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Design internet of things for smart waste bin management with wemos based and firebase application

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ABSTRACT

The communication process for notifications involves sending alerts to users through a combination of automation and telecommunications technologies. The design smart trash, utilizing the Wemos microcontroller, performs various automated tasks such as opening and closing, compacting the garbage, and providing status notifications. These notifications are transmitted through the Firebase web server communication and an Android application on smartphones. Following successful testing, the system functions according to the programmed specifications. It achieves automatic opening and closing within a proximity range of ≤ 10 cm, demonstrates an average waste compaction rate of 45%, and delivers notifications to users indicating the trash status—whether it's empty, halfway full, or completely full.

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1. INTRODUCTION

The issue of waste poses a significant challenge for all segments of society, particularly in urban areas. The daily escalation of waste generation is closely linked to population growth and evolving lifestyles. This surge in waste production gives rise to various health concerns and environmental pollution. The accumulation of waste, particularly from households, is influenced by multiple factors, including the absence of direct monitoring by waste collectors. The waste collection process follows a routine schedule, leading to situations where collectors might arrive even when bins are not filled or fail to show up when bins are at capacity. This discrepancy arises from a lack of information about which bins require immediate attention. To safeguard public health and maintain a hygienic environment, there is a pressing need for efficient waste collection management.

Many studies explore waste management with diverse technologies, including ultrasonic technology [1]–[3], the Internet of Things (IoT) [4]–[9], Telegram [10], [11], SMS [12], the utilization of Arduino [13]–[15] though Arduino can also be applied in robot development [16]–[18] and medical technology [19], fuzzy logic [20], image processing [21], deep learning [22], and GSM modules [23].

2. METHOD

In this section, we will explain the general architecture, flowchart of design waste-bin hardware and software design.

Our Method smart waste-bin system:

a. In the automatic trash can opening lid, when the proximity sensor HC-SR04 reacts to human hand movements, the sensor will send a signal to the Wemos microcontroller to drive the servo motor as the main mover for the trash can lid
b. Every certain period of time the garbage pressing DC motor will move forward for a few seconds, then automatically moves in the opposite direction until it touches the limit switch which will send a signal to the Wemos microcontroller to stop the DC motor movement
c. When the garbage is at full level, the HC-SR04 proximity sensor will send a signal to the wemos to provide notification to the android application with the help of the Firebase Webserver

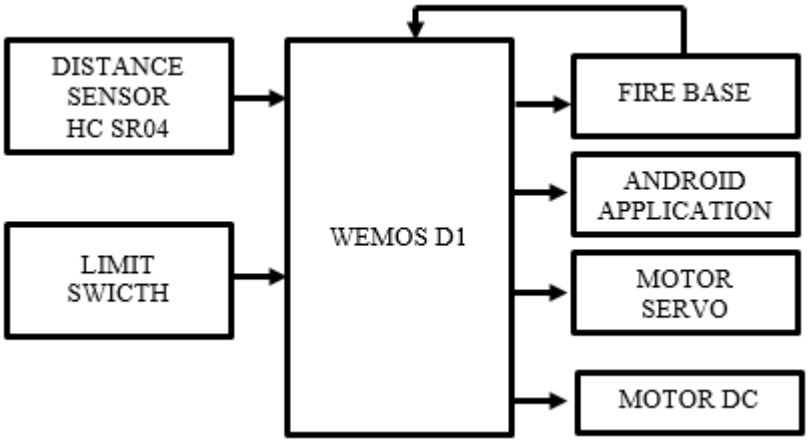


Figure 1. General architecture of smart waste bin

From figure 1 can be explained:

a. Ultrasonic sensor HC-SR04. The PING HC-SR04 proximity sensor is a sensor that uses ultrasonic waves for the amount of distance you want to know. This sensor is capable of measuring object distances from 2 cm to 4 meters with an accuracy of 3mm. There are 4 pins to support them, including the vcc, Gnd, Trigger, and Echo pins. Vcc pin for positive electricity and Gnd for ground. Trigger pin to trigger the signal from the sensor and Echo pin to capture the reflected signal from objects.
b. Sevro motor. A servo motor is a device or rotary actuator (motor) designed with a closed-loop (servo) feedback control system so that it can be set-up or adjusted to determine and ensure the angular position of the motor output shaft. A servo motor is a device consisting of a DC motor, a series of gears, a control circuit, and a potentiometer. A series of gears attached to the DC motor shaft will slow down the rotation of the shaft and increase the torque of the servo motor, while the potentiometer with the change in resistance when the motor rotates functions as a determinant of the angular position of the rotation of the servo motor shaft. The angle of the servo motor axis is adjusted based on the pulse width sent through the signal leg of the motor cable. The wider the OFF pulse, the greater the axis movement clockwise and the smaller the OFF pulse, the greater the axis movement in a counter-clockwise direction
c. Wemos D1. Wemos is a board module that can function with Arduino, especially for projects that carry the IOT concept. Wemos can run stand-alone without the need to be connected to a microcontroller, in contrast to other wifi modules that still need a microcontroller as a controller or the brain of the circuit, Wemos can run stand-alone because there is already a CPU in it that can program via serial port or OTA and transfer programs wirelessly.
d. DC motor. stationary part (stator) is where the field coil is placed which functions to produce magnetic flux, while the rotating part (rotor) is occupied by a series of anchors such as the anchor coil, commutator, and brush. Direct current motors work on the principle of the interaction between two magnetic fluxes. Where the field coil will produce a magnetic flux in the direction from the North Pole to the South Pole and the anchor coil will produce a circular magnetic flux. The interaction between these two magnetic fluxes creates a force.

e. Arduini IDE. Arduino IDE software is a software used to create programs to give commands to Arduino. IDE itself stands for Integrated Development Environment or simply an integrated environment used for development. This software can be programmed using the C ++ language developed by Arduino.

f. MIT app inventor. This web application was originally developed by Google and is currently managed by the Massachusetts Institute of Technology (MIT). App Inventor is a drag/drop based tool and visual blocks programming for developing applications that run on the Android Operating System. Visual Blocks Programming features can transform the coding of a text-based programming language into a visual language in the form of program codes. MIT App Inventors are often chosen by those who want to create Android applications online and offline.

g. Firebase. Firebase is a service for database storage created by Google. Firebase can make it easier for application developers to develop their applications so that applications created can have high quality and can generate more profits. With a variety of interesting features, Firebase is the right choice for users who are serious about developing their application.

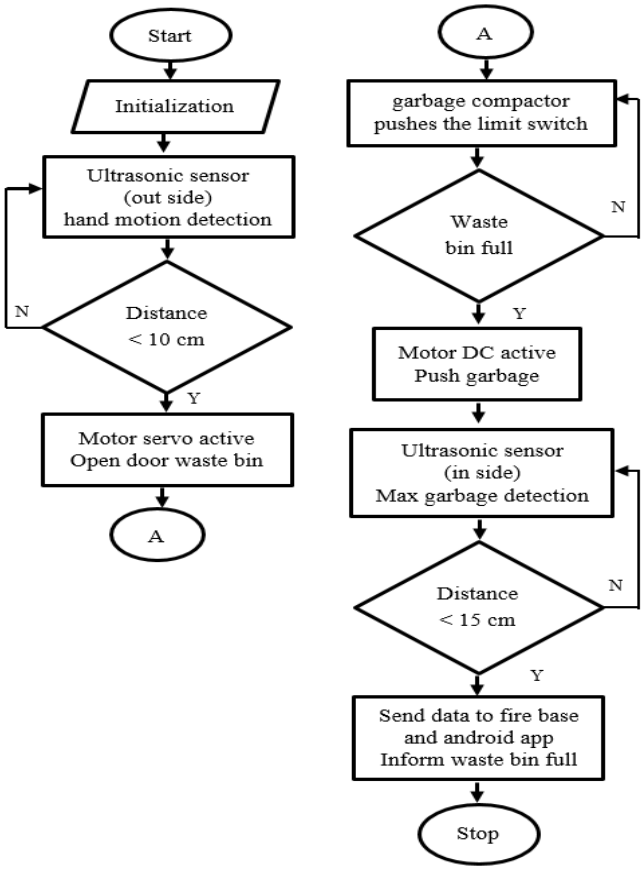
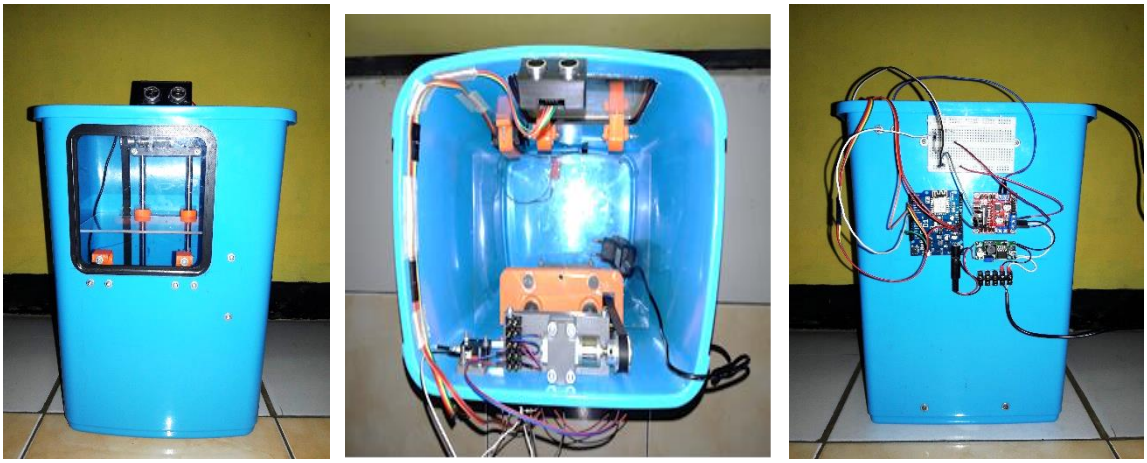


