

# Smart Waste Management

Dnyaneshwar Kanade<sup>1</sup>, Aniket More<sup>2</sup>, Nilesh Binnar<sup>3</sup>, Paridhi Narnaware<sup>4</sup>, Atharv Narote<sup>5</sup> and Niraj Patil<sup>6</sup>  
<sup>1-6</sup>Vishwakarma Institute of Technology (<sup>1</sup>Department of Multidisciplinary Engineering, Department of Computer Engineering), Pune, India

Email: dnyaneshwar.kanade@vit.edu, aniket.more21@vit.edu, binnar.nilesh21@vit.edu, paridhi.narnaware21@vit.edu, atharv.narote21@vit.edu, niraj.patil21@vit.edu

**Abstract—** It is the responsibility of every individual to ensure the cleanliness and sustainability of the environment. We have created a waste management model that utilizes various sensors such as soil moisture sensors, ultrasonic sensors, and inductive proximity sensors, along with a conveyor belt, to automate the process of waste segregation. The ultrasonic sensor is used to detect dry waste based on its distance from the sensor, while the soil moisture sensor is employed to identify wet waste by measuring the moisture content in the waste. The inductive proximity sensor plays a crucial role in identifying metal waste by detecting any metallic objects present in the waste stream.

The entire system is designed to streamline the waste separation process, thereby minimizing the need for manual sorting and enhancing overall efficiency. By integrating these sensors with the conveyor belt mechanism, the system enables real-time waste detection and segregation, thereby optimizing waste management operations. The proposed intelligent waste management system offers numerous advantages, including enhanced precision in waste categorization, reduced human errors, increased efficiency in waste collection, and the potential for recycling and resource recovery.

**Index Terms—** IOT, Actuator, Arduino, Proximity Sensor, Conveyer Belt, Ultrasonic Sensor, Moisture Sensor

## I. INTRODUCTION

Waste segregation stands as a critical step within the broader scope of effective waste management strategies. This intricate process involves the careful division of various waste materials, ultimately paving the way for their appropriate disposal, potential recycling, and the recovery of valuable resources. Leveraging cutting-edge technologies, including moisture sensors, inductive proximity sensors, ultrasonic sensors, conveyor belts, and servo motors, can significantly elevate the efficiency and precision of waste segregation operations.

The incorporation of moisture sensors into the waste management system proves to be instrumental in discerning between wet and dry waste types, primarily based on their distinct moisture levels. This capability holds particular significance in distinguishing organic waste, typically characterized by its high moisture content, from dry materials like paper, plastics, and metals. In parallel, the adept utilization of inductive proximity sensors plays a crucial role in swiftly identifying any metallic objects present within the waste stream. This capacity is pivotal in isolating metallic materials for subsequent and separate recycling processes.

Complementing these functions, ultrasonic sensors emerge as indispensable tools for precisely gauging the size

and structure of individual waste items. By accurately measuring the distance to each object on the conveyor belt, these sensors furnish crucial data that informs subsequent sorting and handling requirements. This streamlined approach to waste management not only enhances the efficiency of the segregation process but also significantly minimizes potential disruptions that may arise during waste sorting operations.

The core infrastructure of the waste segregation system revolves around the integration of a conveyor belt network. This foundational element serves as the primary conduit for transporting waste materials across various stages of the segregation process. By ensuring a consistent and controlled flow of waste materials, the conveyor belt system effectively facilitates the seamless detection and sorting of waste materials by the network of integrated sensors. The coordinated operation of servo motors, regulated by the system, drives the precise actuation of diverter mechanisms strategically positioned along the conveyor belt. These mechanisms play a critical role in guiding the waste items into designated sections or containers based on the outputs received from the network of sensors.

Through the symbiotic integration of these advanced technologies, the process of waste segregation is seamlessly transformed into a fully automated and streamlined operation. The unified efforts of sensors, conveyor belts, and servo motors culminate in the accurate identification and efficient diversion of waste materials into their respective and appropriate categories. This integrated approach not only fosters effective waste recycling and composting but also ensures the optimal and sustainable disposal of waste materials, thereby contributing to the overall goal of promoting a cleaner and more sustainable environment.

