International Information and Engineering Technology Association
Advancing the World of Information and Engineering

Ingénierie des Systèmes d'Information
Vol. 28, No. 1, February, 2023, pp. 149-154
Journal homepage: http://iieta.org/journals/isi

Classification, Collection, and Notification of Medical Waste Using IoT Based Smart Dust Bins

Check for updates

Uppala Rakesh[1*], V. Ramya[2], V. Senthil Murugan[3]

[1] Department of Computer Science & Engineering, Annamalai University, Chidambaram 608001, Tamil Nadu, India
[2] Department of CSE, FEAT, Annamalai University, Chidambaram 608001, Tamil Nadu, India
[3] Department of Computer Science & Engineering, School of Computing, Viswam Engineering College, Madanapalle 517325, Andhra Pradesh, India

Corresponding Author Email: rakesh.uppala99@gmail.com

https://doi.org/10.18280/isi.280115

Received: 26 August 2022
Accepted: 8 November 2022

Keywords:
biomedical waste, sensing unit and classifier, IR sensor, GOM, smart waste bin

ABSTRACT

Hospitals generate a significant amount of highly hazardous medical waste. Waste collectors were now responsible for the majority of waste separation. Currently, hazardous medical waste, including substrate materials, syringes, and other items were separated manually, causing serious problems. Automatic waste separation is proposed for the separation of biowaste produced in hospitals. When waste disposal is identified, the treadmill is moved by an external motor. These wastes would be sent to the Sensing and Classification Units. The source image is captured, preprocessed, median filtered, contrast adjusted, and then classified in five steps. After the steps, the outcome would be assessed using the characteristics collected from the Grey Ordered Model (GOM) and transferred to the trash after the separation procedure. To determine the level of waste in dustbins, an infrared sensor, a moisture sensor, a pressure sensor, and an ultrasonic sensor are used.

1. INTRODUCTION

A modern city would stimulate the efficiency of operations like the information management of local departments, universities, bookshops, transport networks, hospitals, hydroelectric dams, police, traffic control systems, solid waste disposal, and other municipal services by connecting all data into one platform. The design and implementation of Internet of Things (IoT) technologies have recently been a top priority to reach the goal of becoming a smart city [1]. Here, waste management encompasses a large number of waste containers with varying loading levels and different requirements for dumping, ranging from infrequent to very regular. Different types and generally extended uniform loading times. Given the different abnormalities of the waste bin replacement process, including the uneven shape and diversity of the components present, detecting the fill level of urban solid waste bins presents several challenges.

As the population grows the needs of health care facilities and the costs associated with their maintenance are increasing. The amount of waste produced by each medical facility is increasing. The waste is discharged into containers, which are then cleaned up by people. However, over time, people's schedules become increasingly turbulent. This is always a race against time [2, 3]. As a result, all waste must be checked and cleaned regularly. That could contribute to the control of the illness. As a result, we decided to create a smart waste bin that monitors the amount of waste and sends a notice to the municipal government for the shipment of waste. Government authorities can monitor the amount of harmful waste generated in particular health facilities by using web.

The supply photograph is captured, pre-processed, median filtering, comparison improvements, and category are all levels of the sensor and classification gadgets. Cotton, bottles, needles, papers, and other substances have been tested. Waste is classified according to the traits produced by using the GOM method. After the separation system the garbage is moved precise clever bin. To decide the repute of the boxes, an infrared sensor, and an ultrasonic sensor are used. Another objective of the research is to decide how lots time it takes for the garbage nodes to respond to Internet services. It uses four foremost GSM network carriers and three exceptional test situations. ThingSpeak is connected with IoT package is proven in Figure 1. There are 3 hours of the day: Morning, Noon, and Night. The typical widespread reaction time for communique networks is 60 to one hundred seconds, in step with the outcomes presented in Figure 2.

Related works are explained in section 2, Methodology is explained in section 3, Implementation details are explained in section 4.