Figure 2. Flowchart of design waste-bin

In figure 2, it can be explained that when the hand approaches a distance of <10 cm, the waste bin door will open and when the contents of the garbage <15 cm, the system will inform the firebase that the contents in the waste bin are full.

Hardware Design

The front view of the design has an ultrasonic sensor that will open the door to the trash if an obstacle is approaching.



(1) (2) (3)

Figure 3. Waste Bin design (1) infront (2) inside component (3) Arduino part

a. The Design of The Opening and Closing of The Trash

The opening and closing of this trash can is designed to open and close itself without touching the trash can. This can be done by utilizing proximity sensors and servo motors as the driving components. When the user's hand approaches the sensor with a certain distance, this sensor will send a signal to the microcontroller to order the servo motor to move the trash can cover so that trash can be inserted through the existing hole.

Figure 4. Door open and close

b. Waste Compactor Design

The design smart trash can is designed to do the compaction or pressing of trash automatically. This waste pressing system uses several components as its constituent, including stainless shafts, linear bearings, timing belts, timing pulleys, tooth idlers, dc and acrylic motors.

Figure 5. Waste compactor

Software Design

The software in this design consists of several parts, namely Application Design in the App Inventor, Database Design in Firebase and Programming on the Arduino IDE.

a. Application Design in App Inventor

Figure 6 the application on the Android smartphone which is used as a notification media sent by Wemos is made by utilizing an open source web-based application provided by Google, namely App Inventor.

Figure 6. App inventor

b. Programming on the Arduino IDE

Figure 7 is notification reader application from the smart trash can is made in such a way that it can work properly as desired. The blocks created have been adjusted to the program and system so that they can communicate with Wemos and Firebase

As a central database that can be accessed in real-time, Firebase is used for IoT communication between the microcontroller and applications that have been created in figure 8.

