Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 15, Issue. 1, No.11: 2024
ISSN : **1906-9685**

SMART WASTE MANAGEMENT AND CLASSIFICATION USING IOT

Mrs. Sk. Rahimunnisa1, P. L. M. Sri Satya2, K. Udaya Sree3, M. Jhansi4, R. Bhavana5
1,2,3,4,5 Department of Computer Science and Engineering, Vignan's Institute of Engineering for Women Visakhapatnam, Andhra Pradesh, India

Abstract
This project presents the development of a smart dustbin system. The system integrates ESP8266 microcontroller, ultrasonic sensors, servo motors, and a metal detector sensor. Waste levels in separate compartments are monitored in real-time, enabling efficient waste segregation. Servo motors are controlled remotely via the mobile application to open lids based on waste levels detected by ultrasonic sensors. Additionally, the system employs metal detection to identify metallic objects within the waste stream. User interaction and data visualization are facilitated through a user-friendly mobile application interface, offering convenience and insight into waste management practices. This project aims to provide a comprehensive solution for automated waste segregation and metal detection with seamless mobile app interface.
Keywords: Waste Segregation Automation, NodeMCU ESP8266 Integration, Soil Moisture Sensor, IR Proximity Sensor, NPN Inductive Proximity Sensor ,Servo Motor Control ,UltrasonicFill Level Monitoring,

Introduction

As urban populations continue to grow, the challenge of managing increasing volumes of waste with efficiency and sustainability becomes paramount. Traditional waste management practices, often reliant on manual segregation and collection, are proving inadequate in addressing the environmental and logistical demands of modern urban ecosystems. In response to these challenges, technological innovation offers a promising pathway to revolutionize waste management systems. The Smart Waste Classification System, leveraging the integration of NodeMCU and ESP8266, represents a significant leap forward in this context.

This system is designed to automate the process of waste segregation, a critical step in enhancing the efficiency of recycling operations and minimizing the environmental impact of waste disposal. By categorizing waste into distinct types — wet, dry, and metal — the system ensures that recyclable materials are effectively separated from non- recyclable waste, thereby facilitatingmore efficient recycling processes and reducing the volume of waste sent to landfills. At the core of this system is the NodeMCU microcontroller, integrated with the ESP8266 WiFi module, which serves as the brain of the operation. This setup not only controls the sensory and actuation mechanisms but also enables remote monitoring and management of the waste classification process through IoT connectivity.
In summary, the Smart Waste Classification System epitomizes the integration of smart technology and environmental management, offering a scalable, efficient, and sustainable solution to the challenges of urban waste management. Through the innovative use of NodeMCU and ESP8266, coupled with an array of sensors and actuators, this system sets a new standard in waste management, marking a pivotal step towards achieving cleaner, greener, and smarter cities.

Literature Survey: Smart Waste Classification

Implementation of IoT-Based Waste Classification System (Abudayyeh et al., 2019):

http://doi.org/10.36893/JNAO.2024.V15I1N01.259-263

To develop a smart waste classification system using IoT devices and machine learning algorithms, Performed Integration of sensors, cameras for real-time data collection on wastecomposition and fill levels. Utilized machine learning algorithms to process sensor data andclassify waste into recyclable, organic, and non-recyclable categories.
Deep Learning-Based Framework with Edge Computing (S. Singh et al., 2020):
Deployment of neural networks, such as convolutional neural networks (CNNs), for image recognition and waste item classification. Integrated edge devices for real-time image analysis and classification at waste collection points, minimizing latency and bandwidth usage.

RFID-Enabled Smart Waste Classification System (M. Rahman et al., 2021):
Affixing RFID tags to waste bins for tracking and identification of waste items. Utilization of RFID readers at collection points to capture data on waste type, volume, and disposal frequency.Application of data analytics techniques for waste categorization and actionable insights generation.

Existing Systems
Traditional waste management systems heavily rely on manual sorting and collection processes. However, advancements in technology have led to the development of automated waste sorting systems. These systems utilize conveyor belts, sensors, and robotic arms to sort waste based on predefined criteria such as material type, size, and color. Optical sensors, including infrared (IR) sensors and color sensors, are commonly used in these automated systems to identify different types of materials in the waste stream.
Radio Frequency Identification (RFID) technology has also been integrated into waste management for waste tracking purposes. RFID tags attached to waste bins enable automated tracking of waste movements and fill levels, providing real-time data on waste collection routes and bin capacities
Disadvantages:
- Existing waste sorting systems may struggle with accuracy, especially in distinguishing between complex waste items, leading to occasional misclassifications.
- The initial investment required for implementing automated waste sorting technologies, including sensors and robotic systems, can be substantial, posing financial challenges for some waste management facilities.