### II. LITERATURE SURVEY

After a comprehensive review of multiple research papers pertaining to smart waste segregation, the following insightful findings have emerged:

The first research paper [1] introduces an automatic segregator system proficient in distinguishing and separately storing dry and wet waste. The control mechanism relies on the Raspberry Pi 3, with the moisture sensor and raindrop sensor serving as the primary modules. The actuator segment incorporates direct DC motors and servo motors. Notably, the AWS (Automatic Waste Segregator) system seamlessly integrates as an integral part of a smart bin, thereby enhancing the bin's functionality with an additional layer of intelligent waste management capabilities.

The second paper [2] proposes a system designed for segregating dry waste, general waste, and metallic waste within a smart dustbin setup. To achieve this, the researchers utilize a metal detector, infrared sensor, and moisture sensor. This system is specifically engineered to ensure the timely cleaning of dustbins once the threshold level for dry or metallic waste is reached, thereby maintaining the cleanliness and efficiency of the waste disposal process.

The third research [3] focuses on the development of an automatic segregator bin capable of sorting waste at the source, thereby streamlining the overall waste processing time and reducing the complexity associated with segregating significant volumes of waste during subsequent stages. The components integrated within this system include ARM7, IR sensor, rain sensor, metal sensor, GSM technology, LCD display, ultrasonic sensor, DC motor, and robotic arm, showcasing a comprehensive approach towards waste management automation.

In the fourth paper [4], the emphasis is placed on an IoT-enabled waste segregator engineered to efficiently categorize municipal waste into biodegradable and non-biodegradable segments. Equipped with an IR sensor, moisture sensor, and metal sensor, this smart waste segregator effectively identifies and separates metal waste, wet waste, and dry waste. The integration of three DC motors with the conveyor belt is instrumental in facilitating the seamless movement of waste across the system's surface, thereby optimizing the waste segregation process.

The cumulative insights from these research papers underscore the progressive developments in the field of smart waste management, highlighting the integration of advanced technologies to streamline and enhance waste segregation processes for a more sustainable and efficient waste management ecosystem.

### III. SYSTEM ARCHITECTURE

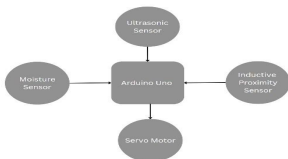


Figure 1 System Architecture

#### IV. FLOW CHART

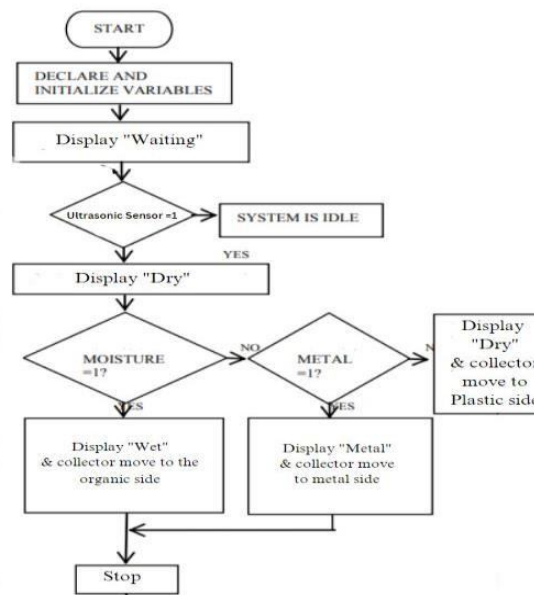


Figure 2 Flow Chart

#### V. METHODOLOGY

The initial step in establishing an effective waste segregation process involves the setup of a meticulously arranged conveyor belt system. This system comprises distinct sections dedicated to waste input, sensor detection, and waste segregation. Strategically positioning the moisture sensor, inductive proximity sensor, and ultrasonic sensor along the conveyor belt, these sensors are seamlessly integrated into a centralized control system, which governs the sensor readings and orchestrates the precise functioning of the servo motor.

Each sensor undergoes a meticulous calibration process to ensure accurate and reliable readings. Fine-tuning the sensitivity and thresholds of the moisture sensor, inductive proximity sensor, and ultrasonic sensor is essential to align with the diverse characteristics of the waste and specific segregation requirements.

Once the waste is introduced onto the conveyor belt system, it is set into motion along the designated pathway for comprehensive sorting.

##### A. Moisture Sensing

During the transit of waste along the conveyor belt, the moisture sensor diligently measures the moisture content. Based on predetermined moisture thresholds, the control system swiftly ascertains whether the waste is categorized as dry or wet.

