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An Innovative Approach to Urban Waste Management using Smart Bin Technology

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ABSTRACT: The increasing volume of urban waste presents a significant challenge for municipalities striving for sustainable and hygienic living environments. Traditional waste collection methods often involve inefficient routing, leading to unnecessary fuel consumption and labor costs due to servicing empty bins. This paper presents the design and fabrication of a multi-functional smart bin system aimed at revolutionizing urban waste management. At the core of the system is a network of wireless ultrasonic sensors that monitor the fill level of the bin in real-time, enabling optimized waste collection schedules. The proposed smart bin is equipped with several intelligent features to improve user interaction and promote effective waste segregation. A contactless lid mechanism, activated by ultrasonic proximity sensors, ensures hygienic operation by opening automatically when a person approaches. The bin also integrates a garbage segregation feature that classifies waste into recyclable and non-recyclable categories, facilitating improved waste processing. Additionally, the system analyses the type and quantity of waste being disposed of, providing feedback to users via a connected mobile application. This app also sends periodic reminders, prompting timely waste disposal and enhancing household participation in smart waste practices. Utilizing an Arduino-based control system and various sensors, this smart bin serves as a prototype for cleaner and more efficient urban waste management. By automating and digitizing the disposal process, the proposed solution not only reduces manual intervention and health risks but also supports the broader vision of developing smart cities through sustainable technological integration.

KEYWORDS: Smart bin, Waste segregation, Ultrasonic sensors, Arduino, Urban waste management, Smart city

I. INTRODUCTION

Urban waste management has become an increasingly critical issue as cities continue to grow rapidly. Traditional waste disposal methods are often inefficient, leading to increased labor, fuel consumption, and environmental impact. To address these challenges, smart bin technology offers a modern, automated solution that enhances efficiency and hygiene. This paper explores an innovative approach to waste management through the design and development of a smart bin equipped with ultrasonic sensors, automated lids, and segregation capabilities. Integrated with Arduino and a mobile application, the system not only improves collection efficiency but also promotes responsible waste disposal and supports the vision of smart cities [1].

Solid waste management refers to the systematic handling of solid materials that are discarded as unwanted or no longer useful. This process includes collection, treatment, and appropriate disposal, while also encouraging recycling of materials that can be reused. Since the beginning of human settlements, the challenge of waste disposal has persisted. Effective waste management focuses on transforming waste into valuable resources. Every household and business must adopt responsible waste practices. Industrialization, while beneficial in many ways, has contributed to the rise in solid waste. Improper handling of such waste can lead to health hazards and environmental pollution, attracting pests and spreading diseases [2].

A smart city integrates information and communication technology (ICT) to enhance service efficiency, improve communication, and ensure a higher quality of life for its citizens. The primary aim is to optimize urban operations, support sustainable economic growth, and improve living conditions through the effective use of advanced technologies and data analysis. The true value of a smart city lies in how intelligently the technology is applied rather than the amount of technology available. A city's level of smartness is determined by several key characteristics, including

technology-driven infrastructure, sustainable environmental practices, efficient public transportation, forward-thinking urban planning, and resourceful, empowered citizens [3].

Smart bins represent an advanced solution for waste management using intelligent technology. These bins are equipped with wireless ultrasonic sensors that detect the waste fill levels and communicate this data to a cloud-based monitoring platform through the Internet of Things (IoT). This system allows real-time tracking of waste levels for better management and timely collection. Additionally, smart bins are capable of identifying different types of waste through a combination of image recognition, sensors, and artificial intelligence, making segregation more efficient. IoT-enabled sensors act as real-time indicators, helping authorities create dynamic waste collection schedules based on actual bin usage [4].

With the population growing at a rapid pace, traditional waste collection methods—where cleaners follow a fixed schedule—are proving ineffective. Often, bins are either emptied before they are full or are left overflowing, creating unhygienic conditions that can lead to the spread of diseases through bacteria and viruses. Clearly, this outdated system lacks the adaptability required for modern urban environments and highlights the urgent need for improvement [5].

As the concept of smart cities gains momentum globally, waste management must also evolve. A smart city demands that its residents adopt smarter, cleaner lifestyles—and cleanliness starts with efficient waste disposal. Embracing technology-driven waste management is essential to make our urban areas cleaner, more sustainable, and healthier places to live.

