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AN INTERNET OF THINGS (IoT) BASED SMART WASTE BIN MONITORING SYSTEM

[1]Erameh Kachikwu B. and [2]Odey Nicholas T.

[1,2] Department of Computer Engineering, University of Benin, Benin, Nigeria.

Abstract

The smart waste bin's goal is to monitor the level of garbage and odor inside the waste bin. An alert is sent to the cleaner's phone when the waste bin is full. The ATMega328P microcontroller serves as the project's brain. The GSM module (GPRS) is used to exchange data between smart waste bins and users (cleaners, end users). In this smart waste bin, the ultrasonic sensor is used as the primary sensor to detect the distance between the garbage and the waste bin, as well as the distance between the waste cleaner and the waste bin. This smart waste bin also includes a MQ135 sensor, which detects bad odors in the waste bin.

Keywords Internet of Things, waste bin, sensor, microcontroller, GSM, MQ135 Sensor, Ultrasonic sensor

Nomenclature	
Vo	Voltage entering the GSM module
D	Distance
S	Speed
DC	Direct current
mS	Micro Seconds
Vcc	Supply voltage

1.0 Introduction

In this project, we developed an IoT-based smart waste bin monitoring system that detects waste and odor levels in the waste bin. This is accomplished through the use of IoT, or the internet of Things, which refers to the process of expanding the power of the internet beyond computers and smartphones to a diverse range of other things, processes, and environments. Those "connected" things either collect data, send data back, or both [1].

There are now a lot of apartments in the rapidly urbanizing neighborhood. This is due to a high demand for housing, which has increased dramatically as people relocate from villages to towns in search of work. In order to accommodate the expanding population in metropolitan regions, the government also built new apartment complexes [2].The residents of these flats are dealing with a number of challenges. One of them is solid waste disposal. Unlike in individual homes, tenants of all units share the same rubbish can, which soon fills up. This garbage overflow is a sanitary hazard that could lead to diseases including cholera, diarrhea, and dengue fever [2]. Furthermore, it is a waste of fuel to drive around a complex or an area only to discover that some of the rubbish bins are full while others are not. On rare occasions, there may be so much rubbish that the truck does not have adequate capacity. When we saw the trash truck driving around the city collecting solid waste twice a day, the thought struck. Despite its thoroughness, this approach proved useless. The above mentioned problems are recurring and unsolved, so we have developed an IoT-based intelligent waste monitoring system to correct the situation We have modeled this prototype to solve these issues stated above.

Existing works have only focused on recognizing rubbish in waste bins, which has limited relevance in reducing the general pollution we face. It has also been noticed that most research concluded on particular significant characteristics that may be adjusted to provide optimal trash bin performance after analyzing the sort of garbage in the waste bin. Such parameters include; waste size, waste bin surface area, Microcontroller used, Type of sensors used. Shwetashree et al [3], devised an automated method for distinguishing wet and dry waste. Arduino serves as the system's microcontroller. The system accomplishes this by utilizing sensors such as an infrared sensor, a moisture sensor, and an ultrasonic sensor. An infrared sensor detects the presence of either wet or dry waste, whereas a moisture sensor detects the presence of wet waste. The distance between the container and the lid is measured by the ultrasonic sensor. When only the IR sensor detects readings, the rotor spins towards the dry waste region; when both the IR sensor and the moisture sensor detect

Correspondence Author: Odey N.T., Email: tochinicolas@gmail.com, Tel: +2348057645210

readings, the rotor spins towards the wet waste area. The incapacity of this work to warn the user when it is overwhelmed with garbage, i.e. the lack of a real-time monitoring mechanism, limits it. Kavya et al [4], created a system that employs an ARM microcontroller and a variety of sensors to successfully sort out the varied rubbish that is placed into the waste bin and assists the trash collector with the recycling process. It demonstrates a real-time technique in which the system detects each rubbish put into it using sensors such as infrared, moisture, and metal sensors. When the garbage can be filled, the system uses a GSM module to send a ping to the phones of trash collection businesses, informing them of its condition. One of the system's flaws is that it lacks a real-time monitoring platform, making it impossible to keep end users and trash collection agencies up to date. Michael et al [5], created a smart waste bin that uses an Arduino Uno as its CPU and a Passive Infrared sensor (PIR) to detect human heat signals and open or close the waste bin's lid. This sculpture exclusively makes use of technology to show how the lid opens and closes. As a result, it is at a severe disadvantage when it comes to understanding the volume of waste in the bin and controlling waste disposal through the use of IoT capabilities.