##### B. Inductive Proximity Sensing

The inductive proximity sensor efficiently detects any metallic objects present within the waste stream as they pass through. In the event of metal detection, the control system promptly triggers the servo motor, diverting the waste into a dedicated container intended for metal waste collection.

##### C. Ultrasonic Sensing

The ultrasonic sensor contributes by gauging the distance, thereby providing crucial insights into the size and shape of the waste items as they traverse the conveyor belt. This valuable data aids in determining subsequent sorting or handling requirements to streamline the segregation process.

Based on the output generated by the sensors, the control system commands the servo motor to initiate the precise actuation of the conveyor belt diverter mechanisms. For instance, upon detecting wet waste, the servo motor

seamlessly repositions the diverter, redirecting the waste into a specified section or container reserved for wet waste. Correspondingly, dry waste is guided towards a separate section or container, whereas metallic waste is channeled into an exclusive collection area designated for metals.

Following the successful segregation of waste, the respective waste categories are collected from their designated sections or containers for subsequent processing or disposal. Dry waste may be channeled for recycling or landfill purposes, wet waste for composting or anaerobic digestion, and metals for specialized recycling initiatives. Notably, the Arduino UNO assumes control over all the sensors, the servo motor, and facilitates the seamless acquisition of sensor values, thus ensuring the smooth operation of the waste segregation system.

## VI. TOOLS AND TECHNOLOGY

Different IOT components are used in model making like:

### *A. Arduino UNO*

The Arduino UNO serves as the central control unit, responsible for managing and coordinating the various components within the system. It facilitates the integration of the sensors, interprets their readings, and governs the operation of the servo motor and the conveyor belt. Its programmable interface allows for the implementation of customized algorithms and protocols that optimize the efficiency of the waste segregation process.

### *B. Inductive Proximity Sensor*

The inductive proximity sensor is instrumental in detecting the presence of metallic objects within the waste stream. It operates based on electromagnetic induction principles, enabling the system to identify and segregate metallic waste materials for specialized recycling procedures.

### *C. Ultrasonic Sensor*

Leveraging sound waves, the ultrasonic sensor measures the distance and dimensions of the waste items as they move along the conveyor belt. This data provides crucial insights into the size and shape of the waste materials, facilitating accurate sorting and categorization based on specific parameters and requirements.

### *D. Moisture Sensor*

The moisture sensor plays a vital role in assessing the moisture content of the waste materials. By accurately measuring the moisture levels, the sensor enables the system to differentiate between wet and dry waste, streamlining the segregation process and facilitating appropriate disposal or recycling methods for each waste category.

### *E. Conveyor Belt*

The conveyor belt serves as the primary transportation medium for the waste materials throughout the segregation process. Its robust and controlled movement mechanism ensures the smooth and continuous flow of waste items, enabling efficient detection and sorting by the integrated sensors and actuator components.

### *F. Servo Motor*

The servo motor is responsible for actuating the diverter mechanisms along the conveyor belt. Controlled by the Arduino UNO, the servo motor precisely redirects the waste materials into designated sections or containers based on the sensor outputs, facilitating the systematic segregation of different waste categories with optimal accuracy and efficiency.

### *G. 9V Volt Battery*

The 9V volt battery serves as a reliable power source for the IoT-based waste segregation system. It provides the necessary electrical energy required to drive the various components, ensuring uninterrupted and efficient operation throughout the waste segregation process. The consistent power supply from the battery guarantees the seamless functioning of the system, enabling it to carry out its waste management tasks effectively and reliably.

## VII. LIMITATIONS

Implementing advanced sensor technologies, IoT devices, and the necessary infrastructure for waste management systems can present significant cost challenges, particularly for smaller waste management organizations or regions with limited financial resources. The initial investment required for procuring and installing these sophisticated technologies can serve as a notable barrier, potentially impeding the adoption of efficient waste management practices in such settings. Moreover, the recurrent costs associated with the

maintenance, calibration, and potential upgrades of the sensor systems further contribute to the overall financial burden, posing additional challenges for organizations operating within constrained budgets.

Additionally, the limited range of sensors, particularly those activated only when the garbage is in close proximity, can potentially restrict the overall effectiveness of the waste management system. Such limitations may lead to incomplete or inaccurate data capture, consequently impacting the system's ability to comprehensively monitor and manage waste disposal processes. The constrained sensing range may result in missed or delayed detection of waste, leading to inefficiencies in waste segregation and potential disruptions in the overall waste management workflow.