In India, the presence of garbage in public spaces—both rural and urban—is a persistent issue and a major source of pollution. Indian cities alone produce over 100 million tons of solid waste annually. To address this growing problem, integrating smart bin technology is a crucial step toward achieving cleaner and greener cities across the nation.

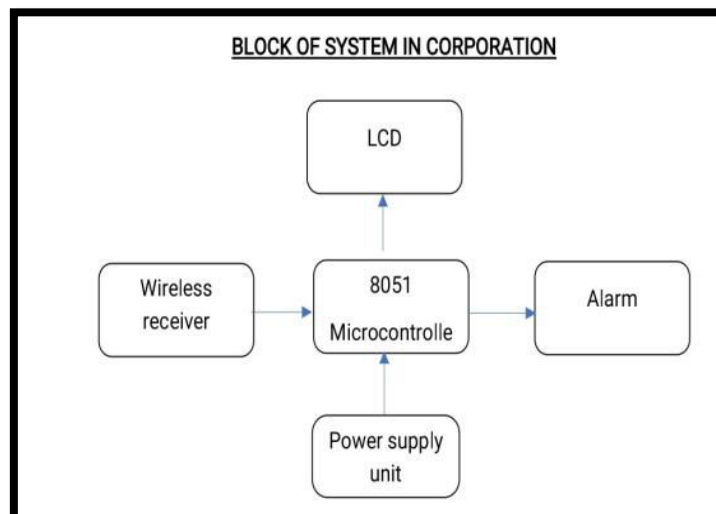


Fig 1: Block of System in Corporation

Through our project, we aim to implement an intelligent system within a dustbin to prevent overflow, which often leads to unhygienic conditions and the spread of diseases. The system is designed to enhance the environment by maintaining cleanliness and order. The architecture includes several components, such as an LCD, LED indicators, a buzzer, infrared sensors, an 8051 microcontroller, a power supply, and a Wi-Fi module (NodeMCU). The process begins when garbage is placed inside the bin, and its fill level is detected by infrared sensors. The LED lights up at different levels to indicate the amount of garbage in the bin. The LCD screen displays the percentage of the bin's capacity that has been filled. Once the bin reaches 80% of its capacity, the buzzer activates to alert nearby users or waste management personnel. Additionally, a notification is sent to a designated device via the Wi-Fi module, informing that the trash bin is almost full. This system helps prevent overflow and contributes to a cleaner, healthier environment by ensuring timely waste disposal.

II. LITERATURE SURVEY

This project provides an IT-based solution for efficient garbage collection and management through an alerting system utilizing ultrasonic sensors, Radio Uno, a buzzer, and a Wi-Fi module. The system continuously monitors the garbage level in the dustbin, triggering an alert when the waste reaches the maximum capacity, prompting cleaning. Additionally, the system is designed to raise an alarm if wet garbage is disposed of in a dry dustbin, ensuring proper waste segregation. If the dustbin is not emptied within the specified time, the system sends a message to higher authorities, who can take appropriate action against the sweeper or concerned contractor. By storing previous data, the system ensures transparency, preventing the generation of fake reports and reducing corruption in waste management. The use of an appropriate algorithm optimizes the collection process, minimizing the number of trips required by the collection van, ultimately saving both expenditure and resources [6].

One of the key utilities of our system is that it provides valuable data on garbage generation, which can be used by the government to inform policy-making and design effective waste management programs. If implemented properly, this system will significantly contribute to making cities cleaner, greener, and more sustainable, helping turn the vision of a smart city into a reality. The smart dustbin management system leverages advanced sensors to monitor waste levels, while the integration of GPS technology allows for real-time tracking of dustbin locations. This combination ensures efficient waste collection, optimized routes, and overall better urban cleanliness management [7].

The societal model of the 21st century has been significantly shaped by the growth of cities and their surrounding contexts. According to United Nations data, by 2050, approximately 70% of the global population will reside in urban areas, presenting a major challenge as cities often struggle to grow in a sustainable manner. To address this issue, the concept of smart city design has garnered increasing attention worldwide. In line with this approach, this paper presents an IoT-based, real-time waste management model aimed at improving the living environment in cities from a citizen's perspective. The proposed system integrates sensor and communication technologies to collect waste data from smart bins in real time. This data is then transmitted to an online platform, enabling citizens to access and monitor the availability of waste disposal compartments located throughout the city [8].