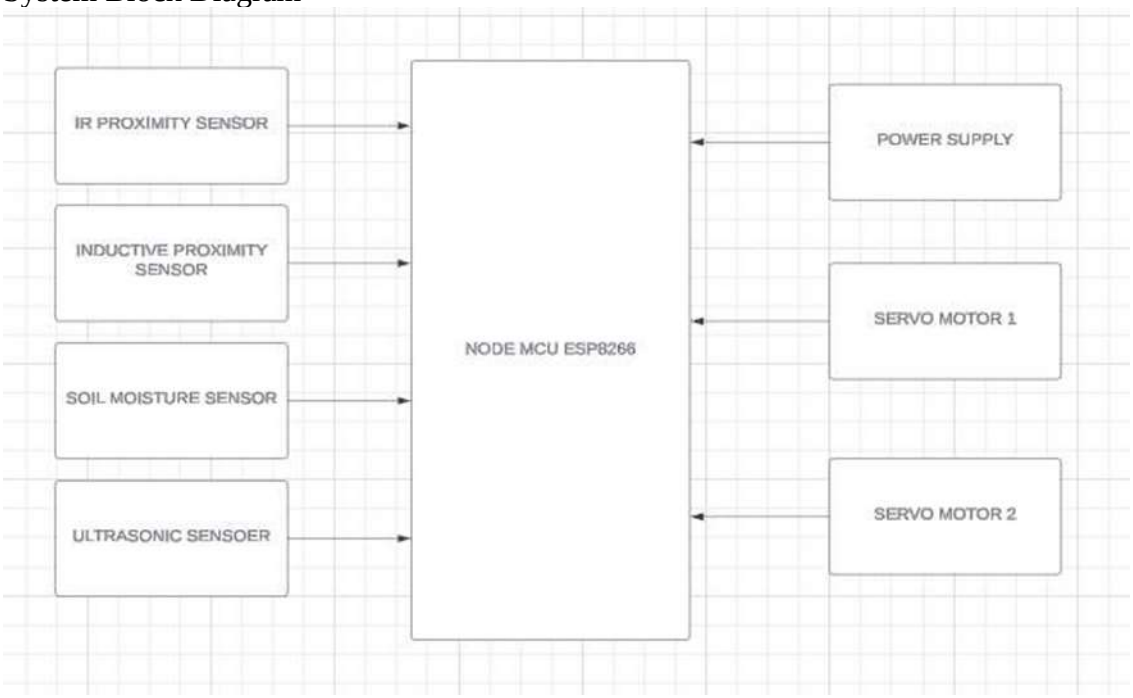
Proposed System:
Our proposed smart waste classification system utilizes embedded systems, specifically NodeMCU ESP8266, along with three sensors for segregating wet waste, dry waste, and measuring the content of each segregation using an ultrasonic sensor.
The NodeMCU ESP8266 serves as the central processing unit, interfacing with the sensors and coordinating the waste classification process. Three sensors are employed: one for detecting wet waste, another for dry waste, and an ultrasonic sensor for measuring the level or content of waste in each segregation. The wet waste sensor is designed to detect moisture levels, distinguishing wet waste from other types based on its moisture content. Similarly, the dry waste sensor identifies dry waste materials, such as paper, plastics, and metals.
The ultrasonic sensor plays a crucial role in measuring the volume or level of waste in each segregation. By emitting ultrasonic waves and measuring the time taken for the waves to bounce back, the sensor can accurately determine the content or fill level of waste in the respective binsor compartments.
Advantages:
- Real-time monitoring and classification of waste types based on moisture content andmaterial composition.
- Accurate measurement of waste contentin each segregation, enabling efficient wastemanagement and optimization of collection processes.

http://doi.org/10.36893/JNAO.2024.V15I1N01.259-263

• Cost-effective and scalable solution, suitable for implementation in various wastemanagement settings.

• Integration with IoT platforms for data visualization, analysis, and remote monitoringcapabilities.

System Block Diagram



Result:

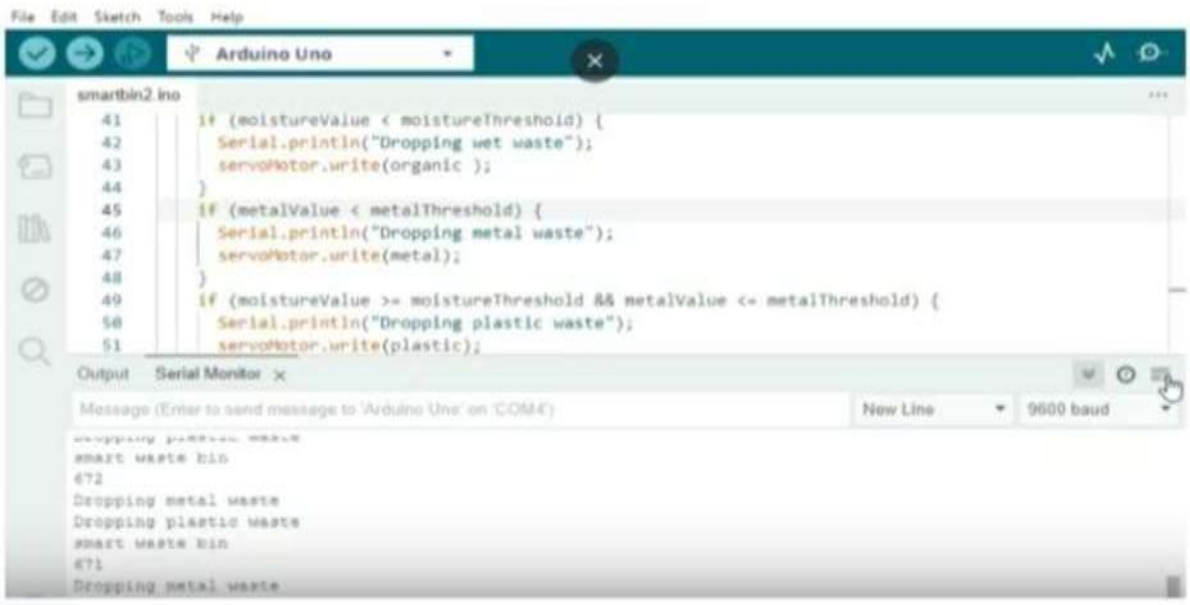


FIG: BLOCK DIAGRAM OF SMART WASTE CLASSIFICATION.

http://doi.org/10.36893/JNAO.2024.V15I1N01.259-263

Fig: Before Seggregating Waste

Fig: After Seggregating Waste

Conclusion:

In conclusion, the smart trash categorization project represents a substantial improvement in waste management technology. The system offers effective segregation of wet and dry trash while correctly measuring waste content through the use of embedded systems, sensors and actuators. This helps to streamline waste management procedures, improve resource usage, and decrease environmental impact. The combination of NodeMCU ESP8266, servo motors, inductive proximity sensors, infrared proximity sensors, soil moisture sensors, ultrasonic sensors, and power sources results in a reliable and customizable system for smart trash sorting. The system's scalability, real- time monitoring capabilities, and data-driven decision-making make it an invaluable resource for waste management facilities looking to increase operational efficiency and sustainability.

http://doi.org/10.36893/JNAO.2024.V15I1N01.259-263

References:

1. Ajayi, O. O., Olaniyan, O. M., & Olojede, A. O. (2020). Design and Implementation of Smart Waste Management System Using IoT. International Journal of Scientific & Technology Research, 9(3), 196-200.
2. Anand, A., Singh, S., & Gautam, N. (2019). IoT-based Smart Waste Management System. International Journal of Computer Applications, 182(14), 14-18.
3. D.V., & Raju, K. V. (2021). Design and Implementation of IoT-Based Smart Waste Management System using Ultrasonic Sensor. International Journal of InnovativeTechnology and Exploring Engineering, 10(6), 156-160.
4. Canzian, L., Bezzi, M., Lodi, M. B., & Montanari, R. (2017). Waste collection optimization through the Internet of Things: A smart city application. In 2017 IEEE International Smart Cities Conference (ISC2) (pp. 1-6). IEEE.
5. Chang, C. H., Lin, C. Y., & Huang, H. Y. (2020). Smart Waste Management System for Environmental Sustainability Using IoT and Machine Learning. Sustainability, 12(8), 3378.
6. Kumar, A., & Singhal, S. (2019). Internet of Things based smart waste management. International Journal of Computer Applications, 181(14), 29-34.
7. Mazhelis, O., Suomi, H., & Tyrväinen, P. (2019). IoT-based waste management solutions: Towards sustainable smart cities. Sustainable Cities and Society, 51, 101732.
8. Verma, A. K., Kumar, M., & Garg, A. (2019). IoT based smart waste management system. International Journal of Engineering & Technology, 8(1.9), 224-228.
9. Wang, L., Li, Y., Ma, C., Yang, Z., & Tang, L. (2020). The Application of Internet of Things in Solid Waste Management. In 2020 7th International Conference on Systems and Informatics (ICSAI) (pp. 379-383). IEEE.
10. Yashaswini, C., & Kiran, H. K. (2020). Smart waste management system using IoT and machine learning. International Journal of Advance Research, Ideas and Innovations in Technology, 6(4), 253- 259.
11. Zhang, S., & Cheng, L. (2020). Research on IoT technology in solid waste management system. In 2020 4th International Conference on Intelligent Transportation Engineering (ICITE) (pp. 642-645). IEEE.
12. Zhu, X., Zhen, X., Ren, W., Wu, Y., & Liu, C. (2019). A novel IoT based solid waste classification system. In 2019 IEEE 5th International Conference on Computer and Communications (ICCC) (pp. 2522-2526). IEEE.