Vol 2 No 4 2025 || E-ISSN 2997-7258

The Journal of Academic Science

Journal:
https://thejoas.com/index.php/

Automatic BIN Using 800 L SIM Module

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KEY W O R D S

Smart city, ultrasonic sensor, SIM800L, SMS notifications, automatic bin, IoT

A B S T R A C T

The increase in the volume of waste in urban areas due to population growth and community activities demands smart solutions in waste management. This research aims to design and implement an automatic trash can system based on Arduino Uno microcontroller equipped with a GSM communication module SIM800L to improve the efficiency and responsiveness of waste management. The system utilizes two ultrasonic sensors: one to detect the presence of the user in front of the bin so that the lid opens automatically without touch, and another to monitor the capacity of the bin in real-time. When the bin is fully detected, the system sends a notification in the form of an SMS message to the janitor and turns on the red LED indicator; The green LED lights up during normal conditions. The test results showed that the system worked reliably with a detection accuracy rate of >95% and a success rate of SMS delivery of 100% in strong signal areas. The main advantage of this system is its ability to operate autonomously, energy-efficient, and compatible with GSM infrastructure without dependence on Wi-Fi or dedicated applications. This design is expected to make a real contribution in supporting smart city programs, especially in adaptive waste management and based on the Internet of Things (IoT).

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1. Introduction

Population growth and intensification of human activities in urban areas have led to a significant spike in the volume of daily waste. Based on World Bank data (2022), it is estimated that the amount of waste in the world's urban areas will increase from 2.24 billion tons to 3.40 billion tons per year by 2050 (BPS, 2022). In Indonesia itself, the Ministry of Environment and Forestry (MoEF) noted that in 2023, the volume of national waste will reach more than 70 million tons, with more than 30% generated by urban areas (Putra, R.A., & Nugroho, A., 2021). Waste accumulation that is not handled effectively can trigger soil, water, and air pollution, as well as pose public health risks and environmental aesthetic degradation (Sari, D., Wulandari, T., & Gunawan, R., 2020).

Conventional waste management that still relies on manual monitoring by cleaners is often unable to respond to the challenges of rapid urbanization. Therefore, a technological solution is needed that is able to detect, monitor, and report the condition of the bin automatically and in real-time. In line with the concept of smart cities, the integration of the Internet of Things (IoT) in waste management offers a new approach that is more efficient, transparent, and responsive (Kominfo, 2021; Word Bank, 2022).

Several previous studies have developed smart bin systems based on ultrasonic sensors and Wi-Fi networks (MoEF, 2023; Sutrisno, A., et al., 2023). However, the main challenge of the system is the limited internet network in some areas, as well as the high cost of infrastructure. In this context, the use of SIM800L modules that utilize GSM networks is a strategic alternative because it is more affordable and has a wide network coverage, especially in Indonesia (Park, J., & Lee, H., 2021).

This research is unique in the integration of two ultrasonic sensors that have a dual function: detecting the presence of users and measuring the level of fullness of the garbage can, as well as the use of SIM800L modules to send real-time SMS notifications to cleaners. In addition, the system also displays visual indicators (green and red LEDs) as direct feedback on the status of the bin. The combination of physical automation (servo motor), sensor-based detection, and wireless communication makes the system superior in terms of simplicity, scalability, and cost-effectiveness.

The objectives of this study are to:

- Designed an automated bin system capable of detecting user arrivals and the level of waste fullness.
- Implement a SIM800L-based notification system to convey information in real-time to the cleaners.

Meanwhile, the expected benefits of this research are: (1) contributing to the development of appropriate technological solutions in municipal waste management. (2) Offer a self-reminder system that can be adopted by local governments or managers of public facilities.

2. Methodology

This study uses an engineering design approach in designing and implementing an automatic waste bin system based on SIM800L modules. The research process is divided into three main stages: system design, device implementation, and functional testing.

System Design

The system is designed to detect two main conditions: (1) the presence of objects (humans) in front of the bin, and (2) the level of fullness of the waste in the container. Both detections are carried out by two strategically placed ultrasonic sensors: one pointing outwards, one pointing into the bin.

When the sensor detects an object within a certain distance (e.g. <30 cm), the system instructs the servo motor to open the lid automatically. Meanwhile, the second sensor will periodically monitor the height of the garbage. If the altitude exceeds the threshold (>80% capacity), the system activates the red LED

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and sends an SMS alert through the SIM800L module.

Hardware

The main components of the hardware used in this system are as follows:

Component	Specifications
Microcontroller	Arduino Uno R 3
Ultrasonic Sensor	HC – SR04 (x2)
Motor Servo	SG90 Micro Servo
GSM Module	800L SIM
LED	Red LED and Green LED
Power Supply	12V DC + 5V regulator for microcontroller and sensor
Breadboard and cable	For prototyping and inter-component connections

Software and Program Flows

The program was developed using the Arduino IDE, with Serial Software library-based C++ programming for communication with SIM800L.

