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SMART DUSTBIN USING IOT

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Abstract—This paper presents the design and development of Smart Dustbin System capable to enhance waste management process which is automation and real time monitoring. Over the past few decades, with urbanization growing quickly and population increasing rapidly, there is a strong demand for efficient waste collection systems, while current traditional wise collection systems mainly rely on manual picking inspection and are by fixed schedule. This is where the proposed system plays a role by utilizing sensors and Internet of Things to detect the content level in the bin. A ultrasonic fill level sensor is integrated and a automatic lid gives the possibility of contact less use. When the garbage bin is reached to threshold level, a visual indication displays so while mobile application based wireless telephonic communication is made to related authority. For optimum efficiency a waste compactor is included to maximise bin capacity and minimise the emptying cycle. This anti-dumping autonomous garbage can aims to reduce exposure of humans, and these bins can prevent the excessive contents outflowing to keep smart clean city

I. INTRODUCTION

In modern world,Waste management is one of the imminent problems faced today in urban areas. This is mainly due to urbanization, rise in population and escalation in consumption. Traditional systems for waste collection are time-consuming and require a lot of manual monitoring and inspection. The waste is collected based on tracks from a time to time visit to the place for inspection, but because of these there is risk of bins getting overflown, foul smell and unsanitary conditions,inefficient utilization of machines, etc. Also these systems tend to affect the aesthetic value of an area and highlight health and environmental hazards. Hence such a phenomenon needs a technology based solution for the management of waste.An intelligent approach would be having the facilities based on inter-connected devices with memory, sensors and communication modules to report the data for each unit and the all units in the form of messages for further storage, analysis and water resource utilities systems, etc. The system is an indication on the operations and functioning of intelligent city

II. SURVEY METHODOLOGY

The study sought to assess the present status of solid waste management, operational challenges in traditional disposal, and acceptance of the solution, which involves an IoT-enabled Smart Dustbin by the community. This survey mainly focused on realizing the failures of manual monitoring with scheduled pickups, resulting in overflowing bins, bad odors, and unhygienic conditions, besides measuring the level of interest among users in such automated features as contactless lid operation and real-time filling level alerts. The survey targets a diverse audience, including students, faculties, and janitors who frequently use campus or urban waste infrastructure. From the perspective of ease in data collection, the survey was prestructured and launched using an online surveying tool. The first section was on demographic information, while the following tried to identify existing manual system limitations, operational pain points with a focus on hygiene and collection inefficiency, and feature preference with regard to functionalities such as automated lid control and waste segregation. Most questions were closed-ended, with multiple choice and a fivepoint Likert scale quantifying user perceptions on usability and necessity. This was, however, complemented with open-ended questions seeking qualitative comments on proposed enhancements such as solar power or GPS tracking. It was carried out for a specific period; responses were collected anonymously to ensure that people participated with integrity. A reliable response was also ensured since adequate representation of administrative as well as field staff was hired. Descriptive statistical analysis of the data helped identify the common user pain points and an overall tendency toward embracing smart urban infrastructure. The findings, in particular, helped guide the project, serve the purpose of verifying its problem statement, and thus call for involvement in critical system features such as ultrasonic fill-level detection, moisture-based waste segregation, and automatic cloud notification. Thus, in this regard, during the survey process

III. LITERATURE REVIEW

In contemporary urban spaces, waste management has emerged as an important issue to be addressed with regard to urbanization, population growth, and consumption patterns. Recent literature has emphasized that existing approaches to waste management through waste collection practices often face problems of overflowing bins, unpleasant smells, and unhygienic environments. To cope with such problems associated with waste management, researchers have tried to introduce technology-based solutions to waste management practices through the Internet of Things (IoT) paradigm. Recent studies have often utilized ultrasonic sensors to identify waste level with communication technologies such as Wi-Fi, GSM, or LoRa to send automated notifications to authorities to collect waste on time. It is an important milestone to introduce IoT and sensor technologies to build smart urban spaces

A. Smart Garbage Monitoring System Using IOT

In this study, The recent research on IoT based smart garbage monitoring systems is considered as efficient,practical, affordable,reliable,scalable to be used for large cities, practical for the use of the users1. Various designs are built by various research works, mostly using ultrasonic sensors for sensing the trash due to the affordability, although a few attempt some hybrid models with weight sensors and RFID's for better accuracy, dependability and traceability. The communication methods used in most of the prototype implementations comprises of GSM and GPS indicating the use of location while a few others use Lora and NB-IoT for large city deployments.2 several studies of the literature show that there are some prevalent issues2, which still are common across all the studies sensor accuracy and errors,low battery consumption,communication costs,scaling of the system. many studies lack in the aspect of online deployment which measures and studies the results over a period of time and takes into account the effect on the citizen benefiting from the service and governing authorities3.

