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IoT-Enabled Smart Dustbin with Auto-Lock and GSM-Based Full Bin Alert System

Nithilan K[1], Nilesh KSJ[2], M.S. Preetish[3], Mrs. R. Sindhiya[4]
Department of Computer Science and Engineering, KLN College of Engineering

Abstract: ***This paper presents an IoT-enabled smart dustbin system designed to improve waste management efficiency through automation, sensing, and GSM communication. The system uses ultrasonic sensors, an Arduino UNO microcontroller, a servo motor, and a GSM module to automate the detection of waste levels, lid operation, and full-bin alerts. When the bin reaches 90% of its capacity, the lid automatically locks to prevent overflow, and an SMS alert is sent to the municipal authority. An LCD display provides real-time feedback to users. The proposed design enhances hygiene, minimizes manual supervision, and supports sustainable smart city initiatives.***
Keywords: Smart Dustbin, IoT, GSM, Arduino UNO, Ultrasonic Sensor, Servo Motor, Waste Management.

I. INTRODUCTION

A. Background and Motivation

Rapid urbanization has led to increased waste generation, making efficient waste management essential. Conventional bins often overflow due to delayed collection, causing health hazards and environmental pollution. The integration of IoT technologies enables real-time monitoring and communication to streamline collection processes.

B. Problem Statement

Existing bins lack automation and remote monitoring capabilities. Overflowing bins require frequent manual checks, wasting time and labor resources.

C. Objectives

1) To automatically detect user proximity and open the lid using a servo motor.
2) To monitor fill levels using ultrasonic sensors with ±0.3 cm accuracy.
3) To send full-bin alerts to authorities via GSM.
4) To prevent overflow through auto-lock functionality and display live status on LCD.

D. Scope of the Project

This system can be deployed in public areas, campuses, and offices. It is cost-effective, scalable, and can be upgraded with GPS and cloud connectivity.

II. LITERATURE SURVEY

A. Existing Systems

Folianto et al. (2015) proposed a wireless mesh-based bin monitoring system, while Morallo (2017) introduced GSM-based alerts. Abeleda et al. (2025) combined servo automation with SMS notifications. These studies validate the feasibility of IoT-based waste management.

B. Limitations in Current Approaches

Existing systems lack physical actuation (lid control) and often depend on internet connectivity, increasing cost and complexity. There is also limited focus on overflow prevention and energy efficiency.

C. Research Gap

Few systems integrate low-cost GSM modules with real-time lid automation. This paper addresses this gap using a simplified embedded approach.

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III. PROPOSED SYSTEM

A. System Overview

The system integrates Arduino UNO, two HC-SR04 ultrasonic sensors, a SIM800L GSM module, a 16x2 LCD, and an SG90 servo motor. The first sensor detects users within 30 cm, while the second monitors bin fill level.