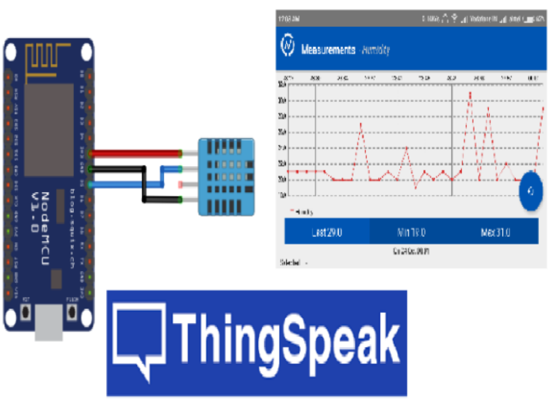

Figure 1. ThingSpeak

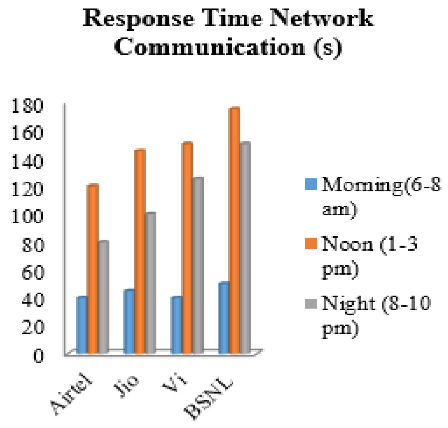

Figure 2. Response time network communications

2. RELATED WORKS

The basic idea behind smart waste management is to manage all the garbage in the municipality while keeping a record of the whole operation. A smart garbage bin is made up of sensors nodes for smart communication, detecting devices, a Bluetooth, Global System for Mobile Communication (GSM) module for transmitting data, a Smartphone application, web-based tracking for wastewater treatment interface, and information exchange [4]. Intelligent bins are equipped with a sensor node for data transmission. There are 2 methods of sensing. The first approach is to use a level sensor to monitor the contents of the garbage container. The second option is to use an intelligent charge sensor to determine wasted weight [5]. This technology can gather precise information in real-time, which can then be integrated into the management tool. This load cell calibration technique simplifies the calibration process so that it can be mounted on a typical garbage bin without having to replace or modify it.

Intelligent buildings would aim for both reliable and efficient communications. The amount of waste in the waste bins may cause hazardous gases. A mobile gadget that reflects the amount of waste can help to decrease this [6]. If waste is not safely removed, bins can become overfilled. A waste management system is introduced, consisting of Short Message Service (SMS) notifications and GSM modules. Adopting an intelligent waste collector saves time and labor [7]. The waste could be loaded until the cutoff limit is exceeded in the smart bins. As it approaches the limit, the state of the bin is improved and the bin conditions are reported and stored in the cloud. Such a state is accessible by the in-charge of the department, and urgent actions were made to clean the waste, ensuring that the waste is disposed of effectively without the need for human interference [8]. Sensors are used to monitor the state of the bins, and the data is detected by the detectors and sent to the control center via GSM systems. Such devices are mounted on a microprocessor that processes the information and communicates with the GSM system [9]. An Android-based platform is also being developed to detect information across multiple domains and collect waste effectively.

The design of a new effective waste management system for waste treatment in Smart City applications is deemed necessary for future smart cities. IoT could be utilized in Media Access Control (MAC), resulting in a well-developed plan for future management. Special strategies can be used to improve the technologies used to have an efficient waste management strategy with a high Quality of Service (QoS) [10]. For effective waste management, IoT elements such as sensors, sensors, and controllers have been incorporated into the Intelligent System (IS) and Inspections technologies. To boost effectiveness and inform appropriate authorities, automatically notify enabled smart bins or waste collection technology were devised, and to notify the authorities such as corporations or municipal illegal dumping teams [11]. The GSM modem, microprocessor, and infrared sensor were used in the creation of a new system. These ultrasonic devices are installed to calculate the distance between the waste and the ceiling of the garbage container. When the bins are full, the GSM modem sends a message to the owner, asking him to empty the bins.