This project creates a novel garbage disposal idea by utilizing an automatic waste level using ultrasonic sensor, as well as a sensor MQ136 for odor detection, and will offer real-time information on waste containers throughout the city. When the waste bin is full or an odor is detected, the relevant authority or persons must receive this information to clean the waste bin via a website that has already been developed. For real-time data, we rely on GSM. GSM is now the backbone of communication systems, a low-cost, high-performance, and simple-to-implement device. When the dustbin is full, the GSM module sends a message to the cloud, reads the cloud message, and interprets it in the form of an alert message to the user.

1.1 Basic Concepts and Definitions

Internet of Things: The internet of things (IoT) is a network of interconnected computing devices, mechanical and digital machines, objects, animals, or people that have unique identifiers (UIDs) and the ability to transfer data over a network without the need for human-to-human or human-to-computer interaction. IoT devices share sensor data by connecting to an IoT gateway or other edge device, from which data is either sent to the cloud for analysis or analyzed locally [6]. These devices occasionally communicate with other related devices and act on the information they receive from one another. The devices do the majority of the work without human intervention, though people can interact with them to set them up, give them instructions, or access data.

ATMEGA328P Microcontroller: The ATmega328P is a high-performance AVR microcontroller with a large number of pins and features. It is built with 8-bit CMOS technology and an RSIC CPU, which improves its performance and power efficiency. It also has an internal temperature sensor and auto sleeps. This ATmega328P IC includes internal safeguards and multiple programming methods, allowing engineers to prioritize this controller for various situations. The IC enables multiple modern-era communications methods for other modules and microcontrollers.

Ultrasonic Sensor: An ultrasonic sensor is an electronic device that emits ultrasonic sound waves and converts the reflected sound into an electrical signal to determine the distance between a target object and itself. Ultrasonic waves travel at a faster rate than audible sound waves (i.e. the sound that humans can hear). The transmitter (which emits sound via piezoelectric crystals) and the receiver are the two main components of ultrasonic sensors (which encounters the sound after it has travelled to and from the target).

GSM: GSM, or Global System for Mobile Communications, is the most widely used wireless cellular communication technique for public use. The GSM standard was created to define protocols for digital cellular networks of the second generation (2G).It began as a circuit switching network, but after incorporating General Packet Radio Service (GPRS) technology, packet switching was implemented. GSM frequency bands that are commonly used are 900 MHz and 1800 MHZ.

Servo Motor: A servo motor is a type of electromechanical device that generates torque and velocity based on the current and voltage supplied. A servo motor is part of a closed loop system that provides torque and velocity as commanded by a servo controller, with the loop closed by a feedback device. The feedback device sends information to the servo controller, which adjusts the motor action based on the commanded parameters, such as current, velocity, or position.

MQ135 Sensor: Ammonia, nitrogen, oxygen, alcohols, aromatic compounds, sulfide, and smoke are all detected by the MQ-135 gas sensor.

Web Development: The work involved in creating a Web site for the Internet (World Wide Web) or an intranet is known as web development (a private network).

DC to DC Converter:A DC-DC is an electronic power transformer that accepts a DC input voltage as well as a DC output voltage

1.2 Definition of Variables

DC=Direct Current

Vo =Voltage entering the GSM module
Vcc =Supply Voltage
D = Distance
S = Speed
mS = Micro Seconds

2.0 Methodology

The Ultrasonic Sensor and MQ 135 sensor in this project detect the level of solid trash and odor extracted. The sensors are interfaced with ATMega328P microcontroller. GSM and IOT are integrated into the system for microcontrollers to provide real-time garbage disposal status updates.

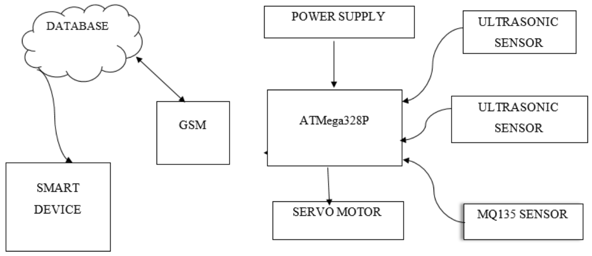

Figure 1. Block Diagram

2.0.1 GSM Module

The principal function of this module is to enable wireless connection between the smart waste bin system and the IoT web platform. The module is used to link the hardware to the IoT platform by utilizing its GPRS capability. The GSM module utilized in the project work is SIM800L, which runs with a voltage range of 3.4 – 4.4v to avoid damage. To protect the module from damage, a voltage divider is utilized to scale the voltage from the microcontroller's transmit line down before it reaches the module.