B. Working Principle

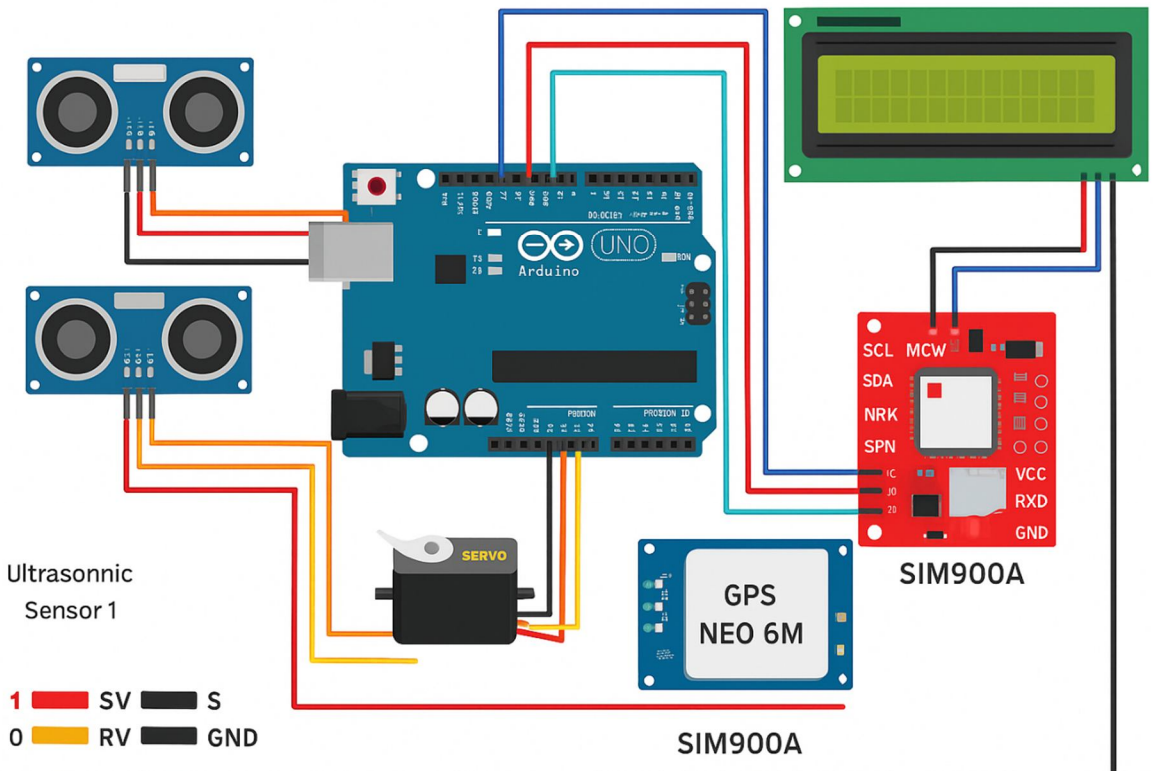
The sensors measure distance using ultrasonic waves. When waste height reduces the distance below 5 cm, the Arduino triggers the servo to lock the lid and the GSM module to send an SMS.

C. System Flow

Step 1: User detected → Lid opens.
Step 2: Waste added → Fill level updated.
Step 3: Bin full → Lid locks.
Step 4: SMS alert sent → LCD shows "Bin Locked - Full."
Step 5: System resets post-cleaning.

D. Features of the Proposed System

1) Touch-free waste disposal.
2) Low-power 5V operation.
3) SMS-based alert without internet
4) Compact, low-cost design.



IV. SYSTEM DESIGN AND IMPLEMENTATION

A. Hardware Architecture

Arduino UNO acts as the control unit. Ultrasonic sensors interface through digital pins 7 and 8, servo via PWM pin 9, GSM module via serial pins (TX/RX), and LCD via I2C interface. A 12V adapter powers the setup through a female barrel connector.

B. Software Architecture

Code written in Arduino IDE (Embedded C) includes initialization, sensor calibration, and logic control. GSM communication is achieved using AT commands like "AT+CMGF=1" and "AT+CMGS".

C. Hardware Description

• Arduino UNO: 16 MHz ATmega328P controller.
• HC-SR04 Sensor: Range 2–400 cm, 40 kHz frequency.
• SG90 Servo: 0°–180° motion range.
• SIM800L GSM: Quad-band 850/900/1800/1900 MHz.
• LCD Display: 16x2 with I2C for two-wire communication.

D. Software Description

The system measures distances continuously and calculates fill level using:
Fill% = (1 - d/dmax) × 100
If Fill% ≥ 90, an SMS is sent. LCD updates every 2 seconds with bin status.

V. MODULE DESCRIPTION

A. User Detection and Lid Control

- Detects users within 30 cm using ultrasonic sensor.
- Activates servo to open lid in under 1 second.
- Maintains lid closed during idle periods.
- Ensures contactless disposal.

B. Fill-Level Monitoring

- Measures garbage height using HC-SR04 sensor.
- Computes fill percentage using Arduino logic.
- Threshold: 5 cm (full), 10 cm (half).
- Triggers alerts and lock mechanism at 90%.