Figure 7. Display on Firebase

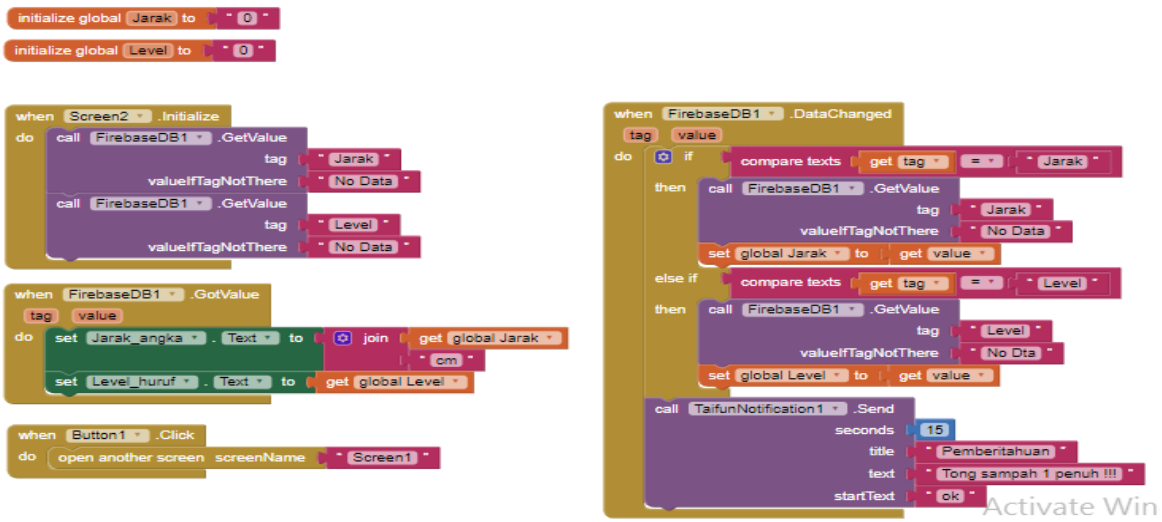


Figure 8. Wemos and firebase editor program

3. RESULTS AND DISCUSSIONS

In this section, the test results will be presented, such as detection distance, Level of Waste Before Compaction, Waste Level After Compaction, and Display on Firebase.

Testing of Garbage Opening and Closing Circuits

This test is carried out by bringing objects closer to the ultrasonic sensor with a specified distance of 5 samples, including 5 cm, 10 cm, 15 cm, 20 cm and 25 cm. Then, record the results on the Arduino IDE Serial Monitor for each sample tested.

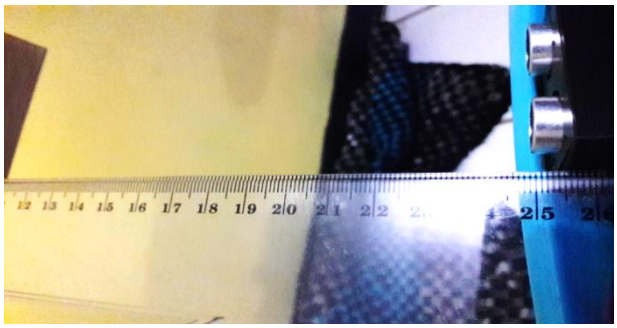


Figure 9. Detection distance

The results of testing the opening and closing series of this trash can be seen in Table 1. The maximum distance obtained is 10 cm.

Tabel 1. Distance measurement

Distance (cm)		0pen/close
Sensor	**Real Distance**	**door**
28,42 cm	30,00 cm	Close
23,77 cm	25,00 cm	Close
19,16 cm	20,00 cm	Close
14,52 cm	15,00 cm	Close
9,45 cm	10,00 cm	Open
4,53 cm	5,00 cm	Open

Testing of the Garbage Compactor Circuit

This test is carried out to find out what percentage of waste compactors.

Figure 10. Level of waste before compaction

It can be seen that the level of waste before compaction is at the level of 20 cm.

Figure 11. Waste level after compaction

After the compaction process is complete with various waste level samples, the following are the results of the testing on the automatic waste compactor system. Table 2 shows the percentage data of the success of this solid waste compaction system where the space in the trash will increase so that it is still possible to accommodate other waste. Thus, referring to the table, it can be seen that this system has succeeded in reducing the volume or level of waste by up to 45% on average.

Table 2. Results of the solid waste compaction test

No	Level Garbage		Percentage
	First Level conditions	Final conditions	
1	5 cm	2 cm	30 %
2	10 cm	6 cm	40 %
3	15 cm	9 cm	60 %
4	20 cm	10 cm	50 %
Average			45 %

Testing IoT Systems

The IoT system in this tool is with the sending of notifications from tools made through the Firebase webserver and the application on the delivery smartphone depending on the signal and the test results get information if the waste bin is fulL see in figure 12.

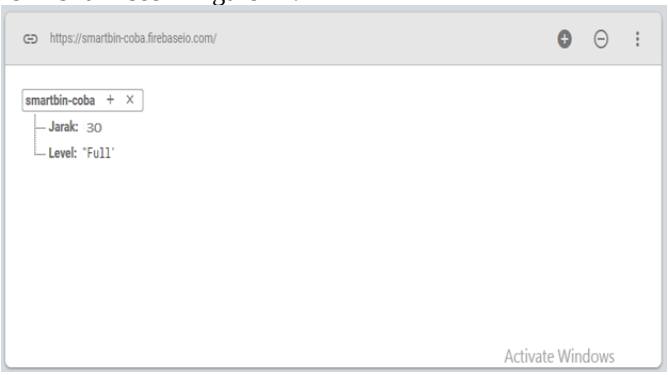


Figure 12. Display on Firebase

4. CONCLUSION

After going through various stages of design and testing, finally, with several reviews carried out on the existing system, it can be concluded that: (a) The opening and closing of the trash can work properly, indicating the servo is reacting to the ping proximity sensor which detects objects with a distance of ≤ 10 cm, (b) compaction has succeeded in reducing the waste level by up to 45% on average, thereby increasing the

empty space in the bin, (c) The microcontroller successfully sends notifications to the Firebase Webserver and applications on the smartphone, so that users can periodically know the condition of the trash.