The Arduino board serves to build the Smart Bins. It is equipped with a GSM modem and an ultrasonic transducer (HC-SR04) [12]. There was also a siren and LEDs to display the amount of waste in the bins. All waste in the bins is marked with 3 LEDs representing three different levels of elevation [13]. This represents an empty bin, while the red represents a laden bin. Each time the bin is full, the integrated buzzer rings 3 times, signaling the end of waste disposal in the bins. This GSM modem is used to give this information. Several people could receive the message at the same moment. Applying IoT concepts including constructing a database for each bin that can be managed to utilize SQL technologies, and a login portal to assure permitted inputs may be performed to integrate numerous bins, including one with a unique ID [14, 15]. To further enhance it, an automation system that can pick up waste in or around the container, sort it, and place it in appropriate bins can be built.

Various approaches are already being developed and used for effective waste/solid waste monitoring. These current developments, Zigbee and Global Systems for Mobile Communication (GSM) are among the ideal combinations to use within the program. It follows that some of these techniques are combined in the program [16]. These systems are deployed in typical garbage bins located in common spaces to provide a quick overview of the concept. When the waste exceeds the scanner levels, an indication is sent to the ARM 7 controllers. Each waste truck driver would be notified by the supervisor of the waste bins which are fully full and require immediate attention. ARM 7 would send a text message using the GPS tracking system [17] to signal its presence.

GSM is a collection of technologies for a second-generation digital cellular network used amongst cellular phones [18]. With more than 80% market share, it has become the worldwide standard for wireless telecommunications. The ARM plug-in is connected to the GSM network. If the waste can is overflowing and an SMS alarm must be issued to the corporate headquarters through GSM, then every person who gets SMS has a cell phone in his or her hands. MAX 232 serves to connect GSM technology to the ARM microprocessor. If there is an error, the mobile module is used to send an SMS to the client. These are used to send and receive text messages and MMS notifications.

3. METHODOLOGY

Stage 1: Classification and collection

The graphical representation of this proposed work (Figure 3) displays two modules: Detection and Classification Units and Garbage Disposal. The source image is captured, pre-processed, median filtering, contrast enhancements, and classification are all phases of the sensor and classification units. Cotton, bottles, needles, papers, and other materials were examined. Waste is classified according to the characteristics produced by the GOM method. After the separation process, each garbage shredder, which includes Arduino, relays, buzzer, GSM, Universal Asynchronous Receiver/Transmitter (UART), and actuators would be computerized. To determine the status of the bins, an infrared sensor, a water sensor, a gas sensor, and an ultrasonic sensor are used. Contrary to the above, 3 motors empty the garbage according to its categorization. To prevent the spread of disease in clinics and also to decrease the laborious procedure, health care waste is separated electronically. The proposed method is presented as a series of phases, and a flow diagram (Figure 4):

1. The original image was acquired by the camera.
2. The image is processed and the waste is classified by the detector and classification system.
3. The method senses waste.
4. If the waste is identified as plastics, motor 1 would start and the waste would drop into the appropriate container.
5. If the waste is cotton, motor 2 would start and the waste would drop into the proper container.
6. If somehow the system identifies garbage other than plastics and cotton, motor 3 would activate and the garbage would fall into the appropriate container.
7. The device would be turned off when the detection procedure is completed.
8. Control of waste levels in the container.
9. Wireless data provides data to those who need it.
10. The information shall be made public at all times and in all locations.

Stage 2: Receive and disposal

The given packets would be tagged with Radio Frequency Identification (RFID) tags that are continuously issued and searched by a network in 75, 50, and 25 km radius in the center installed at suppliers. Weight detectors were reportedly installed in the bins where these bags are placed, triggering the truck transporting the waste. This quantifiable weight rating for a certain color-labeled bag would be delivered immediately to government agencies via a microprocessor connected to the Internet. Concerning government institutions, it would immediately document appropriate and unnecessary information. It could also help the government analyze and retrieve documents monthly or maybe even one or two times. Big data review technologies could be used for categories as well. Such a method always overcomes other potential weaknesses in the previous decentralized system because it is completely dispersed and inspired by real information. Computer configuration IoT architectural style gadgets have enabled devices to communicate effectively with servers. Such intelligent and incredibly fast response mixing connectivity could also help prevent fraudulent data activities because the evidence is available on many endpoints before it has been synchronized.