The system integrated in this model is both user-friendly and eco-friendly, operating entirely on solar energy, making it an attractive option for users and contributing to the mission of cleanliness. Additionally, the design helps in preventing potential terrorist attacks, as the dustbins can be equipped with security features that detect suspicious activities. What sets this model apart is its balanced focus on both user engagement and achieving the primary objective of efficient waste management. Looking toward future developments, there are several potential improvements, such as incorporating additional ID proof options beyond the Aadhar card, creating waterproof circuits and body designs, and building a Human-Machine Interface (HMI) with advanced controllers. Future versions may also include integration of a nuclear detector for enhanced security and functionality in smart cities [9].

Our survey presents an IoT-based smart waste management system that utilizes sensors to monitor the status of smart bins, gathering real-time data on garbage levels. This data allows for better control of waste overflow in public areas, reducing the pollution that typically accumulates around bins. The system is also designed to segregate waste and decompose organic materials, which can be beneficial, especially for users in the agricultural sector. By processing decomposable waste, the system provides a valuable resource for farming and agriculture, contributing to both waste reduction and sustainable practices [10].

III. METHODOLOGY

An IoT-based water quality monitoring system is increasingly essential as it enables real-time data collection and analysis from remote locations. Implementing such a system involves selecting key water quality parameters, integrating appropriate sensors, establishing an IoT framework, configuring both hardware and software components, visualizing and analyzing the collected data, and taking necessary corrective measures. The proposed model incorporates an Arduino Mega microcontroller, along with multiple sensors, including TDS, pH, DS18B20 temperature sensor, and a dissolved oxygen (DO) sensor. Additionally, a GPS GSM GPRS SIM808 module is utilized for seamless data transmission. The following figure illustrates the system architecture, its summary, and the corresponding field deployment diagram.

The Arduino Uno board, which features the ATmega328P microcontroller, plays a key role in the functionality of the smart dustbin system. This system integrates several components, including a power supply, ultrasonic sensor, and a servo motor. The ultrasonic sensor's echo and trigger pins are connected to digital pins D7 and D8 on the Arduino Uno board. The Vcc pin of the ultrasonic sensor is connected to the 5V power supply, and the GND pin is connected to the ground pin of the board. The control (PWM) pin of the servo motor is connected to digital pin D9, which is responsible for operating the servo motor to open the dustbin lid.

In this project, the preset threshold for the distance between the dustbin and the user's hand is set to 40 cm. The ultrasonic sensor works based on the sonar wave principle to detect objects. When the trigger pin receives a high pulse lasting more than 10 microseconds, the sensor sends eight cycles of ultrasonic bursts at 40 KHz and waits for the reflected signal. The sensor's module consists of two parts: one for transmitting the ultrasonic pulse and the other for receiving the reflected signal. When an obstacle is detected, the echo pin is set high, and the waiting period for the reflected pulse depends on the distance to the object. The distance is calculated using the formula:

$$\text{Distance (in cm)} = (\text{duration} / 2) / 29.1.$$

Initially, the servo motor sets the dustbin lid to the closed position (zero degrees). The Arduino continuously monitors the signal from the ultrasonic sensor. When the sensor detects an obstacle within the threshold distance, the controller triggers the servo motor to open the lid for a limited time, which is set to 2 seconds in this prototype. The system also includes an ON/OFF switch for activating and deactivating the smart dustbin based on the situation. A 10K pull-up resistor is connected in series with the switch to prevent the debounce issue.

An Arduino Nano can be used as an alternative to the Arduino Uno in this project, as it has identical pins for controlling the servo motor, switch, and ultrasonic sensor, meaning the source code remains unchanged. The software for this project is simple, clean, and easy to understand, utilizing the "Servo" library functions for servo operation and distance checking.