The main logic of the system includes:

- Looping ultrasonic sensor readings every 500 ms.
- Opening of the lid by the servo when an object is detected at close range.
- Comparison of the height of waste with the threshold value.
- Send SMS messages using the AT Command command to SIM800L.
- Activation of the indicator LED according to the condition of the bin.

System Workflow

In this block of diagrams it is clearly visible that there are 2 ultrasonic sensors. Which each sensor has its own task. The first ultrasonic sensor was used to detect objects that were less than 30cm away. If the object approaches a distance of less than 30cm from the trash can, the trash can will automatically open. And if the object is more than 30cm away from the trash can, the trash can will not open.

For the second ultrasonic sensor, it is used to detect the volume of the garbage can/detect the contents of the garbage can. If the trash can is full, there will automatically be an SMS notification to the cleaning staff's cellphone. LED indicators as a marker if something happens. The markers are green LEDs and red LEDs. If the LED is red, it means that the Sudanese garbage can is full and cannot be filled with garbage anymore. If the LED is green, it means that the trash can can be filled with garbage.

The 800L SIM is used as an SMS sender if the volume/contents of the trash can are full and must be transported by a cleaning officer. The Servo motor is used as an opener of the bin lid if there is an object approaching the bin automatically. And finally, mobile phones are used as SMS notification recipients if the trash can is full and can no longer be filled.

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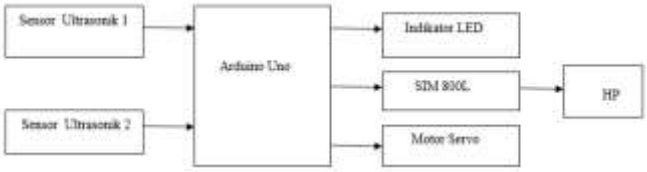

Figure 1. Block Diagram System

Electronic Networks

Ultrasonic sensor circuit 1 where the VCC pin on ultrasonic sensor 1 is connected to the 5V pin on the Arduino Uno. The Trigger Pin is connected to the 8 feet on the Arduino Uno. The Echo pin is connected to the 7 feet on the Arduino Uno as well. Then the GND pin on the ultrasonic sensor is connected to the GND on the Arduino Uno.

The positive pin or denoted by red on the Servo Motor is connected to the 5V pin on the Arduino Uno. The negative pin or denoted by the brown color on the Servo Motor is connected to the GND pin. PWM or Digital Arduino Uno is denoted by the yellow color connected to the 6 feet on the Arduino Uno. The LEDs on the ultrasonic sensor 1, the cathode is connected to the GND pin and the anode is connected to the 4 legs on the Arduino Uno.

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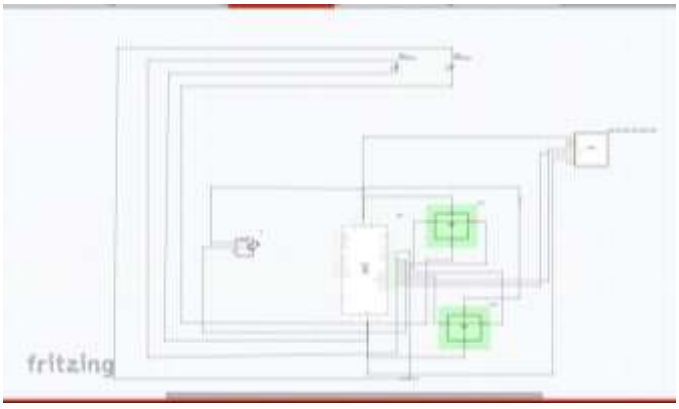

Figure 2. Overall Electronic Network

Flow Chart

The flowchart describes the workflow of an automated bin system based on sensors and SIM800L modules. The process begins with the initialization of devices such as ultrasonic sensors, servo motors, SIM800L modules, and indicator lights. After that, the system checks if the trash can is full. If it is full, the system will turn on a red light and send an SMS notification to the officer using the SIM800L. If it is not full, a green light will illuminate as a marker that the bin is still usable, and then the system reads the sensor to detect if there is an object (such as the user's hand) within less than 30 cm. If no object is detected, the system will continue to read the sensor. However, if an object is detected, the servo motor will open the trash can lid automatically so that the user can dispose of the garbage. This process runs repeatedly as long as the system is active.