The original document of its ARM microcontroller has been developed into programming languages. The Arduino (IDE) software is a free open source program that makes it easy to code and publish on maps. It operates on various platforms, including Windows, Mac OS, and Linux. The application is based on Java, and therefore this program can be used with just about any Arduino board before installing the Java IDE program on the system.

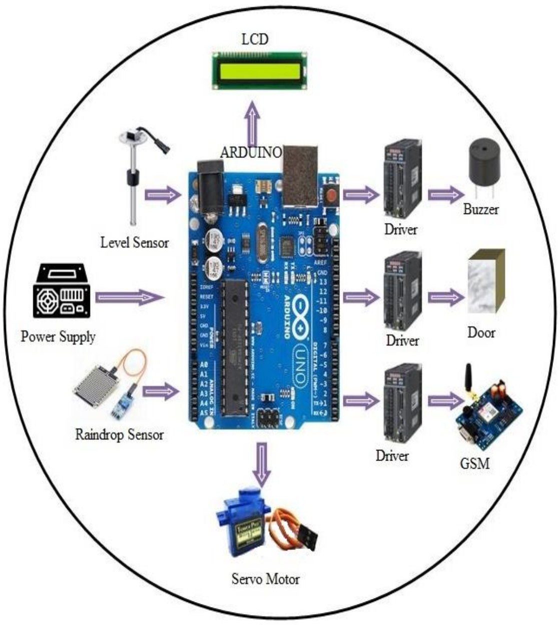

Figure 3. Block diagram of proposed method

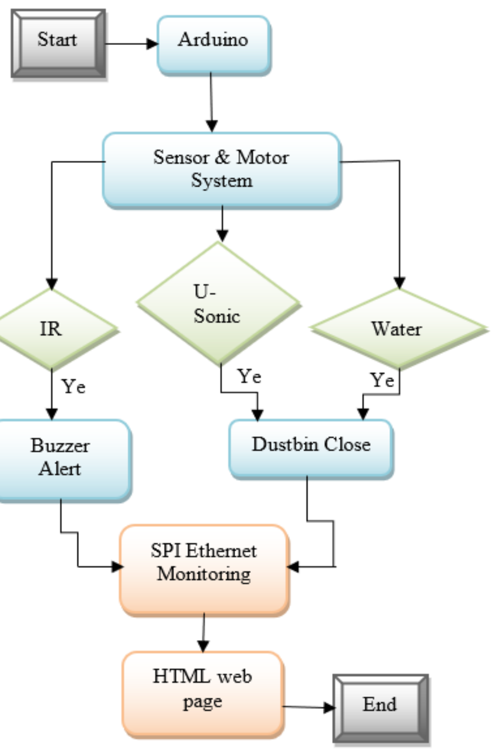

Figure 4. Flow diagram of the proposed method

3.1 Modules

The purpose of this measure is to determine whether the components were cotton, plastic, or something else. The source image, the preprocessing, the filtration, the contrast adjustment, and the classification are the 5 phases. The example of the result of the 5 images is presented in Figure 5, and the step-by-step result is presented in columns b to e. Gray-scale image conversion, median filtering, and dynamic histogram equalization are all phases of the pretreatment process. The greyscale transformed image in column b of Figure 5 is treated to the average filter, which involves moving a 3x3 sliding window across the image and calculating the middle value of the pixels corresponding to the moving window. It is a regressive filtering method that replaces the median mid-pixel value to minimize noise and improve signal quality. Figure 5 presents the result of the median filtration in column c. Adaptive Histogram Equalization (AHE) as illustrated in Figure 5 of column d, was used to increase image contrasts, and the result clearly shows that the margins in the image have been improved. The dynamic approach varies from the AHE that calculates multiple histograms, each corresponding to a different part of the image, and uses them to scatter the brightness levels of the image. Finally, as shown in Figure 5, column e, the sobel edge detection approach is used to identify the limitations of objects.