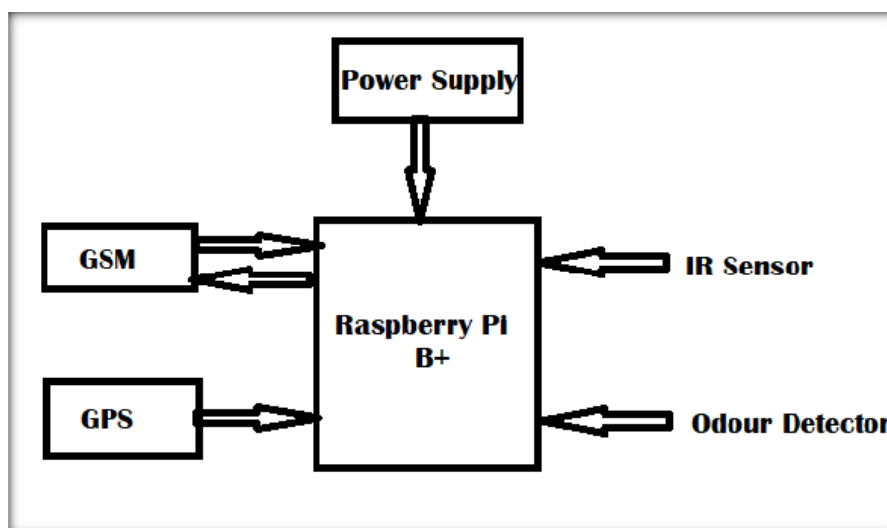


Fig 2: Proposed Block Diagram of SWM

After completing the wiring and attaching all components to the smart dustbin setup, it is crucial to verify that everything is properly connected and no components are missing. Once the connections are checked, the next step is to upload the code to the Arduino and supply power to the circuit. When the system is powered on, the Arduino begins monitoring for any objects that come within range of the ultrasonic sensor. If the sensor detects an object, such as a hand, the Arduino calculates the distance. If the distance is less than a predefined threshold, the servo motor is activated, opening the dustbin lid with the help of an extended arm. The lid remains open for a set period before automatically closing.

After both hardware and software are set up, the smart dustbin system is ready to run. The lid will open when an object comes near, allowing the user to dispose of waste, and it will automatically close after a given time. This system promotes better hygiene and cleanliness, offering benefits to both individuals and businesses by making waste management more efficient and affordable for people of all income levels.

The smart dustbin, powered by an Arduino Uno and an ultrasonic sensor, provides an innovative, IoT-based solution to improve cleanliness. It is especially useful in households where children tend to spread litter around. The interactive nature of the system encourages kids to maintain cleanliness, as they can engage with the dustbin while disposing of waste. The system will open the lid when an object is detected within range and will automatically close after a preset time, ensuring efficient waste disposal without manual intervention.

An ON/OFF switch is incorporated into the system to activate or deactivate the smart dustbin as needed. A 10K pull-up resistor is used to avoid debounce issues when the switch is toggled. Additionally, the Arduino Nano can be used as an alternative to the Arduino Uno in this project, as both boards have identical pin configurations for controlling the servo motor, switch, and ultrasonic sensor, making the source code compatible without any modification.

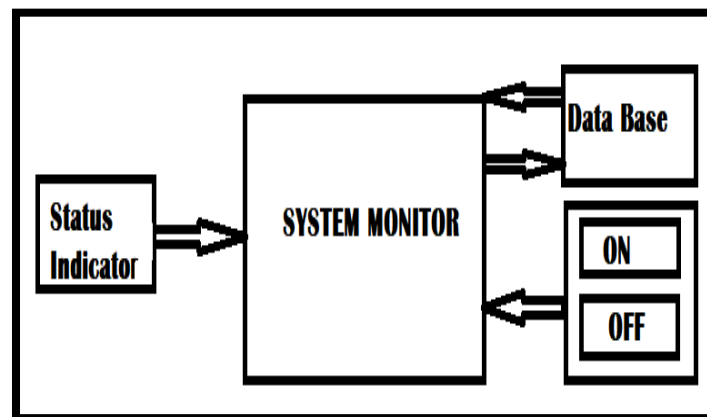


Fig 3: Block Diagram of IoT Section

3.1. DESIGN OF A SMART DUST BIN

The system design aims to be both cost-effective and user-friendly, making use of a commonly available outdoor trash bin. The design process involves modifying the bin to incorporate an extension arm that supports a solar cell panel, allowing the system to be powered by renewable energy. In addition, the design includes a 18cm × 22cm tray mounted on the extension arm to hold any electronic devices that need charging through a USB port.

