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Smart Waste Bin

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ABSTRACT: This innovative system revolutionizes waste management in small organizations by harnessing the power of AI to optimize waste disposal and promote sustainability. Through AI-powered screening, the system accurately identifies biodegradable and non-biodegradable waste, directing each type to its corresponding bin and composting unit, where biodegradable waste is converted into nutrient-rich compost, reducing waste sent to landfills and promoting sustainable practices. The system continuously monitors bin levels, detecting when the bin reaches 75% capacity, and also monitors gas levels and temperature within the bin, ensuring a safe and healthy environment. When the bin reaches 75% capacity, the system sends automatic notifications to authorized personnel, ensuring timely waste collection and minimizing the risk of overflow. Once the bin is full, the lid remains locked until the waste is removed, preventing any further waste from being added and ensuring a secure and efficient waste management process. By automating waste classification and disposal, this system reduces waste disposal costs, minimizes environmental harm, and fosters responsible waste management practices, promoting a cleaner environment.

KEYWORDS: AI-powered Waste Detection, Composting Unit, Bin Level Monitoring, Gas Detection, Temperature Monitoring, Sustainability, Waste Disposal Optimization.

I. INTRODUCTION

Waste management is a pressing concern, with the global waste generation rate expected to reach 3.4 billion tons by 2050. Inefficient waste management has severe environmental, economic, and social implications. Small organizations face significant challenges in managing waste effectively, but recent advancements in AI and machine learning offer new opportunities for improvement. This work proposes the development of an intelligent waste management system for small organizations and has made optimal use of AI to optimize waste disposal and promote sustainability. The writer primarily focuses on implementing Smart Waste Bins with AI Screening and Sensor-Based Segregation that can easily determine biodegradable and non-biodegradable waste and direct the individual type to its corresponding lid and composting unit.

Effective waste management is a critical challenge facing organizations of all sizes, particularly in small-scale environments like college departments, where proper waste segregation and disposal can significantly impact sustainability efforts and environmental responsibility. The proposed system addresses several key issues in current waste management practices, including incorrect waste segregation, inefficient monitoring of bin fill levels, lack of on-site composting solutions for biodegradable waste, and manual oversight requirements. By leveraging technology, this smart bin system aims to automate and optimize the waste management process, promoting better waste segregation, facilitating on-site composting, and reducing the manual effort required for bin maintenance.

II. LITERATURE REVIEW

Abeygunawardhana et al. worked on AI-driven smart bin for waste management, using computer vision and machine learning algorithms to identify and segregate waste, reducing the cost of waste disposal and enforcing sustainable waste management practices.

Murugaanandam et al. presented an efficient IoT-based smart bin for clean environment that uses ultrasonic

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sensors for monitoring waste levels and detecting harmful gases, thus reducing waste disposal costs and promoting sustainable waste management practices.

Alizera Hassani et al. proposed an IoT-enabled smart waste disposal system that utilizes the context management platform, automatically determines the type of waste, guide users to the nearest available container, and encourages more sustainable waste management practices.

Mohammad Akidul Hoque, et al. proposed an IoT and machine learning-based smart garbage management and segregation approach for Bangladesh which integrates RFID and IoT technologies to track levels of garbage, humidity, temperature, and flame detection in real-time.

A smart bin system that has been proposed by Adi Suvarnamma et al. using IoT and equipped with waste tracking and sorting mechanism aims at segregating the domestic waste from metallic, plastic, and glass categories, providing information about the amount of waste produced by each household.

J.M.U. Aguila et al. proposed the development of smart waste bin with built-in volume and weight sensor using ultrasonic sensors and load cell that manages and monitors waste, provides real-time monitoring of the waste levels, and weight.

Harnani Hassan et al. proposed low-cost automated sorting recycle bin powered by Arduino microcontroller employing advanced sensors to classify waste materials like metals, paper, and plastics in an effort to streamline waste segregation and enhance efficiency.