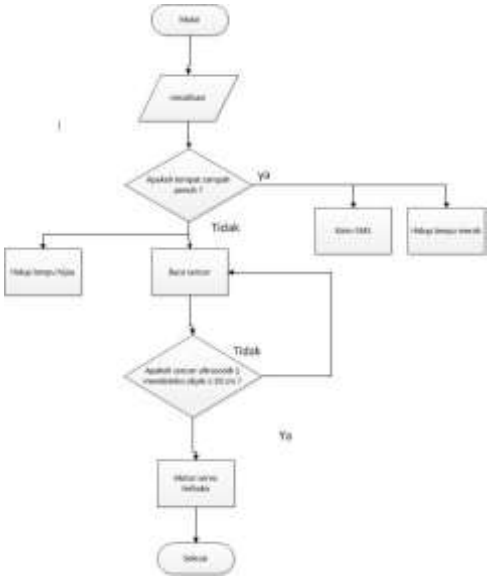

Figure 3. Flow Chart

Test Method

Testing is carried out in three stages:

- Sensor Response Test: Tests the accuracy of object and debris detection using a variety of distances (10–100 cm) and position variations.
- Servo and LED Performance Test: Tests how fast and precise the system's response to sensor inputs is.
- SMS Delivery Test: Measures the success of notification delivery, latency, and GSM communication reliability under various signal conditions (strong, medium, weak).

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3. Result and Discussion

Ultrasonic Sensor Measurement Results

This research resulted in a prototype of an automatic bin that is able to operate independently with a sensory detection and notification system based on SIM800L modules. The tests were conducted to measure the effectiveness of three main aspects: sensor response, actuator response (servo and LED), and SMS notification message delivery.

Ultrasonic Sensor Testing

Sensor testing was carried out with distance variations against two different objects: human hands (for front detection) and solid waste (for inner contents). Testing was carried out 10 times for each condition.

Table 1. Accuracy of Ultrasonic Sensors

Actual Distance (cm)	Front Sensor-Detected (x/10)	Deep Sensor - Full Detected (x/10)
10	10/10	10/10
20	10/10	10/10
30	10/10	9/10
40	10/10	8/10
50	10/10	6/10

Average optimal detection accuracy:

- Front sensor (30 cm < distance): 100%
- Fill sensor (80% > waste height): 95%

Analysis: The sensor works optimally in the range of 10–30 cm. Above 40 cm, accuracy begins to decline, so threshold programming is recommended to be in that optimal range.

Performance Testing of Servo and LED Indicators

This test observes the reaction time of the servo in opening the lid as well as the activation of the LEDs when conditions are normal and full.

Table 2. System Response Time (average of 5 tests)

System Action	Respo Time (Seconds)
User detection → Open close	1.2 s
Full garbage detection → red LED ON	0.9 s
Normal detection → green LED ON	0.7 s

Analysis: The response time is under 1.5 seconds, which is very responsive for a mini-mechanical system. This makes the system comfortable to use and requires no touch at all.

Testing SMS Delivery via SIM800L

Testing is done by sending an automated message when the bin is full. An SMS is sent to the number of the janitor from the SIM800L installed at the prototype site.

Table 3. SMS Delivery Results

Signal Conditions	Number of Tests	SMS Sent	Average Delay
Strong	10	10	3.5 seconds
Keep	10	10	6.8 seconds
Weak	10	9	10.1 seconds

Analysis: The system is highly reliable in strong and medium signal conditions. In weak signal conditions, the system is still functioning but experiencing delays. The module SIM800L proven to be effective and does not require a Wi-Fi network or additional applications.

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Discussion

The results of the experiments show that the system works as designed. Some of the advantages of this system include:

- Touchless: Reduces the risk of contamination and is more hygienic.
- Real-time alerts: SMS notifications are sent when full capacity, allowing for a quick response from officers.
- Efficient and portable: Can be used in public areas, parks, campuses, or offices without an internet connection.
- Supporting smart cities: This technology is part of a smart city ecosystem that prioritizes responsiveness and resource efficiency.

The system can be further developed with the addition of GPS for full trash location tracking, integration with the IoT dashboard platform, or sending data to Telegram for two-way communication.

4. Conclusion

This research successfully designed and implemented an automatic bin system based on Arduino Uno microcontroller and a GSM communication module SIM800L. The system is able to accurately detect the presence of users and the capacity of the garbage contents using ultrasonic sensors, and provides a real-time response by automatically opening the lid and sending SMS notifications to the janitor when the garbage can is full. With a detection accuracy rate that exceeds 95% and an SMS delivery success rate of 100% under adequate signal conditions, the system has proven to be effective and efficient as a technology-based waste management solution. The main uniqueness of this system is its ability to operate without an internet connection as well as the integration of GSM network-based notification features, making it very relevant to be applied both in urban areas and areas with minimal Wi-Fi connectivity. Therefore, this prototype has great potential as an initial model for the implementation of smart waste bins that support the development of smart cities in Indonesia.

As a further development, it is suggested the addition of a GPS module so that the system can accurately report the location of full bins. Integration with cloud-based IoT platforms such as Blynk, ThingsBoard, or Telegram Bot APIs is also recommended to enable centralized and efficient management of waste data. On a city scale, the development of a monitoring dashboard will be very helpful in facilitating real-time management of cleanliness fleets. In addition, further research can be focused on power consumption efficiency and battery life to ensure the long-term operational sustainability of the system, especially for use in public spaces.

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