In addition, the schematics shown in the literature take into account hybrid sensing approaches, and low power consumption to be used widely and on deployment2.

B. Smart Garbage Management System for Sustain able Urban Life

The rapid urbanization and increasing population density in metropolitan areas have brought about significant challenges in waste management. Traditional systems often fail to cope with the volume and complexity of modern waste generation, prompting researchers and technologists to explore intelligent solutions. One promising approach is the use of Internet of Things (IoT) technologies in smart waste management systems (SWMS), which leverage real-time data, automation, and communication capabilities to enhance operational efficiency and sustainability. IoT in Waste Management Various researchers have proposed the integration of IoT technologies into municipal waste systems. For instance, proposed an Android-based application that connects users with city corporations and volunteers. This application allows users to locate nearby dustbins via GPS, view available volunteers on a map, and notify relevant parties for waste collection or cleanup activities. Such systems promote citizen participation and community-driven waste management, which is critical for maintaining a clean urban environment. The literature on IoT-based smart waste management systems highlights their potential to revolutionize how urban waste is collected, processed, and managed. From citizen engagement tools like mobile apps to fully automated smart bins using sensors and microcontrollers, the integration of technology brings efficiency, sustainability, and cost-effectiveness to traditional waste management. As demonstrated in the Dhaka case, even low-cost prototypes can significantly improve environmental hygiene, reduce human effort, and foster civic participation when supported by proper infrastructure and governance.

C. Smart Plant Monitoring System

*a) Description of the Smart Plant Monitoring System:*A Smart Plant Monitoring System is an intelligent solution that uses the Internet of Things (IoT), sensors, and data analytics to automate plant care. This system provides comprehensive monitoring and management of plants in various environments, such as agriculture, horticulture, or indoor gardening. Its primary goal is to optimize plant growth, conserve resources, and enhance productivity.

*b) Key components and functions:*The foundation of the system is built on sensor networks, which can collect significant data regarding soil moisture, temperature, humidity, and light intensity. This information is collected periodically and transmitted to a central control system or cloud-based platform via Wi-Fi or Bluetooth. Such a process permits real-time monitoring and makes information accessible remotely from wherever internet connectivity is available. The incoming data is further processed using data analytics, along with machine learning algorithms, to gain meaningful insights, identify anomalies, and suggest the best course of action for plant care. Such intelligent insights promote automatic changes in watering schedules or modifications in environmental controls.

*c) User Interaction and Benefits:*The system has a simple interface, either a web or mobile application, through which users can view the plant status in real time. Sensors' readings are available to the users through the system, and the system will notify them of any abnormal conditions, such as water shortage or pest infestation. Of course, the advantages of such a system would be vast, including better crop yields, less consumption of water and energy, reduced labor costs, and disease and pest identification at the earliest stage. Indeed, a smart plant monitoring system will integrate sensor technology, data analytics, and automation into one revolutionary way of looking after plants that will help the user grow healthier plants more easily and precisely.

D. IoT based Smart Water Tank Level Monitoring and Motor Pump Control System

The Smart Water Tank Monitoring and Motor Pump Control System has been developed by a team of researchers from the Bangladesh University of Business and Technology (BUBT) as a direct response to the worldwide problem of water scarcity and inefficient manual water management practices. In this research paper, a team of undergraduate students from various departments of BUBT have focused on the practical application of Internet of Things technologies to build a sustainable urban infrastructure. The main objective of this research is to design a system that is not only technically sound but also cost-effective and scalable so that it can be easily implemented across various scenarios, from an individual home to a large commercial complex. It has filled the gap between embedded hardware and cloud-based software to provide a complete solution. The system's architecture is based on a highly advanced and reliable dual microcontroller configuration. The NodeMCU ESP8266 is used as the central hub of control for the overhead tank and utilizes an ultrasonic sensor to provide high-precision water level readings. The readings are processed and displayed instantly on an LCD connected locally, as well as being uploaded to the Blynk IoT system via Wi-Fi. The system has a dedicated relay module, which can control the submersible motor via the