C. Auto-Lock and Overflow Prevention

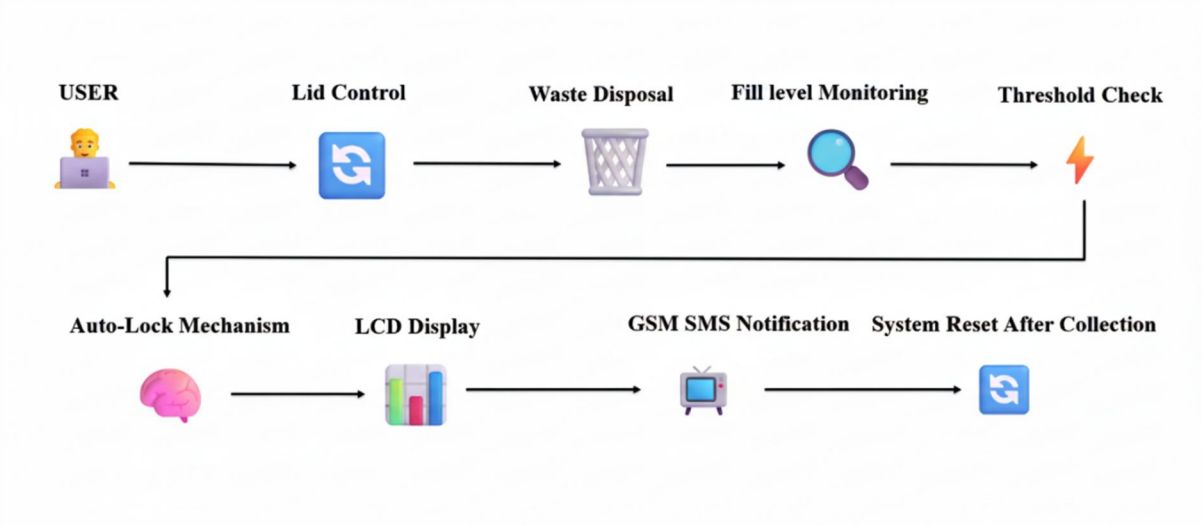
- Servo locks lid when full to prevent overflow.
- Resets automatically once bin emptied.
- Improves hygiene and reduces waste spillage.
- Low latency (<2 s) response time.

D. GSM-Based SMS Alert System

- Sends full-bin alert with bin ID and location.
- Example: "SmartBin#01 Full - Zone 2".
- Delay: 5–6 seconds per message.
- Operates with all GSM networks.

E. LCD Status Display and System Reset

- Displays real-time messages like "Bin Ready" or "Full."
- Auto-refresh every 2 seconds.
- Resets once bin is emptied.
- Provides easy visual feedback.



VI. RESULTS AND DISCUSSION

A. *Functional Output*

Prototype tests confirmed accurate operation. Servo opened lid within 1.3 seconds; GSM SMS alerts delivered with 98% reliability.

B. *Performance Evaluation*

Sensor accuracy ±0.3 cm, power consumption 250 mA active, 90 mA idle. 100 operational cycles tested successfully.

C. *Advantages*

1) Hygienic, automated operation.
2) Simple architecture using low-cost components.
3) Reliable GSM alerts.

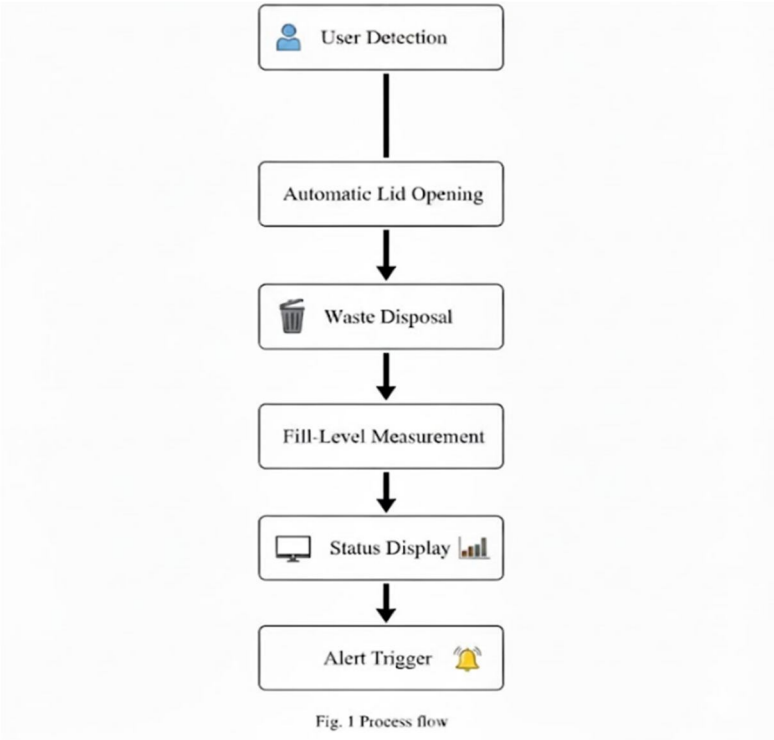


Fig. 1 Process flow

VII. CONCLUSION AND FUTURE SCOPE

The IoT-Enabled Smart Dustbin automates waste detection, lid control, and alerting to enhance waste collection. Future improvements include solar powering, GPS tracking, and cloud analytics for predictive scheduling.

