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Smart Trash Can Design in Gandaria Elementary School Based on Internet of Things

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Abstract

Waste management at SDN Gandaria Utara 08 Pagi is still manual, such as the lid of the trash can that must be opened by itself and the absence of a system to detect full garbage. This causes garbage to often be scattered, causing odors, and disturbing the cleanliness of the school environment. This research aims to create smart trash cans based on the Internet of Things (IoT). This bin uses an ultrasonic sensor to detect fullness, a servo motor to open the lid automatically, and the Blynk app to notify when the bin is full. This system is also equipped with a buzzer as a warning for garbage to be emptied immediately. With the prototype method, this tool is expected to help manage waste more efficiently and maintain the cleanliness of the school environment.

Keywords: *Internet of Things, Smart Trash Can, Prototype Method*

1. Introduction

Gandaria Utara 08 Pagi Elementary School is a place for students to pursue basic education. The school is located in South Jakarta, specifically in the Gandaria Utara sub-district, Kebayoran Baru district. As an educational institution, SDN Gandaria Utara 08 Pagi is committed to creating a clean and healthy environment to support an optimal teaching and learning process. However, waste management at this school still faces several challenges, especially with the current trash can system [1]. A trash can is a temporary container for collecting waste. Some trash cans are equipped with a lid to reduce unpleasant odors from the trash. However, most trash cans must be opened manually, which can lead to hygiene issues due to the difficulty of use. Furthermore, if a trash can is full and not emptied promptly, trash can spill out [2]. Waste management at this school is still done manually [3]. One of the main problems is that the trash can lids are operated manually and are often not closed properly [4]. This can cause trash to scatter, attract insects, create unpleasant odors, and have a negative impact on the health of the students and the cleanliness of the school environment. Additionally, SDN Gandaria Utara 08 Pagi also lacks a system that can detect when the trash cans are full. As a result, trash often overflows before school staff are aware. This makes the waste management process inefficient and worsens the cleanliness of the school. The waste generated at the school is also varied and comes from different activities, such as teaching and learning, administration, and food and drink consumption by students, teachers, and staff. The volume of waste generated each day varies depending on the intensity of school activities, so a more structured and efficient management system is greatly needed.

This is also in line with the School Janitor, Mr. Sarbaini, who stated that the school's central garbage collection point often spreads odor pollution that can disrupt health and environmental cleanliness. This can happen because the garbage collection point is full and cannot accommodate the existing waste. This factor can occur because the waste collection schedule by the officers is often not on time, and sometimes it happens because the garbage is full before the scheduled collection. Therefore, this research was conducted to overcome these problems with the title Smart Trash Can based on [5].

This research will result in a device implementation [6]. Therefore, the solution is a smart trash can designed to address efficient waste management problems [7]. Using an ultrasonic sensor, this smart trash can can detect its fill level in real-time [8]. A servo motor will activate an automatic lid-opening mechanism [9]. The ultrasonic sensor's function is to monitor whether the trash container is full or not, and a buzzer will sound when the trash is full [10]. Additionally, an integrated IoT module will send notifications to the user's device via the Blynk application when the trash can is full [11]. This application allows users to monitor the trash can's condition remotely, such as the fill level. The LCD will also display the maximum, minimum, and average values of the trash level.

2. Research Methodology

2.1. Rapid Application Development (RAD)

The development model used in this research is the Rapid Application Development (RAD) method. This method includes stages such as requirements planning, system design, development, and implementation [12].

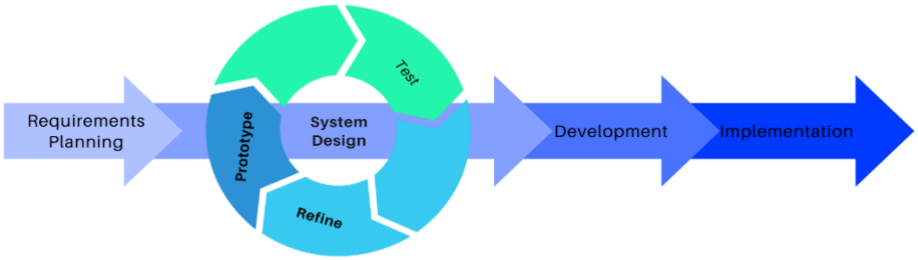

Fig 1. Rapid Application Deveopment (RAD)

This research uses the Rapid Application Development (RAD) model which consists of:

1. Requirements Planning:
   Identifying problems and user needs through observation and interviews.
2. System Design:
   Designing hardware and software components including ESP32, ultrasonic sensors, servo motor, LCD, buzzer, and Blynk application.
   Design system block diagrams, use case diagrams, and flowcharts to visualize tool workflows.
3. Development:
   Assembling electronic components and programming the ESP32 microcontroller.
   Developed Blynk application display to monitor trash bin status in real-time.
4. Implementation:
   The application is ready for use by users after all development stages are completed. The application is ready for use by users after all development stages are completed.