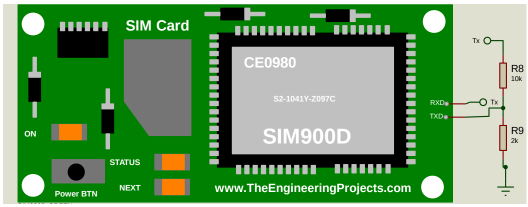

Figure 2. GSM setup

Using voltage divider rule:

$$Vo = \frac{R1}{R1+R2} * Vcc \text{--} (1)$$

$$Vo = \frac{2k}{2k+1k} * 5 = 3.333v \text{ --} (2)$$

2.0.2 General Packet Radio Services

The General Packet Radio Service (GPRS) is a packet switching technology that allows data to be transferred across cellular networks. GPRS expands the functionality of GSM.

2.0.2.1 How The GPRS Work

The GPRS integration allows the device to connect wirelessly to the web or internet from any location utilizing the available means (in this case the internet access is provided by SIM card).

As a result, GPRS is used to refresh the database with warning system signals or information. GPRS has the advantage of not constantly being actively connected, hence it can be defined as passively connected. It becomes active when there is a signal. As a result, energy is used more effectively.

2.0.3 Ultrasonic Sensor

The ultrasonic sensor's capacity is utilized to monitor the level of waste in the bin as well as detect human presence approaching the waste bin. The sensor is connected to the microcontroller, and its measurements are used to update the web page through GSM (GPRS). It all begins with a pulse on the Trigger pin that lasts at least 10 S (10 microseconds). The sensor responds by sending an eight-pulse sound burst at 40 KHz. The device's "ultrasonic signature" is distinguished by its 8-pulse sequence, which allows the receiver to distinguish the transmitted pattern from ambient ultrasonic noise. The eight ultrasonic pulses move through the air after leaving the transmitter. In the meantime, the Echo pin is set to HIGH to start the echo-back signal. If those pulses are not returned, the Echo signal will timeout and return low after 38 mS (38 milliseconds). As a result, a 38 mS pulse shows that no blockage is within the sensor's detection range. If the reflected pulses are received, the Echo pin goes low immediately. This produces a pulse with a width varying from 150 S to 25 mS, depending on how long it took to receive the signal. The width of the received pulse is then utilized to compute the distance to the reflected item. This can be calculated using a basic distance-speed-time equation.

Distance = 1/2(Speed x Time) --- (3)

2.0.4 MQ135 Sensor

The web platform is being updated using MQ135's ability to detect foul odors in the environment. Holding the gas sensor near the smoke/gas that it should detect and turning the potentiometer until the Red LED on the module begins to glow is how the gas sensor is calibrated. To increase sensitivity, turn the screw clockwise, and to decrease sensitivity, turn it anticlockwise. The comparator on the module is constantly checking to see if the analog pin (A0) has reached the threshold value set by the potentiometer. When it crosses the threshold, the digital pin (D0) goes HIGH and the signal LED illuminates. This configuration is useful for instructing the microcontroller to perform an action when a certain threshold is reached. The microcontroller then sends data from the sensor to the web.

2.0.5 Microcontroller

This unit houses the device's control unit. It is in charge of how the device works. It collects data from the sensing unit, processes it, and sends the results to the database over GSM.

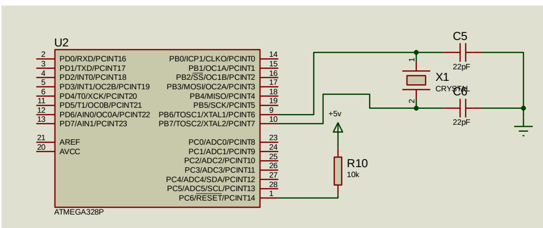

Figure 3. ATMEGA328P setup

2.0.6 Cloud/Web Application

The GSM module's GPRS capability is used to transfer data from the GSM module to the web-based application. The diagram below depicts the data movement diagram, which describes the movement of data across the entire system, from the electronic device to the web platform and back.

