Solar Powered Automatic Waste Management System using LoRaWAN

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Abstract - Solid waste segregation is essential in waste management. This project seeks to present a method of separating four kinds of wastes; metal waste, plastic waste, solid wet waste and paper waste. A short message is sent using LoRaWAN technology to the waste collector alerting him on the status of the waste in the bin. The project has a front ultrasonic sensor which detects the presence of a person 40cm to the bin and then automatically opens the bin for the person to drop the waste. Three sensors made up of inductive and capacitive proximity sensor and a moisture sensor are employed in the dump tray to detect whether the waste is metal, paper or a wet substance and subsequently direct the waste to the appropriate bin. Four other ultrasonic sensors are fitted on top of each of the individual bins to determine the level of the waste in the bins. These four sensors are linked to the front sensor to automatically shut the bin to prevent further addition of waste. A 12volt 60watts solar panel is used to power the system through a lithium rechargeable battery. This project will go a long way to solve the waste challenges wwe have in schools, hotels, hospitals and churches.

Keywords- Segregator, LoRaWAN, inductive proximity sensor, capacitive proximity sensor, SRO4.

I. INTRODUCTION

The rapid increase in population has compounded the challenges in waste management especially in educational institutions, hospitals, hotels and churches. The effects of poor waste management on public health and sustainable environment cannot be over emphasized. For cost effectiveness and time efficiency in solid waste segregating and collection, a smart waste management system is proposed and implemented. There has been a lot of work done to mitigate the problem. Most of which focus on either the automation of the waste segregation and send a notification to the user [1-5] or the automation of the collection which heavily depend on Ethernet, Wi-Fi, GPRS and GSM [6-9]. For a large-scale city-wide deployment, the deployment and maintenance cost of the implementation of the above would be costly due to subscription of internet service and number of nodes required for a unit area. Our system is suitable for urban and rural communities, and areas without internet and electricity.

II. METHODOLOGY

The design is categorized into hardware and software. The hardware part involves the building the mechanism for the waste bin to rotate to accept the waste into the designated smaller bin, wiring and soldering. The software part involves programing the waste bin to automatically open for users to drop their waste and close after dropping the waste. It then locks automatically when the bin is full and send a notification to the waste collector.

A. Detailed design

The front door open and close circuit; this will automatically open for the person to drop the waste into the bin and close when the waste is dropped into the designated chamber. This circuit requires the action of all the sensors coupled with the stepper motor to drive the gate and all are controlled by the Arduino microcontroller.

The sorting mechanism part of the circuit employs a high torque stepper motor which turns to the precise position when it receives signal from the inductive or the capacitive proximity sensor and from the moisture or the SRO4 ultrasonic sensor. This allows the waste to put into its right designation.

The waste monitoring circuit part of the circuit monitors the level of waste in each apartment and send information to the front door to close when the bin is full. This circuit employs four SRO4 ultrasonic sensors controlled by an Arduino

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microcontroller.