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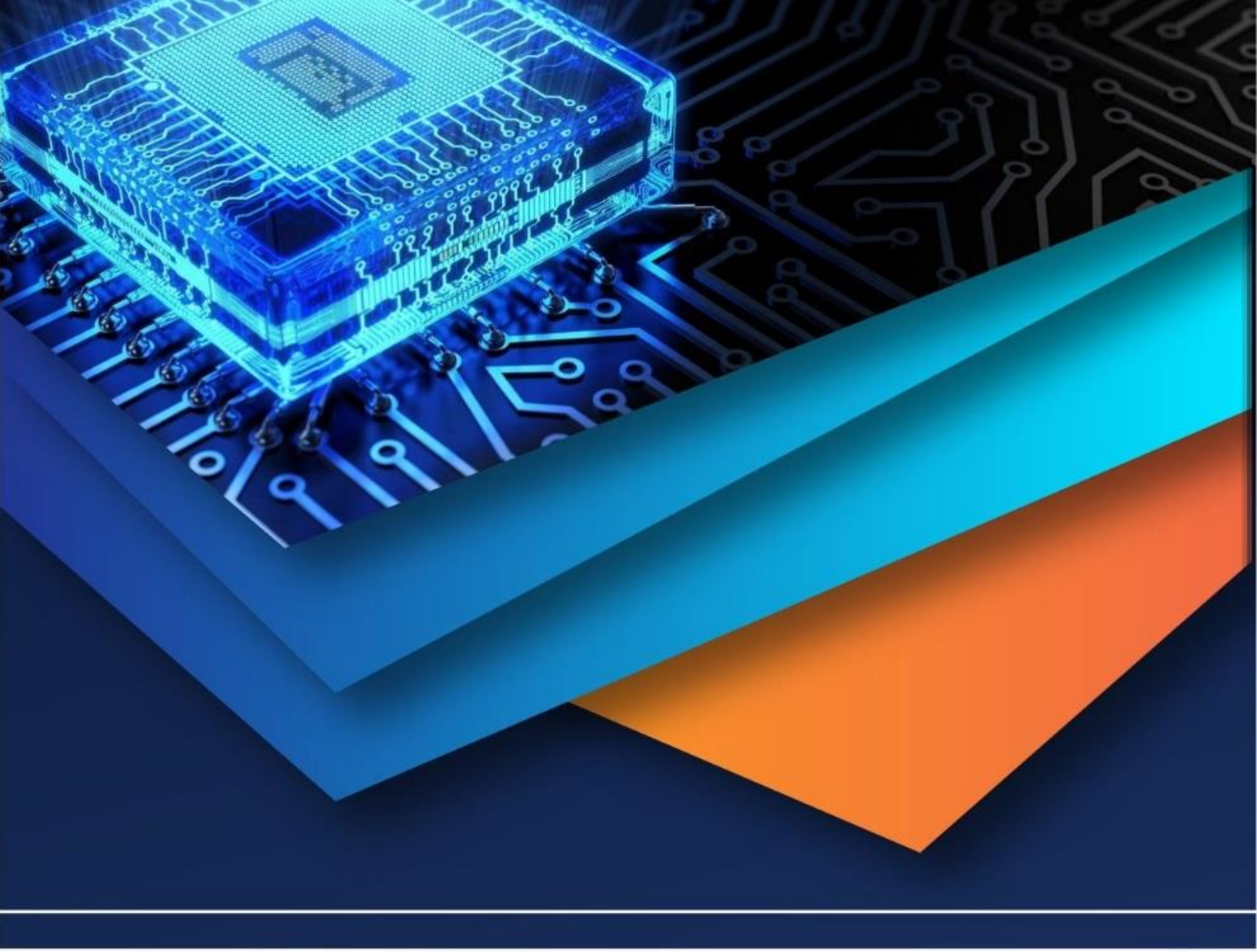

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