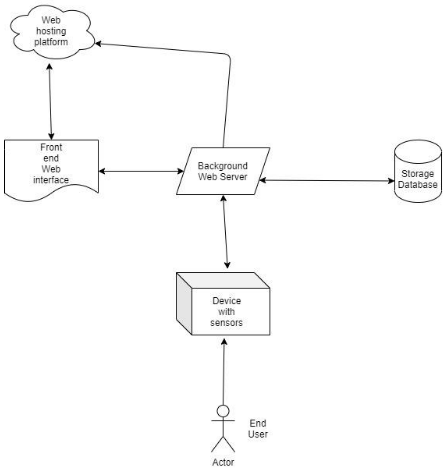

Figure 4. Web movement diagram

2.0.7 Flowchart of the system.

The system flowchart depicts the flow of information and procedure in the Smart waste bin management system. When the system is turned on, it checks for human presence within a predefined range; if it does not detect the presence of a human being, it continues to check until it does. When it detects the presence of a human, the garbage bin opens to allow the human to dispose of their waste. When the waste has been disposed of, the system checks to see if human presence is out of range and then closes.The system performs a continual concurrent check to determine whether the level and filth of waste have reached an alarming level. If it hits a specific level, it sends a prompt to the website.

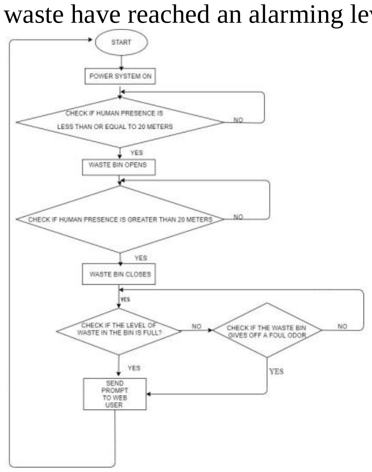

Figure 5. Flowchart of the system

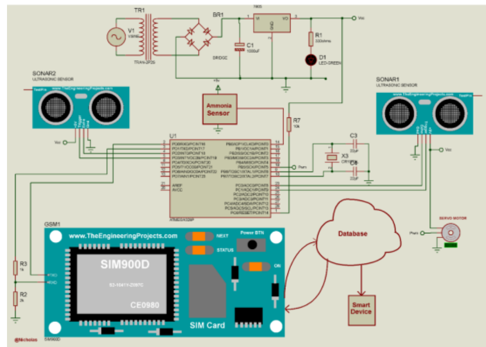

Figure 6. Circuit Diagram

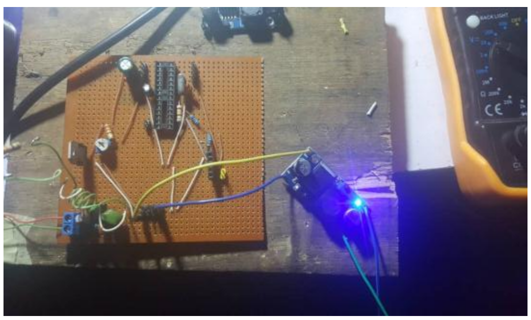

Figure 7. Circuit on Vero board

3.0 Results and Discussion

The system test stage checks that the system functions correctly and meets all the requirements identified in the analysis stage. The IOT intelligent waste monitoring system were tested below following:

1. Functionality Testing
2. Performance Testing
3. User Acceptance Testing
4. Application Testing

2.0.1 Functionality Testing

Functionality testing ensures that the project performs and functions correctly in accordance with the design specifications. We check the web's core application functions, the sensors' response to stimulus, connectivity, and installation during functionality testing. Functionality testing ensures that a project remains fully operational after deployment.

2.0.2 Performance Testing

Performance testing aids in the development of higher-quality software in less time and at a lower cost. The goal is to test performance early and frequently during the development process, as well as to test functionality and performance simultaneously. This is due to the fact that the longer you wait to conduct performance tests, the more expensive it will be to implement changes.

