine learning, Raspberry Pi, and a servo-based bin mechanism. The system features a camera module that captures waste images, which are processed using Teachable Machine, an AI model trained to differentiate between waste types such as recyclable, non-recyclable, and organic. Based on this classification, the servo motor automatically activates the corresponding bin, minimizing the necessity for manual intervention. This innovation streamlines waste management, increases efficiency, and fosters environmental sustainability.

IntelliBin is developed to automate waste separation, thereby enhancing recycling processes, minimizing landfill contributions, and supporting a cleaner ecosystem. By integrating modern technology, the system provides a scalable and effective waste management solution for homes, industries, and municipalities. The combination of machine learning and servo-driven automation ensures precise classification and disposal of waste with minimal human involvement. This tech-centric approach optimizes waste handling procedures while promoting sustainability by encouraging recycling and reducing the ecological footprint of improper waste disposal.

II. LITERATURE REVIEW

Research has focused on creating intelligent dustbin systems to improve waste management efficiency. Implementing Arduino Uno, ultrasonic sensors, and servo motors allows automated lid opening and waste level monitoring. However, while these methods successfully automate fundamental waste-handling tasks, they lack the capability for advanced waste classification, limiting their functionality to basic operations. The study highlights the advantages of incorporating simple automation tools while emphasizing the necessity for more sophisticated solutions to address complex waste segregation challenges.

Other research has explored the development of smart waste disposal systems that employ sensors, such as PIR and ultrasonic devices, alongside IoT and GSM modules for real-time monitoring. While these approaches utilize modern technology to improve waste collection and notification systems, they face scalability constraints and are more applicable to urban environments. Consequently, their ability to manage intricate waste classification processes is restricted, indicating the need for more adaptable and comprehensive solutions.

A Smart Garbage Monitoring System using IoT has been examined to enhance waste collection efficiency through automated notifications and real-time monitoring. This system integrates ultrasonic sensors to gauge waste levels, a servo motor for automatic lid movement, a buzzer for local alerts, an LCD screen for displaying real-time status updates, and a GSM module for alerting municipal authorities when bins reach capacity. A Raspberry Pi acts as the system's core processor, with data storage and analysis performed in ThinkSpeak Cloud to optimize tracking. GPS functionality allows location monitoring, aiding authorities in optimizing waste collection routes. When bins exceed an 80% fill level, an SMS alert is dispatched, while bins below this threshold remain under continuous surveillance. A mobile application and cloud-based dashboard enable authorities to access graphical data, facilitating waste collection scheduling and preventing overflow. The system also promotes waste segregation through a dual-bin mechanism for wet and dry waste, improving composting and recycling efficiency.

Additional research on Arduino UNO-based Smart Dustbin Systems has tackled waste management issues by introducing automated segregation and bin-level monitoring. Traditional waste disposal methods contribute to pollution and health risks, while manual segregation is inefficient. These smart bins incorporate IR and moisture sensors to identify and classify wet and dry waste, directing them into separate compartments via servo motors. Ultrasonic sensors monitor bin fill levels, displaying real-time updates on an LCD screen and triggering alerts when bins reach 90% capacity. Programmed using Arduino IDE, this system enhances hygiene, minimizes human effort, and ensures efficient waste management. Future enhancements include IoT integration, biodegradable waste processing, and advanced material segregation. This approach supports initiatives such as the Swachh Bharat Mission, fostering cleanliness and sustainability. Additional improvements, including solar power, AI-based object detection, and mobile applications, could optimize urban waste management, making cities more liveable.

IoT-powered smart waste bins improve waste management through automated segregation, fill level detection, and harmful gas identification. These systems integrate Arduino Uno, NodeMCU, ultrasonic sensors, gas detectors, and servo motors to notify users when bins are full, ensuring hygienic disposal via an automated lid. Real-time data transmission through Wi-Fi enables remote monitoring. Compared to conventional techniques, this method reduces manual intervention, optimizes waste collection, and mitigates pollution. Despite cost and maintenance challenges, future developments such as AI-driven sorting, mobile applications, and solar energy adoption could make this solution more sustainable and efficient.