3. Result and Discussion

This trash system was built by utilizing several important components that are integrated to carry out its function [13]. Some of these functions are ultrasonic sensor, Esp32, Buzzer, Servo Motor, Jumper Cable, 16x2 LCD, LED and I2c Module [14]. The following is a blueprint for these components:

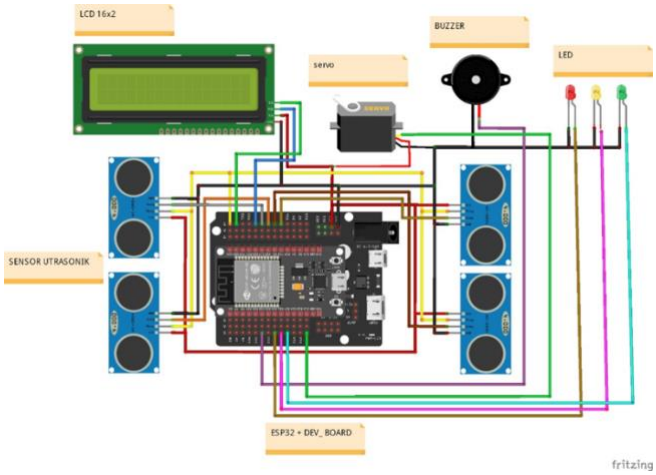

Fig 2. Overall System Design

3.1. Main Components

The following are the components of a smart trash can so that the system runs well:

1. ESP32: It is the main microcontroller used to control the system and connect to the internet network.
2. Sensor Ultrasonic: To detect the proximity of objects and provide a signal to open or close the bin.
3. Motor Servo: Used to open and close the trash can automatically based on sensor detection.
4. Buzzer: Provides sound notification when the trash can is full.
5. LCD 16x12: Displays trash status such as full and empty status.
6. LED: Used to show trash bin status (red trash capacity, yellow normal, green minimum trash).
7. Module I2c: For data communication between ESP32 and LCD or other sensors.

8. Kabel Jumper: Used to connect between components in the system.

3.2. System Implementation Results

The smart trash can prototype was developed to address inefficiencies and hygiene problems in waste management at SDN Gandaria Utara 08 Pagi. This IoT-based system includes several integrated features designed to monitor garbage levels, provide automatic control, and deliver real-time notifications to users [15].

Functional requirements analysis was conducted to identify the core functions that the system must have in order to operate effectively and meet its objectives. These requirements are related to the features and services provided by the system, ensuring that the smart trash can can be used properly and delivers value to its users. The implemented features of the system are as follows:

1. Automatic Lid Control: The servo motor enables the trash can lid to open and close automatically when users approach or when garbage is detected.
2. Garbage Level Detection: The ultrasonic sensor continuously measures the fill level of the trash can in real time.
3. Notification System: The Blynk application provides alerts when the trash can reaches its maximum capacity, enabling faster and more efficient handling by cleaning staff.
4. Visual and Audio Alerts: LED indicators (green, yellow, red) and a buzzer provide immediate on-site feedback about the fill status of the trash can.
5. LCD Display: Displays real-time data of garbage levels including maximum, minimum, and average values, allowing users to check the bin status directly.

The following is a flowchart of the smart trash can that was designed:

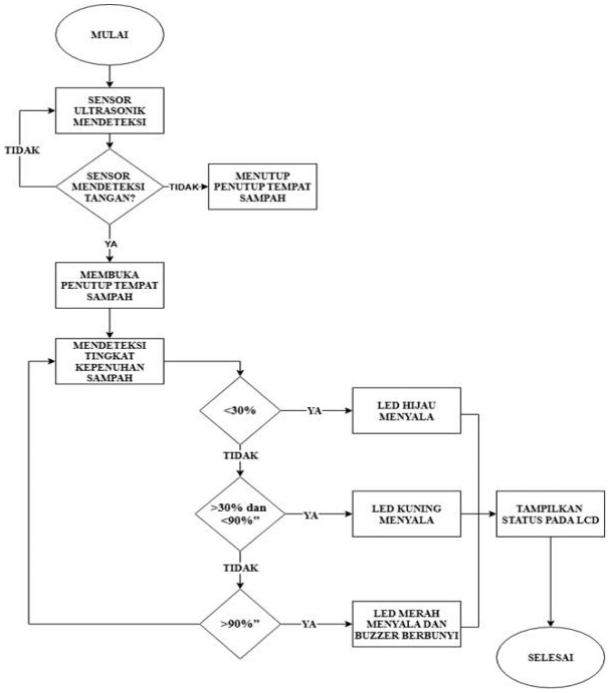

Fig 3. Flowchart System

3.3. Data Collection and Preprocessing

In this study, data collection was conducted through direct observation and interviews with the school staff at SDN Gandaria Utara 08 Pagi. Observations focused on the waste generation patterns, frequency of trash overflow, and the manual process of trash collection. Interviews were carried out with the janitorial staff and Headmaster, who reported that waste often exceeded bin capacity before scheduled collection, causing odor and cleanliness issues.

The datasets collected consist of:

1. Trash Level Measurements: Collected using the ultrasonic sensor during testing at various fill levels (empty, half, three-quarters, full).
2. System Performance Data: Includes response time of servo motor activation, accuracy of ultrasonic readings, and delay in Blynk notification delivery.
3. User Feedback: Gathered through interviews and questionnaires from school staff who tested the prototype.

Preprocessing of the collected data involved several steps:

1. Data Cleaning: Removing incomplete or inconsistent sensor readings (e.g., sudden spikes caused by hand movements not related to trash).
2. Calibration: Adjusting the ultrasonic sensor to ensure accuracy in measuring distances corresponding to different trash levels.
3. Normalization: Converting raw sensor values into percentage-based garbage levels for easier interpretation.
4. Categorization: Mapping sensor outputs to LED indicators (Green = <30%, Yellow = 30–90%, Red = >90%).

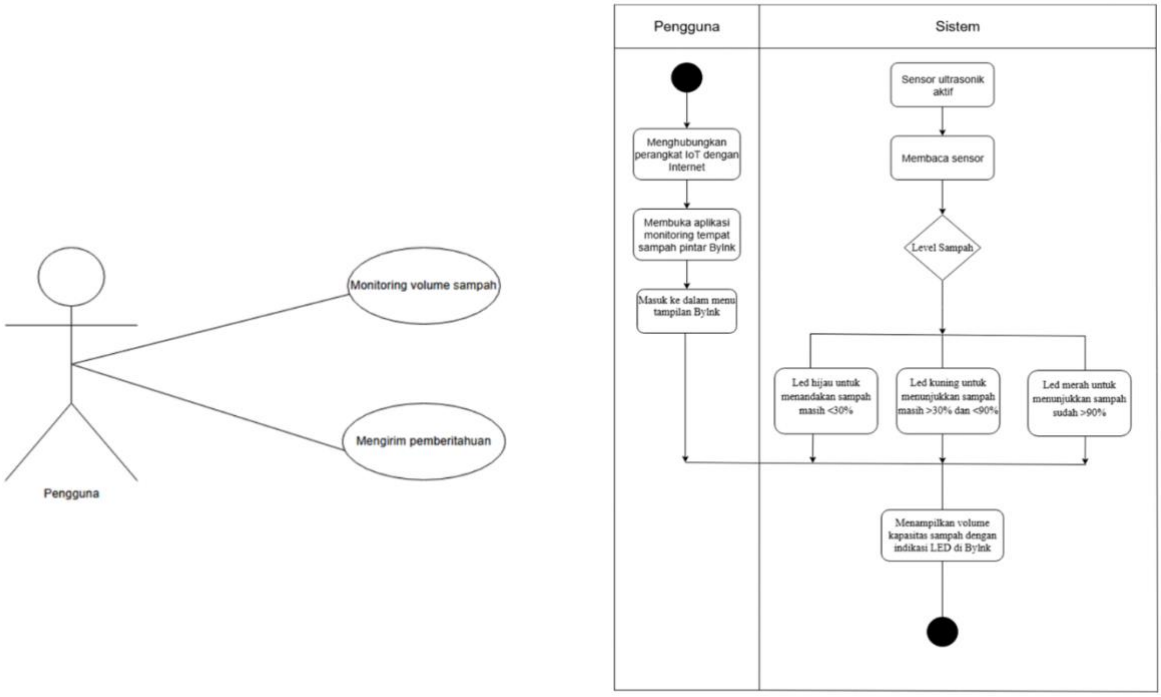

Fig 4. Use Case Diagram and Activity Diagram

3.4. Algorithm Implementation

Testing was carried out to evaluate the performance of the smart trash can prototype in terms of sensor accuracy, notification delivery, and user interaction. The evaluation focused on three key aspects:

l. Ultrasonic Sensor Accuracy

a. The sensor was tested at different fill levels: empty (0%), half (30%), three-quarters (>30% and <90%), and full (100%).
b. Results showed that the sensor was able to measure garbage levels with an accuracy of 96–98%, with minor deviations caused by irregular object surfaces inside the bin.

Fig 4. Code Implementation Led Part 1

2. Notification System via Blynk

a. When the garbage reached the 90% threshold, notifications were sent to the user's smartphone through the Blynk app.
b. The average delay of notification delivery was 1–2 seconds depending on network conditions, which was still acceptable for real-time monitoring.

```
BLYNK_WRITE(V1)
{
  int pinValue = param.asInt();
}

void bynk_notif(const char* nama_event, const char* pesan) {
  //silahkan buat event di blynk terlebih dahulu
  Blynk.logEvent(nama_event, pesan);
}

void bynk_timer() {

  if (status_tong == "penuh")
  {
    persentase = "100 %";
    Blynk.virtualWrite(V2, 0);
    Blynk.virtualWrite(V3, 0);
    Blynk.virtualWrite(V4, 1);
  }
  else if (status_tong == "sedang")
  {
    persentase = "60 %";
    Blynk.virtualWrite(V2, 0);
    Blynk.virtualWrite(V3, 1);
    Blynk.virtualWrite(V4, 0);
  }
  else if (status_tong == "sedikit")
  {
    persentase = "30 %";
    Blynk.virtualWrite(V2, 1);
    Blynk.virtualWrite(V3, 0);
    Blynk.virtualWrite(V4, 0);
  }
  else
  {
    persentase = "0 %";
    Blynk.virtualWrite(V2, 0);
    Blynk.virtualWrite(V3, 0);
    Blynk.virtualWrite(V4, 0);
  }

  Blynk.virtualWrite(V1, status_tong + " " + persentase);


}
```

Fig 4. Code Implementation Part 2

3.5. Software Implementation

The software implementation involved Arduino ID**E** for ESP32 programming and Blynk application for IoT integration, alongside an LCD module for direct data display. The main features are:

1. Blynk Application Displays bin status with digital indicators, Sends automatic notifications when the bin reaches full capacity, Allows both cleaning staff and the principal to remotely monitor trash conditions.
2. LCD Display Shows waste levels in percentages (0–100%), Provides on-device information about status: “Empty,” “Half,” and “Full.”, Provides on-device information about status: “Empty,” “Half,” and “Full.”

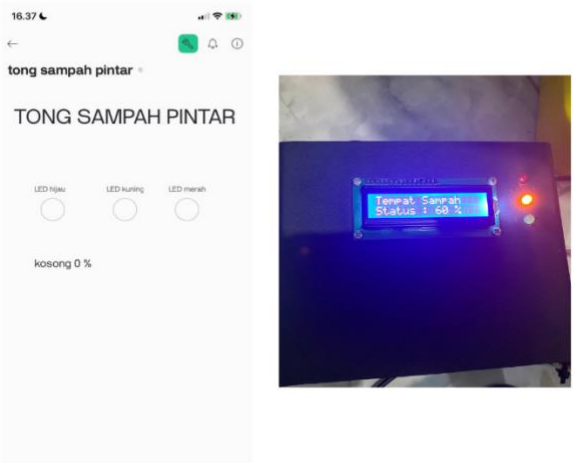

Fig 5. Application Interface

4. Conclusion

This research designed and implemented a smart trash can using IoT technology at SDN Gandaria Utara 08 Pagi. The system integrates ultrasonic sensors, servo motors, buzzer, LED indicators, LCD, and IoT connectivity via Blynk. Testing shows the system works effectively in detecting garbage levels, opening and closing automatically, and notifying users when the trash bin is full. The tool can improve waste management efficiency and help maintain school cleanliness. Future research can focus on larger capacity bins, classification of waste types, and integration with school information systems.

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