NodeMCU, turning it on as soon as the water level drops to a critically low level and turning it off as soon as the tank is full. This prevents human error and, therefore, tank overflows and water wastage. To complement this, an Arduino Uno is also deployed to control the source storage tank using a water depth sensor. This is an important part of ensuring the motor pump is not overloaded and is only attempting to fill the overhead tank when there is enough water available at the source. To keep users informed about the status of the storage levels, the Arduino is also connected to a series of LED lights, which are color-coded to keep users informed about the status of the storage levels. The lights are coded as follows: Red means low, yellow means medium, and blue means high. At the center of the user experience is the Blynk app, which turns the hardware into smart and interactive technology. Through the app, the user can view their water levels in real-time, regardless of their physical location in the globe, and even control the pump settings directly if the need arises. This, therefore, makes the system ideal for the urban dweller of the 21st century, whose lifestyle demands control and monitoring of their water tanks despite their physical location. Through the use of affordable technology such as the ESP8266 and ultrasonic sensors, the project has shown that high-tech conservation of the environment can be achieved at little cost, making the technology an important aspect of water resource conservation in the modern era.

E. WasteNet: Waste Classification at the Edge for Smart Bins

WasteNet, a deep learning framework for ”automating waste segregation at the network edge,” was proposed by White et al. (2020). Due to rapid urbanization and its impact on global waste production, current waste management systems face difficulties in recycling contaminants and human error in sorting.WasteNet overcomes such difficulties by incorporating CNNs into low-power devices such as Nvidia’s Jetson Nano for real-time classification without requiring cloud connectivity.

WasteNet classifies wastes into six types: paper, cardboard, glass, metal, plastic, and others. By performing computations at the edge devices, it minimizes energy consumption, data transmission costs, and decision-making latency. This is considered a major breakthrough compared to existing smart bins that only offer compaction and fill level notifications without any capabilities for sorting.

From a methodological perspective, the authors used a hybrid approach of transfer learning with a pre-trained DenseNet model. This was achieved through a two-stage process involving feature extraction and fine-tuning with discriminative learning rates to prevent ”catastrophic forgetting” and speed up convergence. For data variability and its effect on performance in realistic scenarios, data augmentation techniques were extensively used. These techniques included rotating, flipping, and zooming images.

The model is validated using the publicly available TrashNet dataset with 2,527 images in six categories of wastes. WasteNet demonstrates outstanding performance with 97

The confusion matrix shows low misclassification errors among classes, mostly between materials with visual similarities like metal and glass. This shows high discriminability of WasteNet. Another interesting aspect of the work is the use of gradient-based localization (Grad-CAM) for visualizing CNN’s attention areas. This confirms that WasteNet focuses on relevant areas of wastes during classification.

The key contribution of this work is its proof of concept for using deep learning at the edge of IoT networks for environmental monitoring and protection. By performing image classification at the edge of smart bins, WasteNet eliminates the need for servers and cloud computing. This makes it more efficient in terms of latency and bandwidth usage. Also, its modular architecture makes it easier to integrate with solarpowered bins and compactors, making it more relevant for operational and environmental sustainability.

IV. CRITICAL ANALYSIS AND SYNTHESIS

On analyzing the Smart Dustbin in the context of IoT, it is observed that the application thoroughly manages to address the systemic failures that are inherent in the traditional waste management and municipal sanitation systems. Traditionally, these systems are based on a schedule of waste collection that is conducted manually. Such a system is bound to suffer from problems of overflowing dustbins, unhygienic conditions in cities, and wastage of fuel in vehicles carrying out waste collection. In this project, an automated system is being implemented that makes use of ultrasonic sensors and moisture sensors to monitor waste levels and types in a real-time environment, thus reducing the workload of janitorial staff and facilitating a ”need-based” waste collection mechanism.

The potential of this system to provide immediate feedback to users via LCDs and IoT-based applications such as Blynk is a pointer to the practical potential of embedded systems in city planning. However, this faith in sensor-based automation is also accompanied by problems in calibrating sensors, environmental wear and tear, and a constant internet connection, thus necessitating physical maintenance and monitoring of the system.