Md. Wahidur Rahman et al. proposed an intelligent system using deep learning based on IoT for waste classification and real-time monitoring, using deep learning and IoT technologies for waste classification and real-time monitoring and achieving high accuracy but being limited to five waste categories and two sensors in the prototype

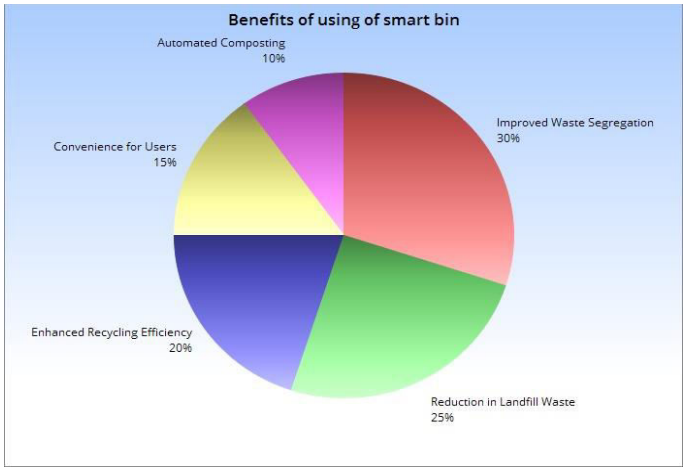

Fig 1: Real-Time data of Benefits of using of smart Bin

III. COMPONENTS

A. HARDWARE

Arduino or Raspberry Pi acts as the main control unit to process sensor inputs and execute commands. Raspberry Pi would be a better choice if AI or machine learning processes are involved due to its higher processing power .Ultrasonic Sensor Measures the fill level by detecting the distance between the sensor and the waste material. Infrared Sensor (IR) Detects different types of waste materials, especially plastics, by measuring the reflection of infrared light. Proximity

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Sensor Detects the presence of a person or object near the bin to trigger the lid or compartment to open automatically .Ultrasonic Sensor Measures the fill level by detecting the distance between the sensor and the waste material.
LCD or OLED Screen To show real-time information, such as bin fill levels, status, or waste type detected.

IV. SOFTWARE SPECIFICATION

The Smart Waste Bin system integrates multiple technologies for efficient waste sorting and management. A microcontroller, programmed via Arduino IDE, handles sensor inputs and motor controls for real-time sorting. Machine learning models, developed with TensorFlow and using OpenCV for image processing, classify waste into biodegradable or non-biodegradable categories. The ESP8266 module enables IoT connectivity for remote monitoring, while a mobile app provides real-time updates on bin status and waste levels. A database stores system activity and waste data for performance analysis and continuous improvement.

V. EXISTING SYSTEM

The existing waste management system in most cities is manual and labour-intensive, relying on waste collectors to gather waste from households and businesses and transport it to landfills or incinerators. This system is often inefficient, with waste not being sorted or segregated properly, leading to environmental pollution and health hazards. The lack of automation and technology in the existing system results in high labour costs, traffic congestion, and limited recycling rates, ultimately contributing to the growing problem of waste management.

VI. DRAWBACKS

Despite improvement in systems, they have various limitations. They do not possess extensive classification of wastes; hence, recyclable and hazardous wastes are unable to be accurately identified. Usually, monitoring sensors provide non-uniform or delayed data, which sometimes cause overflow or poor timing in collections. In addition, scheduling for collection and troubleshooting usually involve a human brain, thus decreasing efficiency. In most cases, waste bins do not integrate safety features regarding the presence of hazardous gases or elevated temperatures. This can present health and environmental risks.

VII. PROPOSED SYSTEM

The system to be proposed is an automatic waste management system, using AI-powered screening cameras to screen the kinds of waste, proximity sensors for opening and closing the lid, and other gas and temperature sensors that monitor the inside conditions of the garbage bin. It should also have a composting unit to include grinding tools to process organic waste, and a liquid crystal display LCD that displays real-time information on the levels of waste, composition, and other parameters monitored by the system. By using screening cameras enabled with AI, the system can accurately determine the nature of waste and sort it into respective streams, hence curbing contamination
And enhancing and recycling