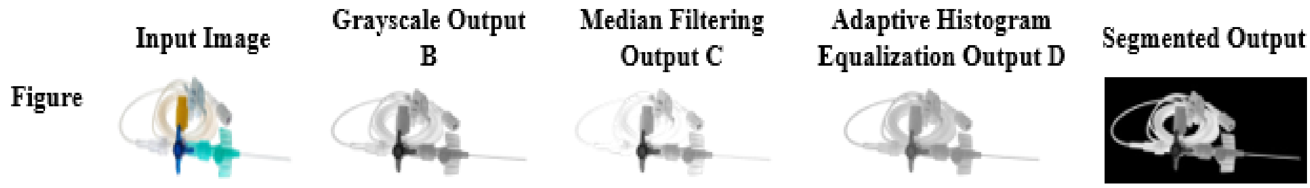

Figure 5. Output of bio-medical waste

In this proposed study, we use the Grey Order Occurrence algorithm to separate the probabilistic texture properties of an image. To evaluate the image area, a series of digital image properties are derived from the GOM. The Local Binary Pattern (LBP) is computed oppositely. To examine the structure of the image for categorization, this proposed study integrates both statistical parameters and LBP.

3.2 Disposal module

Developing and collecting waste in slave bins 1. The waste would be stored in color-coded disposable plastic bags for self-identification. A QR code would be displayed on those packages. The trays of these slaves would be secured and would not be released until the disposable packages met their unique color codes. And it will be attached to a sensor node that would scan the self-identified packets and unlock the slave's bins accordingly. It should ensure that waste is correctly separated and quantified 2. Transferring data from slave bins to master bins before you even collect location 3. Inform the collector van of the condition of the label capacity. These vehicles would be equipped with a low-cost cell phone gadget that would provide information on the capabilities of different health systems 4.

This part of the equipment is supplied by the Detection and Classification Unit to separate the clinical waste and place it in the proper container. The waste management modules included four sensors: a gas sensor, an ultrasonic sensor, an infrared sensor, a moisture sensor, a microcontroller, switches, and an actuator. If the identified substance is plastic, engine 1 would start and the component would fall into the proper bins. If the cotton is found, engine 2 would start and the article would fall into its designated bins. If the discovered substance is neither plastic nor cotton, it is effectively sorted into suitable waste. Whenever the garbage decomposes, a foul odor may develop, which can be detected with a smelly sensing element. Whenever the gas sensors reach a reading of 150 or more, these fans would turn on and attempt to eliminate the odor. If the reading goes below 150, the alarm will ring. Any waste that is located next to the waste bins is detected using an infrared sensor. Whenever a customer is within 20 to 80cm of the dustbins and does not place the garbage in the bins, a beep would ring to remind them to place the waste away. This quantity of waste in the waste is indicated by an ultrasonic collector. Whereas if garbage falls under 10 cm from the top of the wastebasket, a beep would sound and an SMS alert will be sent over GSM to clear the waste bins. When it rains, a rain sensor is used to measure humidity. This alarm starts to sound when it detects moisture from about 500 feet away, suggesting that the bins should be closed.

3.3 Prototype model

Another intelligent prototype of a dustbin is created using the gadgets discussed in the previous section. Its image within the prototypes is presented in Figure 6. They tried some settings to see if the smart waste prototype works well and was adaptable in a real context. This weight detector is tested with a bronze weighing device and four different varieties of traditional bins commonly found on the road and in public places. The first is a 60-liter fiber bin, a 40-liter stainless steel bin, a 45-90 liter sheet metal bin, and a 30-liter plastic bin.