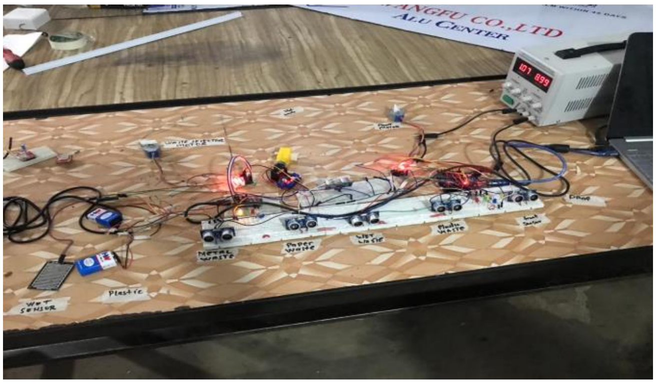

Fig.1. Wiring diagram for detecting the type of waste and sending sms

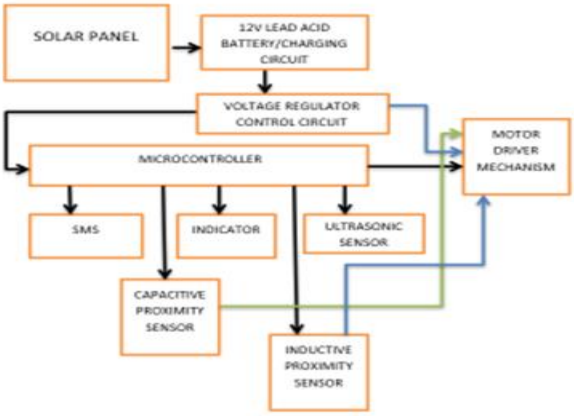

Fig 2. System Flow chart

SMS alert circuit part of the circuit is designed to send sms to the waste collector when the waste in the bin is full. The circuit consists of a sim800l module interfaced with an arduino microntroller.

Fig. 3: Rear view of the solid waste segregator

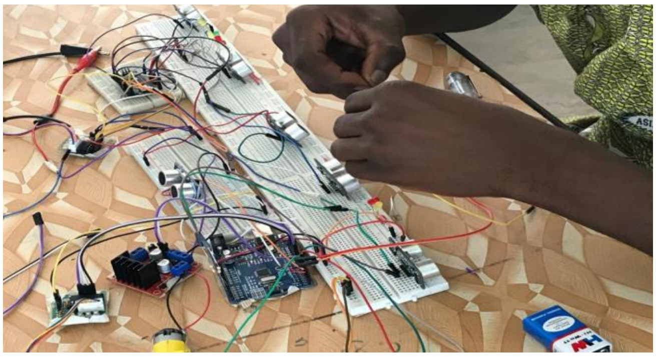

Fig.4. Circuit diagram for opening the front door and determining the waste level in the bins

Fig 5: Front view of the solid waste segregator

B. *Implementation of Interface*

ESp32 boards allows to partition the system flash such that you can use it to store both code and support a file system. This filing system can be used to store infrequently changing data such as web pages, configurations, sensor calibration data etc. The interface was developed using HTML, CSS, and JavaScript. These languages were chosen because we intended to develop a lightweight interface. JavaScript is suitable for this IoT solution development because of its potential to respond to events, asynchronous code execution and Memory Management. HTML and CSS were used to make the interface simple and user-friendly while running on less resources. It is a web interface that shows the current fill level of the bin and alerts the user when the bin is full. With this interface, the user can constantly monitor the changing level status of the bin. When the capacity of the bin is reached, the user is alerted and although the hardware module would be transmitting, the interface would not be updated until the bin is emptied. The interface has the maximum capacity and the minimum capacity of the bin shown at the bottom. there is also a time function to show the time of the day. The interface is served from a local asynchronous server deployed on the receiver module. Fig 4 illustrates the operating mechanism of the monitoring system while Fig 5 shows the dashboard view of the monitoring system.

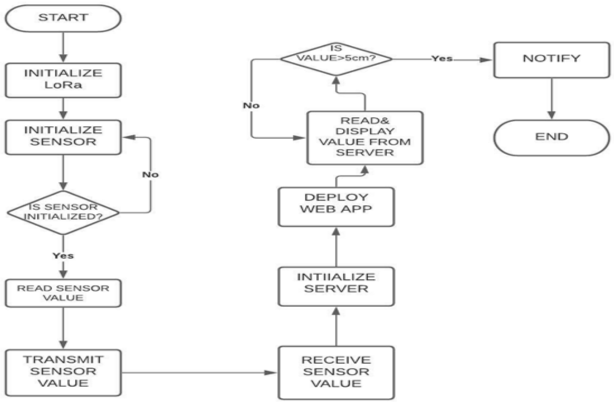

Fig.4: LoRaWAN Flow Chart

Asynchronous servers do not create a new process or thread for a new request. Here the worker process accepts the requests and processes thousands of them with the implementation of highly efficient event loops. Asynchronous means that the threads can be executed concurrently without blocking each other. This ensures the interface is constantly being updated as the transmitter module is transmitting. the interface is such that the maximum and minimum capacity can be calibrated for any bin. The LoRa receiver is running an asynchronous web server and the web page files are saved on the ESP32 FILESYSTEM.