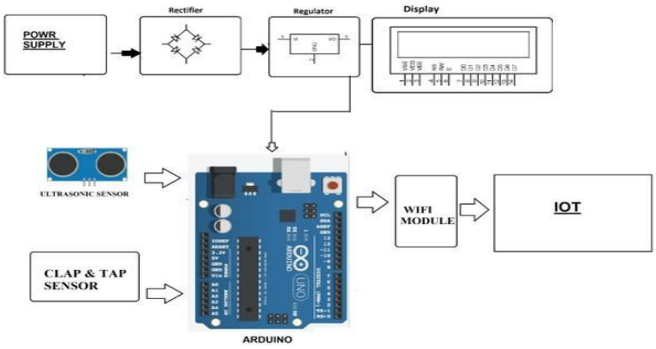

Fig 2: Block diagram for Proposed System:

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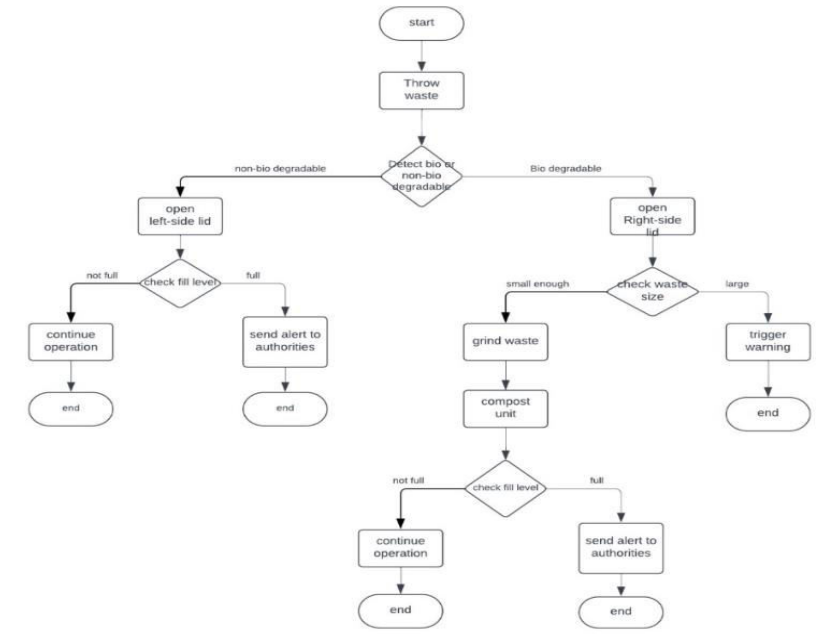

Fig 3: Flow Chart of Proposed System

VIII. MODIFICATION

There should be an initiation of an AI-driven waste classification system to classify biodegradable, non-biodegradable, recyclable, and hazardous materials. Advanced sensors will enable feeding of data on the levels of the bins, gas emissions, and temperature with automatic notification to personnel if action is required. Complete automation of scheduling waste collection with real-time data would further optimize the process. Integrate gas and temperature monitoring; this will enhance safety, and have an on-site unit for biodegradable waste composting on the site as this promotes sustainability.

IX. ADVANTAGES

- Enhanced Waste Differentiation: Smart Waste Bin relies on automated sensor-based detection for the differentiation of bio and non-bio wastes so that they are treated appropriately and their contamination minimized.
- Environmental Sustainability: It reduces the generation of landfill waste and hence methane emissions since it facilitates proper composting of bio-waste. This, therefore, fosters a clean environment.
- Operational Efficiency: Automation eliminates the involvement of humans in the process of managing wastes. The work process thus becomes faster as well as improves collection of wastes.
- Resource Recovery: Composting bio-waste assures successful recovery of organic materials, which are continuously used for various agricultural and landscaping purposes.
- User Convenience: Sensing waste and easy-to-use interfaces ensure smooth user interaction and hence good practices in waste disposal.
- Data Collection and Analytics: Through smart technologies, waste patterns can be collected to optimize strategies for waste management.
- Adaptability and Scalability: This smart waste bin can be designed to suit different urban applications and can scale up to serve any scope of community, making it quite adaptable.

X. FUTURE WORK

We plan to implement a composting unit to recycle biodegradable waste into fertilizer.

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