There are four types of convectional bins used to assess level sensors. 120cm of fiber, 60cm of steel material, 50cm of iron sheet, and 30cm of plastic. The length of the element located on the front of the detector is computed using the detector. The more waste in the container, the closer the item is to the sensors. Researchers use a meter roller to physically monitor the quantity of waste to verify the detector. They set up the level sensors as a percentage of waste in the program bin. Figure 7 shows the results of a leveling sensor in several garbage bins. The pings detector and physical measurement with a meter roller exhibit lower error percentages. The accurate representation of the total sensor error percentage is 3 to 5 percent.

Another objective of the research is to determine how much time it takes for the garbage nodes to respond to Internet services. It uses 4 major GSM network providers and 3 different test conditions. ThingSpeak is connected with IoT kit is shown in Figure 1. There are three hours of the day: Morning, Noon, and Night. The overall standard response time for communication networks is 60 to 100 seconds, according to the results presented in Figure 2. When we compare the time needed to gather information in an hour or a day, it's pretty quick. As a result, technology can react rapidly to monitor the status of the waste container. Jio, BSNl, airtel and Vi networks are used for the study. Following steps are followed to connect with ThingSpeak. 1. Create a ThingSpeak account 2. create a new channel 3. Then enter the information about the new channel 4. After that, go to the API keys section and copy your write API key. 5. Use API code in the code which is used to connect with IoT kit.

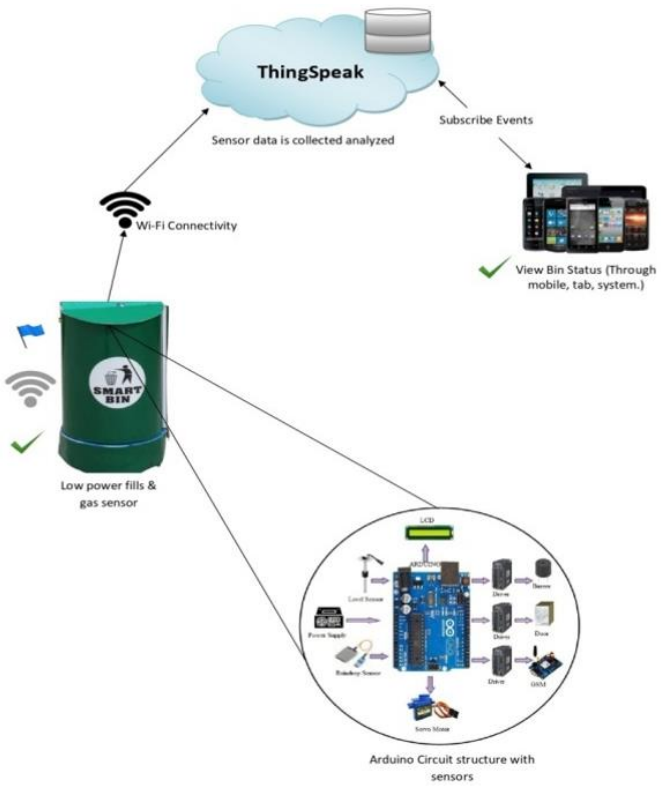

Figure 6. Prototype of smart waste-bin

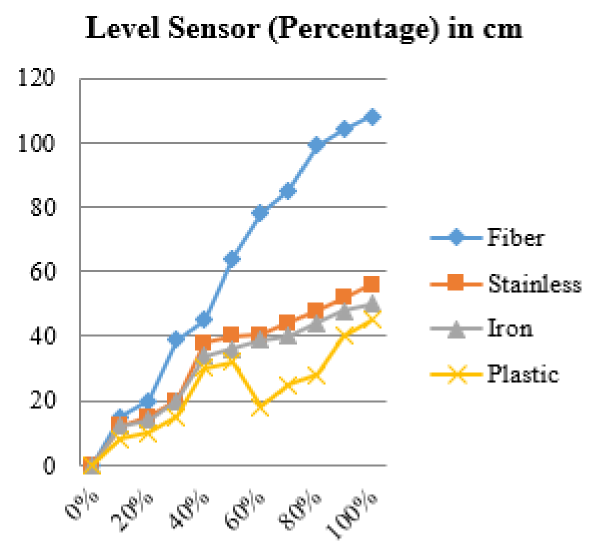

Figure 7. Level sensor test result

4. DISCUSSIONS

This implementation in the medical sector encourages real-time monitoring of health care. This basic strategy minimizes the number of infections that may rapidly spread in clinics. This proposed work gives companies a way to effectively separate sanitary waste to prevent illness. MATLAB is used to build an automatic classification system based on a sensor and a unit classification in healthcare waste management for the separation of organic substances based on color-coding. To eliminate different types of waste, the drain assembly includes an infrared sensor, a humidity sensor, a gas sensor, an ultrasound sensor, a controller, and motors.