2.0.3 User Acceptance Testing

User Acceptance Testing (UAT) is a formal testing of user needs, requirements, and business processes to determine whether or not a system meets the acceptance criteria and to allow the user, customers, or other authorized entity to decide whether or not to accept the system. We already know what kind of feature is being tested by the user and what the user's expectations are in user acceptance test.

2.0.4 Application Testing

We tested the first release of the IoT smart waste bin monitoring system. Testing was carried out in order to obtain feedback on how the actual system functions.The circuit was design using proteus simulation software, the design was implemented using a breadboard and finally transferred to a Vero board, the code was written using Arduino IDE and hex file dumped into the Atmega328p microcontroller using TL866 universal programmer.

The link to the GitHub repository where the source code for this project is based is given thus: https://github.com/nicholasotamendi/smart-waste-bin.git

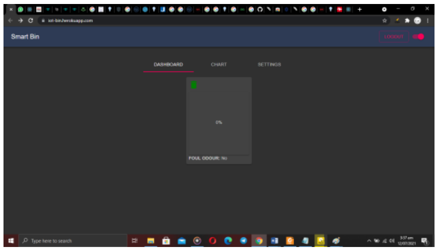

Figure 8. System at 0% waste

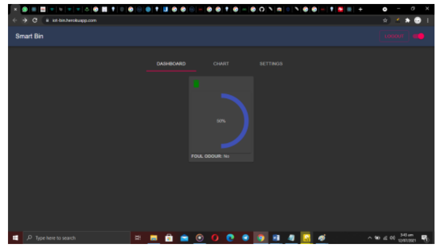

Figure 9. System at 50% waste

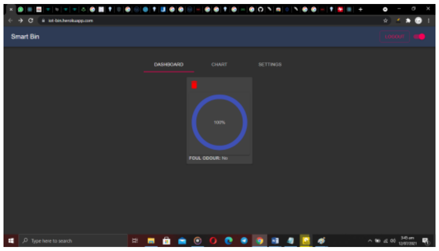

Figure 10. System at 100% waste

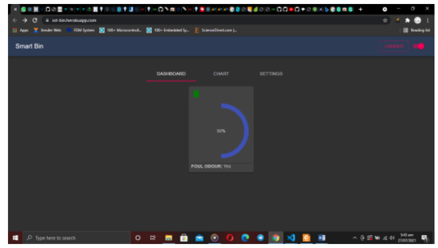

Figure 11. System detecting foul odor

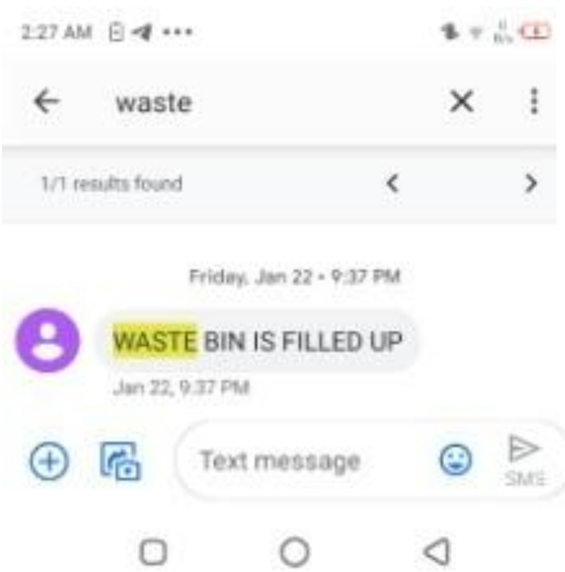

Figure 12. Alert sent to user phone

At the end of this work, the system effectively

i. Detects the level of waste in the waste bin
ii. Detects the smell in the waste bin
iii. Sends the data gathered by the microcontroller from the various sensors to the web platform using the GSM(GPRS) module
iv. Sends alerts to the end users notifying them of its state

6.0 Conclusion and Insights.

The goal of this project was to create a smart waste monitoring system using internet of things technology most efficiently and practically possible, and the goals were met using the best approach possible. The system achieves this with an efficiency rate of 85%. This project will be very useful to individuals and waste companies who have always had problems with waste disposal. The incorporation of IoT into the waste management process is the foundation for addressing Nigeria's widespread pollution problem. It also results in a higher and more efficient work rate for waste disposal services. It will also encourage users of alternative waste disposal systems to purchase and use these systems, which provide a cleaner and smarter source of waste disposal that is safer for the environment.

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