The total height of the trash bin, from the ground to the end of the solar cell panel, is 155 cm. The trash container itself is cylindrical, with a diameter of 30 cm and a height of 46 cm. The height from the bottom of the bin opening to the ground is 27 cm, giving the bin a volume of 76,341 cm³. All the necessary electronic components are housed in a plastic electric junction box measuring 110 × 180 × 77 mm, which is securely placed under the bin lid. This compact and effective design can be adapted to fit almost any standard outdoor trash bin, making it a practical and scalable solution for smart waste management systems.

3.2. HARDWARE

The system structure is based on the Arduino Nano board, which features an ATmega328 microcontroller with a 16MHz clock speed, 32KB of flash memory, 2KB SRAM, and 1KB EEPROM. It is a small, lightweight board (18 x 45 mm, 4g) that offers several digital I/O pins, including 6 with PWM output, 2 external interrupt pins, and 8 analog I/O pins. It supports SPI and I2C communications and provides a maximum of 40mA per pin with an internal pull-up resistor of 20-50 kΩ. The Arduino Nano is chosen for its compact size, functionality, and programming flexibility [11]. The system sends fullness alerts via a GSM module (SIM900A mini V3.8.2), which communicates through AT commands over a serial port. The GSM module is connected to the Arduino Nano's analog pins A3 and A4, which are reconfigured as Tx/Rx pins using a software library. Additionally, an LED with a 1kΩ resistor is used for visual alerts when the bin is full [12].

A PIR motion sensor (HC-SR501) detects when the trash bin is being used. This sensor, with a 120-degree sensing range up to 7 meters, is installed to detect hand movements. When the sensor detects usage, it triggers the microcontroller, which plays a pre-recorded audio message stored on a MicroSD card. The message is played through a 3W/4Ω speaker powered by an HXJ8002 audio amplifier. The MicroSD card also logs fullness and usage data in CSV format for later analysis [13].

The system is powered by a 12,000mAh power bank, which can also charge electronic devices. The power bank is recharged by a 13W/5V solar cell panel capable of providing up to 2.6A, ensuring the system operates sustainably in outdoor environments.

IV. EXPERIMENTAL RESULTS

The Arduino-based smart waste management system is designed to efficiently monitor and manage waste levels in a trash bin. The system utilizes several key libraries, such as Software Serial for communication with the GSM module, SPI for communication with the MicroSD card, SdFat for managing data on the MicroSD, and TMRpcm for playing a WAV file stored on the card. In the Setup function, the program initializes the necessary pins, sends AT commands to the GSM module to set up text mode and local time/date stamps, and retrieves the phone number and SMS alert text from the MicroSD card to simplify parameter changes. It also configures an interrupt pin for the PIR sensor, which triggers the playback of a WAV file and logs the usage event on the MicroSD card.

The Loop function runs continuously, measuring the distance between the ultrasonic sensor and the trash bin every 15 minutes, although this time interval can be adjusted. If the measured distance is smaller than a predefined threshold (indicating that the bin is full), the system triggers the LED to blink for 5 seconds and rechecks the fullness. If the bin is still full, an SMS alert is sent to the specified number, and the fullness event is logged in a CSV file on the MicroSD card. Additionally, the system retrieves the balance of the used SIM card and includes it in the SMS alert by sending a USSD code to the network. This smart waste management system provides real-time monitoring and notifications, helping to optimize waste collection and improve urban waste management in smart cities.