On a 900-1900 MHz grid, all slave containers were attached to master bins. Because this connection has the best cover, these dustbins would be allowed to access the Internet from almost everywhere. As the 2G spectrum is available in most regions, this approach overcomes the difficulty of communicating in remote locations. To communicate to that spectrum, current data devices consume the smallest amount of power. However, the availability of the 2G spectrum can be attributed to the cost of reduced capacity. As they are designed to run on very limited bandwidth, specialized IoT-based techniques could help us transmit data in an extremely fragile and poor connection to the Internet.

Its objective is to eliminate personal interactions and fully automate waste management practices in clinics, laboratories, and diagnostic research laboratories. This software is capable of completing the complete plaster management strategy without requiring any contribution or modification from the client. As a result, it may be viewed as a Black box device that cannot be modified to provide incorrect information. The data produced by IoT applications are based on senor real-time data that is continuously given to administrators on their servers, which allows full automation of the data monitoring system. This method also saves money on the transmission of information by adjusting van schedules if required. By adding automated in the area, this idea completely approaches and solves the administration of bio-medical waste [19, 20].

5. CONCLUSION

The researchers intend to introduce a waste management technique for this study. This real-time reliable statistic from the constructed system could be used for effective solid waste management practices in a network context. The equipment can gather precise information in real-time, which can then be integrated into a management platform. This load cell calibrating technique simplifies the calibration procedure so that it may be fitted to a typical garbage bin without having to replace or modify it. The level sensors can also be installed in a normal waste bag. This makes the prototype suitable for conventional waste management systems. As the future work real time monitoring of waste collection trucks and route optimization for waste collection trucks can be implemented.

REFERENCES

[1] Hancke, G.P., de Carvalho e Silva, B., Hancke Jr, G.P. (2012). The role of advanced sensing in smart cities. Sensors, 13(1): 393-425. https://doi.org/10.3390/s130100393
[2] Pardini, K., Rodrigues, J.J., Kozlov, S.A., Kumar, N., Furtado, V. (2019). IoT-based solid waste management solutions: a survey. Journal of Sensor and Actuator Networks, 8(1): 5. https://doi.org/10.3390/jsan8010005
[3] Misra, D., Das, G., Chakrabortty, T., Das, D. (2018). An IoT-based waste management system monitored by cloud. Journal of Material Cycles and Waste Management, 20(3): 1574-1582. https://doi.org/10.1007/s10163-018-0720-y
[4] Sharma, A., Battula, R.B. (2019). Architecture for Waste Management in Indian Smart Cities (AWMINS). In 2019 International Conference on Information and Communication Technology Convergence (ICTC), 76-83. https://doi.org/10.1109/ICTC46691.2019.8939764

[5] Balamurugan, K., Uthayakumar, M., Sankar, S., Hareesh, U.S., Warrier, K.G.K. (2020). Process optimisation and exhibiting correlation in the exploitable variable of AWJM. International Journal of Materials and Product Technology, 61(1): 16-33. https://doi.org/10.1504/IJMPT.2020.111310

[6] Hussain, A., Draz, U., Ali, T., Tariq, S., Irfan, M., Glowacz, A., Rahman, S. (2020). Waste management and prediction of air pollutants using IoT and machine learning approach. Energies, 13(15): 3930. https://doi.org/10.3390/en13153930