Furthermore, the consistent power supply requirements of these sensor-based systems present an additional logistical challenge, especially in remote or geographically isolated regions. Providing a continuous and reliable power source in such areas often involves complex and resource-intensive efforts. The installation and maintenance of power infrastructure, including electrical wiring or alternative energy sources such as solar panels or generators, can prove to be logistically demanding and financially burdensome, further complicating the deployment of waste management systems in remote locations.

Addressing these challenges necessitates a multifaceted approach that encompasses the development of cost-effective and energy-efficient sensor technologies, the exploration of sustainable and alternative power solutions, and the implementation of streamlined waste management strategies that align with the specific requirements and constraints of the target regions. Collaborative efforts between governmental organizations, private enterprises, and research institutions can foster the development of innovative solutions tailored to the unique needs of smaller waste management entities, thereby promoting the widespread adoption of efficient and sustainable waste management practices in diverse socioeconomic settings.

## VIII. CONCLUSION

In conclusion, the integration of IoT technology into smart waste management systems represents a transformative step toward enhancing waste segregation practices, particularly in the categorization of dry, wet, and metal waste. By leveraging the capabilities of real-time monitoring, automated segregation processes, and data analytics, these innovative systems offer a multitude of benefits that extend beyond traditional waste management practices.

One of the primary advantages lies in the significant enhancement of overall operational efficiency. The real-time monitoring capabilities enabled by IoT technology facilitate the continuous and precise tracking of waste materials, ensuring timely and accurate segregation into distinct categories. This streamlined approach not only optimizes the utilization of resources but also minimizes operational costs, leading to improved resource management and cost-efficiency for waste management organizations, irrespective of their scale or resources.

Moreover, the implementation of automated segregation processes through IoT-enabled systems fosters a more systematic and reliable approach to waste management. By eliminating the reliance on manual sorting, these systems mitigate the risk of human errors and inconsistencies, thereby ensuring the consistent and accurate categorization of waste materials based on predefined criteria. This, in turn, facilitates a more efficient waste disposal process and supports the adoption of sustainable waste management practices within local communities and larger urban areas.

Furthermore, the integration of data analytics capabilities within smart waste management systems empowers organizations to glean valuable insights into waste generation patterns, trends, and composition. By analyzing this data, waste management entities can make informed decisions and devise targeted strategies to optimize waste management processes, minimize environmental impact, and promote sustainable practices that align with global conservation objectives.

Overall, the incorporation of IoT technology in smart waste management systems not only improves the efficiency and accuracy of waste segregation but also contributes to a more sustainable and environmentally friendly approach to waste management. By embracing these innovative solutions, waste management organizations can effectively address the challenges posed by conventional waste management practices and pave the way for a more sustainable future that prioritizes efficient resource utilization and environmental preservation.

## FUTURE SCOPE

Advanced waste management systems can integrate waste-to-energy technologies. Wet waste, such as food scraps, can be processed through anaerobic digestion to generate biogas, while dry waste and metals can be used in recycling or energy recovery processes. This approach can contribute to renewable energy generation and reduce landfill dependency. Also, robotics can play a crucial role in the separation process. Automated robots equipped

with AI, computer vision, and robotic arms can efficiently sort different types of waste into designated containers, reducing the need for manual labour and enhancing accuracy.

We can put forth sustainable development towards nature and educating the public about the importance of waste segregation and providing incentives for proper waste disposal can significantly enhance the effectiveness of smart waste management systems.

#### ACKNOWLEDGEMENT

We would like to express our deep gratitude to Prof. Dnyaneshwar Kanade sir for his kind direction, ongoing assistance, and inspiring encouragement in getting the project done. We also thank the project coordinators for their advice, constructive criticism, and assistance in setting up the facilities required to complete the project work effectively. Additionally, I want to express my thanks to my team members for their assistance in formatting this work. I also want to express my gratitude to all of my other colleagues for their constructive comments on this research. Finally, I'd want to thank my parents for their help with the research.