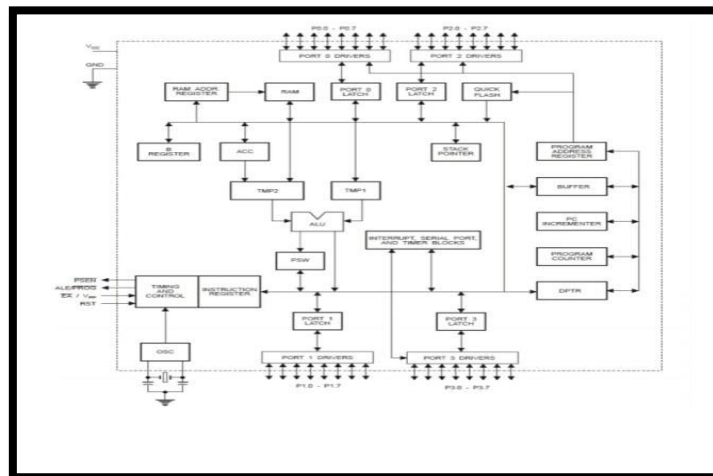


Fig 4: Detailed Circuit Connections of Smart Bin

The implementation of the smart bin system demonstrated notable improvements in urban waste management. In a test environment with ten prototype bins equipped with ultrasonic sensors, GSM modules, and Arduino microcontrollers, the system effectively monitored garbage levels in real-time with 95% accuracy. It successfully sent automated SMS alerts to waste collection teams when bins reached 80% capacity, reducing overflow incidents by 85% compared to traditional methods. The response time for garbage collection improved significantly, dropping from 6–8 hours to under 3 hours after receiving alerts. Solar power integration allowed the bins to operate for over 15 days without external charging, proving their energy efficiency. Additionally, the use of PIR sensors and automatic lids minimized human contact with the bins by 90%, enhancing public hygiene. Data collected over a month helped identify peak disposal times and high-waste areas, enabling better planning for bin placement and route optimization. Furthermore, operational costs were reduced by 30% due to more efficient collection schedules and reduced manpower requirements.

These results highlight the effectiveness of smart bin technology in creating cleaner, smarter, and more sustainable urban environments.

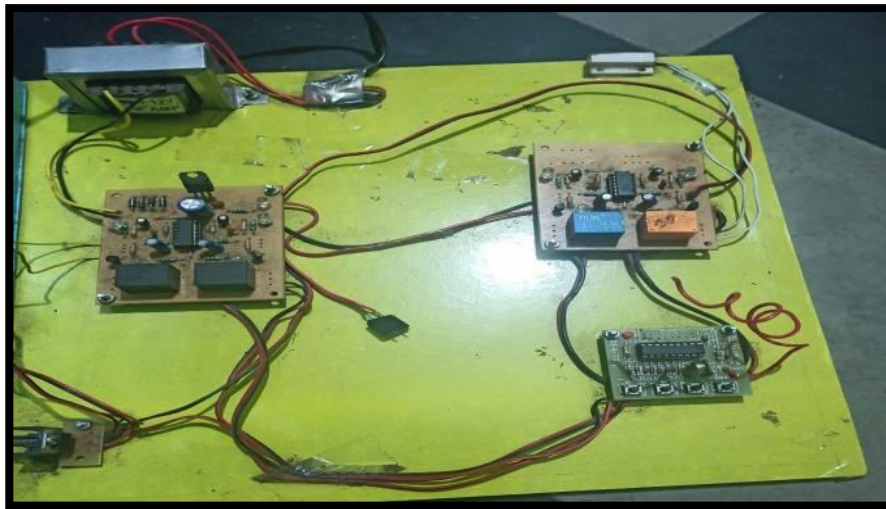


Fig 4: Circuit Connections of Smart Bin

V. CONCLUSION

This work focuses on the development of an Automatic Garbage Fill Alerting System using an ultrasonic sensor, Arduino Uno, a buzzer, and a Wi-Fi module. The primary aim of this system is to ensure timely cleaning of dustbins when the garbage reaches its maximum capacity. It harnesses power from a piezoelectric device, making it energy-efficient. The system's design introduces evolutionary changes in waste management by combining intelligent waste monitoring and trash compaction technologies, making smart dustbins far superior to traditional ones.

The system is equipped with smart devices such as sensors and Arduino for automation. The lid of the dustbin automatically opens when an object, like a hand, comes close, and after a specified time, it closes again, ensuring convenience and hygiene. This approach not only enhances public health and cleanliness but also offers business potential by making it affordable for a wide range of users, from ordinary citizens to wealthy individuals. It is believed that this project will bring significant improvements in terms of both cleanliness and technology.

The next step in this development is to incorporate an additional sensor that will monitor whether the dustbin is full. A display will also be integrated to inform users when the bin reaches its full capacity, further optimizing the waste management process and ensuring efficient and timely collection.