REFERENCES

[1] F. R. Maulana, T. A. S. Widyanto, Y. Pratama, and K. Mutijarsa, "Design and Development of Smart Trash Bin Prototype for Municipal Solid Waste Management," in *2018 International Conference on ICT for Smart Society (ICISS)*, IEEE, Oct. 2018, pp. 1–6. doi: 10.1109/ICTSS.2018.8550013.

[2] D. J. Dasari, V. Satyadeep Velala, B. Ganbaaatar, and N. Kunicina, "Smart Trash Bin Segregation and Identify and Create Alerts on the Level of Waste Present in the Trash Bin," in *2020 IEEE 8th Workshop on Advances in Information, Electronic and Electrical Engineering (AIEEE)*, IEEE, Apr. 2021, pp. 1–6. doi: 10.1109/AIEEE51419.2021.9435755.

[3] C. Kolhatkar, B. Joshi, P. Choudhari, and D. Bhuva, "Smart E-dustbin," in *2018 International Conference on Smart City and Emerging Technology (ICSCET)*, IEEE, Jan. 2018, pp. 1–3. doi: 10.1109/ICSCET.2018.8537245.

[4] M. Awawdeh, A. Bashir, T. Faisal, I. Ahmad, and M. K. Shahid, "IoT-based Intelligent Waste Bin," in *2019 Advances in Science and Engineering Technology International Conferences (ASET)*, IEEE, Mar. 2019, pp. 1–6. doi: 10.1109/ICASET.2019.8714406.

[5] K. F. Haque, R. Zabin, K. Yelamarthi, P. Yanambaka, and A. Abdelgawad, "An IoT Based Efficient Waste Collection System with Smart Bins," in *2020 IEEE 6th World Forum on Internet of Things (WF-IoT)*, IEEE, Jun. 2020, pp. 1–5. doi: 10.1109/WF-IoT48130.2020.9221251.

[6] L. C. Hin, V. A. Hameed, H. Vasudavan, and M. E. Rana, "An Intelligent Smart Bin for Waste Management," in *2021 IEEE Mysore Sub Section International Conference (MysuruCon)*, IEEE, Oct. 2021, pp. 227–231. doi: 10.1109/MysuruCon52639.2021.9641618.

[7] N. A. Antora, M. A. Rahman, A. Al Mosharraf, M. Ibn Ehsan, M. Alve, and M. M. Elahi, "Design and Implementation of a Smart Bin using IOT for an Efficient Waste Management System," in *2022 25th International Conference on Computer and Information Technology (ICCIT)*, IEEE, Dec. 2022, pp. 774–779. doi: 10.1109/ICCIT57492.2022.10055998.

[8] M. Bhuvaneswari, K. Tansin, S. T. Ahamed, N. T. Sri Ram, and S. V. Prasath, "Internet of Things based Intelligent Waste Segregation and Management System for Smart Home Application," in *2022 7th International Conference on Communication and Electronics Systems (ICCES)*, IEEE, Jun. 2022, pp. 1737–1743. doi: 10.1109/ICCES54183.2022.9835844.

[9] S. Lokuliyana, A. Jayakody, G. S. B. Dabarera, R. K. R. Ranaweera, P. G. D. M. Perera, and P. A. D. V. R. Panangala, "Location Based Garbage Management System with IoT for Smart City," in *2018 13th International Conference on Computer Science & Education (ICCSE)*, IEEE, Aug. 2018, pp. 1–5. doi: 10.1109/ICCSE.2018.8468682.

[10] M. S. Chaudhari, B. Patil, and V. Raut, "IoT based Waste Collection Management System for Smart Cities: An Overview," in *2019 3rd International Conference on Computing Methodologies and Communication (ICCMC)*, IEEE, Mar. 2019, pp. 802–805. doi: 10.1109/ICCMC.2019.8819776.