[7] Esmaeilian, B., Wang, B., Lewis, K., Duarte, F., Ratti, C., Behdad, S. (2018). The future of waste management in smart and sustainable cities: A review and concept paper. Waste Management, 81: 177-195. https://doi.org/10.1016/j.wasman.2018.09.047

[8] Deepthi, T., Balamurugan, K., Uthayakumar, M. (2021). Simulation and experimental analysis on cast metal runs behaviour rate at different gating models. International Journal of Engineering Systems Modelling and Simulation, 12(2-3): 156-164. https://doi.org/10.1504/IJESMS.2021.115536

[9] Goel, M., Goyal, A.H., Dhiman, P., Deep, V., Sharma, P., Shukla, V.K. (2021). Smart Garbage Segregator and IoT Based Waste Collection system. In 2021 International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE), 149-153. https://doi.org/10.1109/ICACITE51222.2021.9404692

[10] Bányai, T., Tamás, P., Illés, B., Stankevičiūtė, Ž., Bányai, Á. (2019). Optimization of municipal waste collection routing: Impact of industry 4.0 technologies on environmental awareness and sustainability. International Journal of Environmental Research and Public Health, 16(4): 634. https://doi.org/10.3390/ijerph16040634

[11] Lau, B.P.L., Marakkalage, S.H., Zhou, Y., Hassan, N.U., Yuen, C., Zhang, M., Tan, U.X. (2019). A survey of data fusion in smart city applications. Information Fusion, 52: 357-374. https://doi.org/10.1016/j.inffus.2019.05.004

[12] John, J., Varkey, M.S., Podder, R.S., Sensarma, N., Selvi, M., Santhosh Kumar, S.V.N., Kannan, A. (2022). Smart Prediction and Monitoring of Waste Disposal System Using IoT and Cloud for IoT Based Smart Cities. Wireless Personal Communications, 122(1): 243-275. https://doi.org/10.1007/s11277-021-08897-z

[13] Bhasha, A.C., Balamurugan, K. (2020). Multi-objective optimization of high-speed end milling on Al6061/3% RHA/6% TiC reinforced hybrid composite using Taguchi coupled GRA. In 2020 International Conference on Computational Intelligence for Smart Power System and Sustainable Energy (CISPSSE), 1-6. https://doi.org/10.1109/CISPSSE49931.2020.9212295

[14] Mohanta, B., Das, P., Patnaik, S. (2019). Healthcare 5.0: A paradigm shift in digital healthcare system using Artificial Intelligence, IoT and 5G Communication. In 2019 International Conference on Applied Machine Learning (ICAML), 191-196. https://doi.org/10.1109/ICAML48257.2019.00044

[15] Bhatt, M.C., Sharma, D., Chauhan, A. (2019). Smart Dustbin for Efficient Waste Management. International Research Journal of Engineering and Technologi, 6(7): 967-969.

[16] Zedadra, O., Guerrieri, A., Jouandeau, N., Spezzano, G., Seridi, H., Fortino, G. (2019). Swarm intelligence and IoT-based smart cities: a review. The Internet of Things for Smart Urban Ecosystems, 177-200. https://doi.org/10.1007/978-3-319-96550-5_8

[17] Zhang, Q., Li, H., Wan, X., Skitmore, M., Sun, H. (2020). An intelligent waste removal system for smarter communities. Sustainability, 12(17): 6829. https://doi.org/10.3390/su12176829

[18] Ustundag, A.L.P., Cevikcan, E. (2008). Vehicle route optimization for RFID integrated waste collection system. International Journal of Information Technology & Decision Making, 7(4): 611-625. https://doi.org/10.1142/S0219622008003125

[19] Danladi, M.S., Baykara, M. (2022). Design and implementation of temperature and humidity monitoring system using LPWAN technology. Ingénierie des Systèmes d'Information, 27(4): 521-529. https://doi.org/10.18280/isi.270401

[20] Gherbi, C. (2021). Internet of things and heterogeneous networks technologies: Concepts, challenges and perspectives. Ingénierie des Systèmes d'Information, 26(4): 403-408. https://doi.org/10.18280/isi.260408