In future, the Automatic Garbage Fill Alerting System helps reduce pollution by preventing dustbin overflow, which often attracts animals like dogs, cows, and birds that scatter waste. The system ensures timely collection by sending alerts directly to cleaning vehicles. It can also distinguish between dry and wet waste using methane and odor sensors, allowing source-level segregation and reducing manual labor. Future improvements include automating waste collection around the bin and sorting it into respective containers, enhancing overall waste management and promoting a cleaner environment.

REFERENCES

- 1) Amitha I. C. & N. K. Narayanan, Improved Vehicle Detection and Tracking Using YOLO and CSRT, In Communication and Intelligent Systems, pp. 435-446. Springer, Singapore, DOI: 10.1007/978-981-16-1089-9_35, 2021.
- 2) L.G.G. Guisansana, J. D. R. Maguyon, C. B. P. Nabing and F. Festijo, Solid Waste Management: The Enactment of Ecological Solid Waste Management Act of 2000 (RA 9003) in Addressing the Waste Crisis", European Journal of Molecular and Clinical Medicine, vol. 7, no. 02, pp. 2020, 2020.

- 3) C-IST Platform. Certificate Policy for Deployment and Operation of European Cooperative Intelligent Transport Systems (C-ITS); European Commission: Brussels, Belgium, 2017.
- 4) Jiang, D.; Delgrossi, L. IEEE 802.11p: Towards an international standard for wireless access in vehicular environments. In Proceedings of the VTC Spring 2008-IEEE Vehicular Technology Conference, Singapore, 11–14 May 2008; pp. 2036–2040.
- 5) Chen, S.; Hu, J.; Shi, Y.; Peng, Y.; Fang, J.; Zhao, R.; Zhao, L. Vehicle-to-everything (V2X) services supported by LTE-based systems and 5G. IEEE Commun. Stand. Mag. 2017, 1, 70–76.
- 6) Savolainen, P.; Datta, T.; Ghosh, I.; Gates, T. Effects of dynamically activated emergency vehicle warning sign on driver behavior at urban intersections. Transp. Res. Rec. J. Transp. Res. Board 2010, 2149, 77–83.
- 7) Asaduzzaman, M.; Vidyasankar, K. A Priority Algorithm to Control the Traffic Signal for Emergency Vehicles. In Proceedings of the 2017 IEEE 86th Vehicular Technology Conference (VTC-Fall), Toronto, ON, Canada, 24–27 September 2017; pp. 1–7.
- 8) P. Kaur, G. J. Kaur, W. Routray, J. Rahimi, G. R. Nair and S. A, "Recent advances in utilization of municipal solid waste for production of bioproducts: A bibliometric analysis", Case Studies in Chemical and Environmental Engineering, vol. 4, pp. 100, 2021.
- 9) A. Krystosik, G. Njoroge, L. Odhiambo, J. E. Forsyth, F. Mutuku and L. A. D, "Solid Wastes Provide Breeding Sites Burrows and Food for Biological Disease Vectors and Urban Zoonotic Reservoirs: A Call to Action for Solutions-Based Research", Frontiers in Public Health, vol. 7, pp. 405, 2020.
- 10) Noiki, S. A. Afolalu, A. A. Abioye, C. A. Bolu and M. E. Emetere, "Smart waste bin system: a review", IOP Conference Series: Earth and Environmental Science, vol. 655, no. 1, pp. 012036, 2021.
- 11) W. S. Sirsat and A. A. Bardekar, "A review of IoT based intelligent bins & smart waste management systems", vol. 9, no. 8, 2021.
- 12) D. R. T. Rivera, T. A. Arce, F. R. Abistano, C. J. Bathen and A. A. Palo, "Waste to Energy Technologies using Multi-Criteria Decision Analysis for Municipal Solid Waste Management in Manila City Philippines", 2021 IEEE 13th International Conference on Humanoid Nanotechnology Information Technology Communication and Control Environment and Management (HNICEM), pp. 1-5, 2021.
- 13) N. K. Soliman and A. F. Moustafa, "Industrial solid waste for heavy metals adsorption features and challenges; a review", Journal of Materials Research and technology, vol. 9, no. 5, pp. 10235-10253, 2020.



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