[11] A. Najmurrokhman, E. F. Ramadhan, D. I. Saputra, N. Ismail, and A. Saehu, "Development of Automatic Trash Bin for Sorting Metal and Non-Metallic Wastes Using Proximity Sensors and Notifications via Telegram," in *2023 9th International Conference on Wireless and Telematics (ICWT)*, IEEE, Jul. 2023, pp. 1–5. doi: 10.1109/ICWT58823.2023.10335243.

[12] N. A. Haqimi and R. T. Kusuma, "Timeline reminder system bot and telegram assistant chatbot for a university student and lecturer," *J. Soft Comput. Explor.*, vol. 4, no. 4, pp. 186–195, 2023.

[13] R. Alfiqi and J. P. Sembiring, "Technology for SMS-based assistive device for the visually impaired," *J. Soft Comput. Explor.*, vol. 4, no. 4, pp. 9–17, 2023, doi: https://doi.org/10.52465/joscex.v4i4.225.

[14] A. M. Furqan Durrani, A. U. Rehman, A. Farooq, J. A. Meo, and M. T. Sadiq, "An Automated Waste Control Management System (AWCMS) by Using Arduino," in *2019 International Conference on Engineering and Emerging Technologies (ICEET)*, IEEE, Feb. 2019, pp. 1–6. doi: 10.1109/CEET1.2019.8711844.

[15] B. S. Sasikanth, L. Naga Yoshita, G. N. Reddy, and M. P.V, "An Efficient & Smart Waste Management System," in *2021 International Conference on Computational Intelligence and Computing Applications (ICCICA)*, IEEE, Nov. 2021, pp. 1–6. doi: 10.1109/ICCICA52458.2021.9697316.

[16] Y. Gunardi, D. Hanafi, F. Supegina, and Torik, "Mathematics base for mobile robot navigation using mirror Petri net Method," in *nd International Conference on Mechanical, Electronics, Computer, and Industrial Technology*, Medan, 2018.

[17] Y. Gunardi, A. Adriansyah, and T. Anindhito, "Small smart community: An application of internet of things," *ARPN J. Eng. Appl. Sci.*, vol. 10, pp. 6341–6347, Jan. 2015.

[18] Y. Gunardi, D. Hanafi, F. Supegina, and Torik, "Design of Navigation Mobile Robot Using Mirror Petri Net Method and Radio Frequency Identification," in *2018 Electrical Power, Electronics, Communications, Controls and Informatics Seminar (EECCIS)*, IEEE, Oct. 2018, pp. 102–107. doi: 10.1109/EECCIS.2018.8692926.

[19] T. M. Kadarina and R. Priambodo, "Preliminary design of Internet of Things (IoT) application for supporting mother and child health program in Indonesia," in *2017 International Conference on Broadband Communication, Wireless Sensors and Powering (BCWSP)*, IEEE, Nov. 2017, pp. 1–6. doi: 10.1109/BCWSP.2017.8272576.

[20] D. N. Utama, R. Ariyadi, I. Hadi, M. R. Seputra, and Y. Setiawan, "Fuzzy-DSM for Evaluating Waste's Hazardousness," in *2019 International Conference on ICT for Smart Society (ICISS)*, IEEE, Nov. 2019, pp. 1–6. doi: 10.1109/ICISS48059.2019.8969836.

[21] T. R. R. Escalona *et al.*, "Design and Fabrication of Solar-Powered Smart Waste Segregation Trash Bin with Image Processing," in *2022 IEEE 14th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM)*, IEEE, Dec. 2022, pp. 1–6. doi: 10.1109/HNICEM57413.2022.10109457.

[22] S. Puig and N. Foukia, "CleverTrash: an IoT system for waste sorting with deep learning," in *2022 IEEE International Conferences on Internet of Things (iThings) and IEEE Green Computing & Communications (GreenCom) and IEEE Cyber, Physical & Social Computing (CPSCom) and IEEE Smart Data (SmartData) and IEEE Congress on Cybermatics (Cybermatics)*, IEEE, Aug. 2022, pp. 1–8. doi: 10.1109/iThings-GreenCom-CPSCom-SmartData-Cybermatics55523.2022.00016.

[23] B. Jana, P. Roy, S. Sengupta, S. Porey, and R. Sen, "GSM controlled location specific garbage collecting Smart-bin," in *2019 9th Annual Information Technology, Electromechanical Engineering and Microelectronics Conference (IEMECON)*, IEEE, Mar. 2019, pp. 211–214. doi: 10.1109/IEMECONX.2019.8877007.