Critically, it is observed that the reliability of such a system is heavily dependent upon hardware precision and the reliability of the cloud infrastructure. What makes the Smart Dustbin stand out is its capacity for contactless operation through servo control of its lids; however, it may at times face false triggers in areas of high human traffic, which is another known disadvantage of using ultrasonic sensors for distance detection. There is a partial overlap between the challenges posed in smart city framework research and the actual implementation of such a project; however, it is observed that hygiene is maintained through automatic control of lids but needs further refinement in terms of distinguishing between different types of recyclable materials beyond moisture levels. This poses a dilemma in terms of balancing the low costs of hardware like Arduino and NodeMCU with the necessity for industrial-grade reliability for outdoor use, implying that such IoT devices must be seen as part of a larger framework of more robust and heavy-duty infrastructure. This project, in its synthesis, has effectively brought together concepts from various domains of research, including real-time environmental monitoring, automated waste segregation, and cloud-based notification systems. The concept of Smart Dustbin is a synthesizing platform, and this marriage between sensor-based technology and usercentric notifications via Telegram and Blynk has brought this concept into being. The system is similar to the concept of ”Smart City,” which has relied on technological interventions as an intelligent tool to assist sanitation workers, as supported by literature that has emphasized data-driven logistics in maintaining public health. Furthermore, although this project has brought into being an effective structure for waste collection, it has not yet utilized route optimization algorithms for waste collection vehicles. The addition of GPS-based tracking and prediction algorithms for waste generation patterns has made this platform similar to next-generation autonomous sanitation systems, as emphasized in modern literature. The critical evaluation of this project has emphasized the importance of the Smart Dustbin as an intersection between theoretical IoT research and practical environmental application, thereby proving that automated waste management is not only possible but essential in modern sustainability.

In addition, in terms of adaptation and personalization of the waste management process, it is evident that the Smart Dustbin project is establishing a solid framework but is not taking maximum advantage of data analytics and modeling in its current state. For instance, it is not using data analytics to adapt to user behavior in terms of opening the dustbin lid at a certain distance or sending fill level notifications at a certain percentage. The use of machine learning algorithms to predict fill levels of the dustbin and optimized collection routes would bring it much closer to the next-gen autonomous urban systems discussed in current literature. Ethical considerations such as data privacy for users and electronic waste generated by IoT devices used in smart dustbins would be implicitly and explicitly addressed in future iterations of smart dustbin implementation. Overall, in terms of critical evaluation of the Smart Dustbin project, it is evident that it is a key meeting point of current IoT research and its application in terms of environmental sustainability, demonstrating that not only is smart waste management possible but it is absolutely essential for future sustainability.

V. CONCLUSION AND FUTURE SCOPE

The Smart Dustbin using IoT has been found to be an excellent example of the demonstration of the applicability of Internet of Things (IoT) technology for the automation of waste management in the city. With the help of ultrasonic sensor technology, the system is able to monitor the waste collected in real time, thereby transforming the conventional waste bins into smart devices that are able to send messages to the authorities through Blynk or Telegram. Waste collection through manual monitoring would require a lot of time and would also lead to unhygienic conditions, whereas the automation ensures that waste collection is done only when required, thereby providing a hygienic condition. The incorporation of contactless lids using servo motors and moisture sensor technology makes the system highly applicable for use in schools and hospitals.

The developed platform prioritizes hygiene and efficiency, as the user can interact with the bin without any physical contact, thereby reducing the spread of diseases. The use of local information on LCD screens and remote monitoring with cloud technology ensures the users and the authorities are informed of the status of the system. The addition of moisture sensors to identify dry and wet waste helps in the recycling process, as the waste will be segregated at the point of generation. To conclude, the Smart Dustbin is an epitome of how IoT can be used as an intelligent assistant in the field of municipal sanitation, providing efficient solutions for smart cities.

As far as the future scope of this project is concerned, it is vast in nature since it encompasses a number of enhancements that can be made to increase its scope of functionality and impact. One of the major enhancements that can be made to this Smart Dustbin is the incorporation of Machine Learning algorithms that can help in predicting patterns of waste generation and optimizing the route of the dustbin to reduce fuel costs. Another enhancement that can be made is the incorporation of Solar Power that can help in making this Smart Dustbin independent and allow it to function even in remote areas without any external electricity supply. Moreover, this Smart Dustbin can also be diversified to incorporate compressed air-based waste compacting systems, GPS-based bin location management systems, and gas sensors that can help in detecting hazardous smells and fire.

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