III. METHODOLOGY

This project integrates machine learning and IoT technologies for waste classification and segregation, aiming to facilitate efficient disposal. A camera module captures waste images, processed using OpenCV and Teachable Machines to classify them into recyclable, non-recyclable, or organic categories. The classification results are then relayed to a Raspberry Pi, which activates a servo motor to open the corresponding bin, ensuring accurate waste segregation.

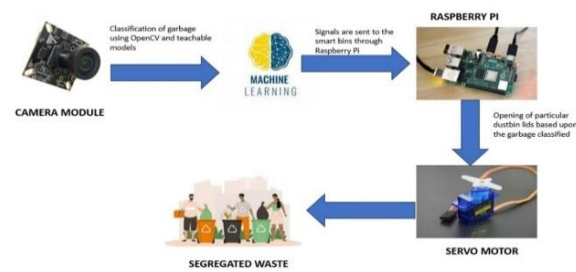

Fig 1:Block Diagram Representing INTELLIBIN

IV. RESULT AND DISCUSSION

This section presents the IntelliBin system's performance, showcasing its effectiveness in categorizing waste using Teachable Machines. Waste is classified into categories such as recyclable, non-recyclable, e-waste, and medical waste. The dataset was meticulously curated, comprising labeled images tailored to these categories. Simulated waste data points were used to demonstrate system accuracy due to the unavailability of extensive realworld data.

The system's capabilities include:

Bounding Box Detection: Objects placed within the bounding box are detected and categorized in real time, with classification results displayed on the interface, such as "Recyclable," "Non-Recyclable," "E-Waste," or "Medical Waste," along with a confidence score.

Classification Logs: The system maintains detailed logs of waste detection, allowing users to analyze performance and trends over time.

Visualization Features: The system provides graphical insights into waste classification results, demonstrating the accuracy and efficiency of IntelliBin.

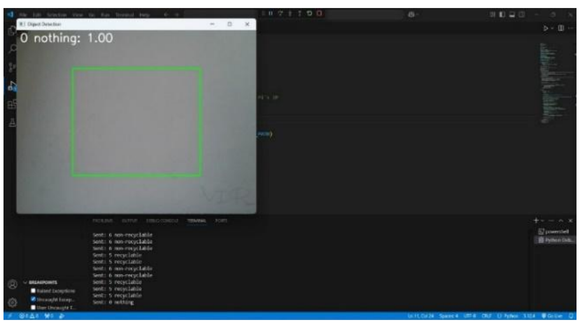

Figure 2: Real-Time Waste Classification Result as "Nothing"

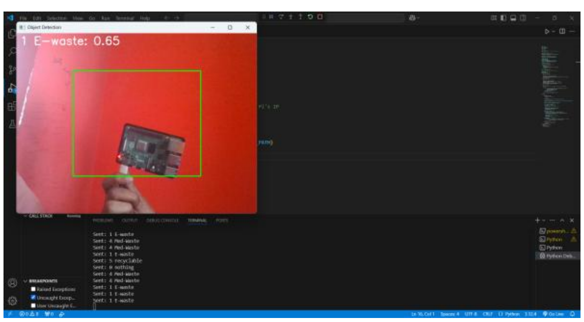

Figure 3: Real-Time Waste Classification Result as "E-Waste"

IV. CONCLUSION

IntelliBin introduces an innovative approach to waste segregation by integrating machine learning and automation for precise waste sorting. Unlike conventional manual methods that are often inaccurate and inefficient, this system automates the categorization of recyclable, non-recyclable, e-waste, and medical waste, minimizing contamination and enhancing recycling efficiency. Its scalability allows widespread implementation across urban areas, industries, healthcare facilities, and educational institutions, ensuring compliance with regulations and promoting responsible waste disposal. By fostering recycling initiatives, reducing environmental impact, and advancing sustainability goals, IntelliBin contributes to a smarter, cleaner waste management ecosystem.

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