#### REFERENCES

- [1] Chander Partap Singh, Manisha, Pao-Ann Hsiung, Shivani Malhotra, "Automatic Waste Segregator as an integral part of Smart Bin for waste management system in a Smart City," IEEE, 2019.
- [2] Mrigank Goel, Amogh Harsh Goyal, Preeti Dhiman, Vikas Deep, Purushottam Sharma, Vinod Kumar Shukla, "Smart Waste Segregator and IoT Based Waste Collection System," IEEE, 2021.
- [3] Deeksha More E.K, Divya S, G Kalyani, Gowthami R, "Automatic Waste Segregator Bin Using Robotic Arm," IEEE, 2018.
- [4] Jeberson Ratna Raj, B. Infant Philo Rajula, R. Tamilbharthi, Senduru Srinivasulu, "An IoT Based Waste Segregator For Recycling Biodegradable And Non-Biodegradable Waste," IEEE, 2020.
- [5] S.I.Shirke, Shubhangi Ithape, Sandhiya Lungase, Madhuri Mohare, "Automation Of Smart Waste Management Using IOT," International Research Journal of Engineering and Technology (IRJET), 2019.
- [6] Girdhar Sarada, Akash Raval, Sohilkhan Pathan, Ritesh Patidar, Rajiv Kumar Gurjwar, "Smart Trash Can Using IoT-International Research Journal of Engineering and Management Studies (IRJEMS)," 2019.
- [7] T. Saminathan, Akash Musipatla, P. Manideep Varma, P. Shahid Khan, G. Mahesh Kumar, "IoT Based Automated Waste Segregator for Efficient Recycling," International Journal of Innovative Technology and Exploring Engineering (IJITEE) - April 2019.
- [8] M.K.Pushpa, Aayushi Gupta, Shariq Mohammed Shaikh, Stuti Jha, Suchitra V, "Microcontroller Waste Automatic Waste Segregator-International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering (IJIREEICE)," 2015.
- [9] Santhosh Kumar B R, Rohit K, Manjunath, Varalakshmi N, Sondarya S Lokeshwari, Sahana D N, "Ecofriendly IOT Based Waste Segregation and Management," 2017 International Conference on Electrical, Electronics, Communication, Computer, and Optimization Techniques (ICEECCOT), 2017.
- [10] Vimali, J. S., "Integration of Multi Access Control System with Door, Device & Location Automation & Remote Network Control," in International Conference for Phoenixes on Emerging Current Trends in Engineering and Management (PECTEAM 2018), 2018.
- [11] Nirmalrani, V., and P. Saktivel, "A Hybrid Access Control Model with Multilevel Authentication and Delegation to Protect the Distributed Resources," Journal of Pure and Applied Microbiology (JPAM) 9 (2015): 595-609.
- [12] Gobinath V, Mary Gladence L, Hari Haran S, Sathiyavathi.R, Maria Anu.V, "Home and Office Automation System-Survey" in 3rd IEEE International Conference On Science, Technology, Engineering Management, 2017.
- [13] Saikumar, P., Bharadwaja, P., & Jabez, J., "Android and Bluetooth Low Energy Device Based Safety System," in 2019 3rd International Conference on Computing Methodologies and Communication (ICCMC), 2019.
- [14] Gowri, S. and Divya, G., "Automation of Garden Tools Monitored Using Mobile Application," in International Conference on Innovation Information in Computing Technologies, 2015.
- [15] Yann Glouche, Arnab Sinha, and Paul Couderc, "A Smart Waste Management with Self-Describing Complex Objects," International Journal on Advances in Intelligent Systems, Vol 8 no1 2, 2015.
- [16] Belal Chowdhury, Morshed U Chowdhury, "RFID-based Real-time Smart Waste Management System," in 2007 Australasian Telecommunication Networks and Applications Conference, 2007.
- [17] Sauro Longhi, Davide Marzioni, Emanuele Alidor, Gianluca Di Bu o, Mario Prist, Massimo Grisostomi, and Matteo Pirro, "Solid Waste Management Architecture using Wireless Sensor Network technology," in Universita Politecnica delle Marche, Dipartimento di Ingegneria dell'Informazione Via BrecceBianche, 2012.
- [18] Shubham Thakker, R. Narayanamoorthi, "Smart and Wireless Waste Management," in IEEE Sponsored 2nd International Conference on Innovations in Information Embedded and Communication Systems, 2015.
- [19] Andrei Borozdukhin, Olga Dolinina, and Vitaly Pechenkin, "Approach to the Garbage Collection in the Smart Clean City Project," in Yuri Gagarin State Technical University of Saratov, Saratov, Russia, 2016.