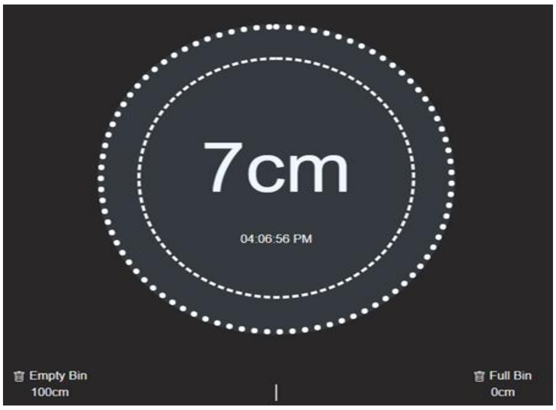

Fig 5: Dashboard View of Web App

III. RESULTS AND DISCUSSION

Preliminary test was conducted on the segregator and the results are as shown in the tables shown below

Table 1: Sensing range between waste and sensor at 10mm

Material	paper	plastic	metal	wet
Percentage sorted	20%	100%	10%	0%

Table 2: Sensing range between waste and sensor at 5mm

Material	paper	plastic	metal	wet
Percentage sorted	40%	100%	50%	0%

Table 3: Direct contact between waste and sensor

Material	paper	plastic	metal	wet
Percentage sorted	100%	100%	85%	100%

Results from Table 1 indicate that at 10mm to the sensors, the ultrasonic sensor was able to detect all the waste material brought near it. The inductive and the capacitive sensors were able to detect only 10% and 20% respectively, but the wet moisture sensor was not able to detect any waste brought near it. When the distance adjusted to 5mm as shown in Table 2, the ultrasonic sensor was able to detect all the waste material brought near it. The inductive and the capacitive sensors were able to detect only 50% and 40% respectively, but the wet moisture sensor was not able to detect any waste brought near it. When the wastes were brought directly in contact with sensors, all the sensors were able to detect all the wastes brought near them as shown in Fig 6.

The test was also conducted during the day to ascertain the performance of the sensors using the solar energy directly and the results are as shown in the bar graph in fig 5. From the graph, the plastic and the wet waste performed well during the day, though the paper and metal didn't perform better during the early and later part of the day, this is because the inductive and the capacitive sensors requires more voltage in their operations more than that of the ultrasonic and the moisture sensor.

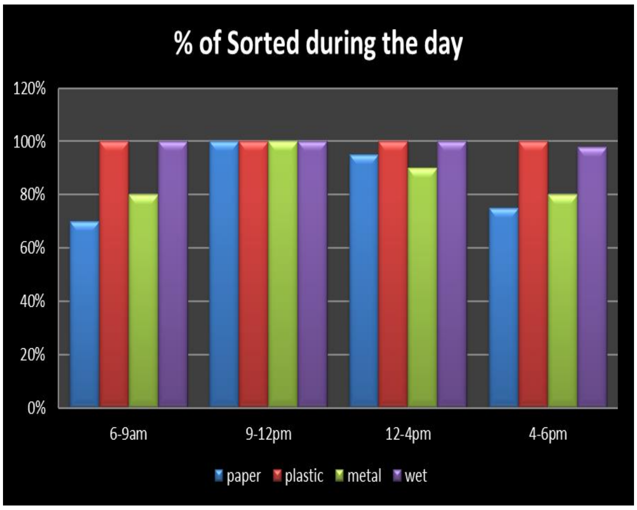

Fig 6. Relationship between percentage sorted during day and night

IV. CONCLUSION

A solid waste management system integrates different sensors and LoRaWAN communication technology to segregate and monitor real-time bin information has been designed and implemented. This system prevents waste bin overflows resulting in clean environment. The system also reduces deployment and operating cost due to the use of solar power and low power, long range LoRa radio communication technology for the monitoring. In addition, it is suitable for use in schools, hospitals, churches hotels environments and in the absence of electricity and internet.

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