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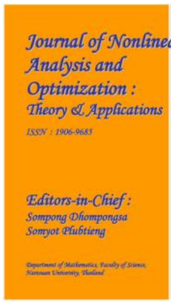

SMART CITY WASTE MANAGEMENT SYSTEM USING IOT

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Abstract:
The "Smart City Waste Management System using IoT" project represents an innovative and sustainable approach to urban waste management. This system harnesses the power of the Internet of Things (IoT) by incorporating gas sensors, ultrasonic sensors, Arduino controllers, and NodeMCU for efficient and environmentally conscious waste handling in smart cities.
This project addresses the pressing challenges associated with waste management in urban areas. It introduces a smart bin system equipped with gas sensors to detect the buildup of toxic gases inside waste containers, allowing for timely and safe waste collection. Ultrasonic sensors are utilized to monitor the fill levels of these bins in real time, optimizing waste collection routes and reducing fuel consumption. The data collected from these sensors is processed by Arduino controllers and communicated to a central hub via NodeMCU, enabling data-driven decision- making for waste collection scheduling and route optimization. By implementing this system, cities can significantly reduce operational costs, minimize environmental impact, and enhance the overall efficiency of waste management processes, contributing to the development of cleaner and smarter urban environments.
Keywords: Arduino, Node MCU, Waste management, gas sensor, Ultrasonic sensor.

1. Introduction

Embedded devices that are connected to the internet and can be controlled remotely are commonly referred to as Internet of Things (IoT) devices. In our system, Smart dustbins are connected to the internet to provide real-time information about the status of the dustbins. With the rapid growth in population in recent years, proper waste management systems are crucial to prevent the spread of diseases. Smart bins are monitored to efficiently manage waste disposal. These bins are equipped with microcontroller-based systems containing IR sensors and RF modules. The IR sensors detect the level of waste in the bin and send signals to the microcontroller, which encodes and transmits them through an RF transmitter. The signals are then received and decoded by an RF receiver connected to the Central System (Intel Galileo). An internet connection is established through a LAN cable from the modem. The data is received, analyzed, and processed in the cloud, displaying the garbage status in the dustbins on a GUI in a web browser. In another study, ZigBee, GSM (Global System for Mobile Communication), and ARM7 are used to create an integrated system for remotely monitoring waste bins. Sensors are placed in common garbage bins in public places. When the garbage reaches a certain level, the sensor sends an indication to the ARM7 controller, which then alerts the garbage collection truck driver through SMS using GSM technology. To address societal concerns over increased resource consumption and waste production, policy makers have encouraged recycling and reuse strategies to reduce the demand for raw materials and decrease the quantity of waste going to landfills.Another proposal suggests an integrated system using Radio Frequency Identification (RFID), Global Positioning System (GPS), General Packet Radio Service (GPRS), Geographic Information System (GIS), and web cameras to address solid waste management issues.A study on municipal solid waste management (MSWM) aims to determine the characterization of waste and evaluate the current management activities. The study provides an overview of the current MSWM system of Thoubal Municipality and offers suggestions for further improvement. In another system, the garbage level in dustbins is detected using sensor systems and communicated to the control room through the GSM system. A microcontroller interfaces the sensor system with the GSM system, and a GUI is developed to monitor garbage-related information for different locations, aiding in efficient garbage collection. A model of "Smart Bin" is described for managing waste collection in an entire city. The network of sensors enables smart bins connected through the cellular network to generate a large amount of data, which is analyzed and visualized in real-time to gain insights into the waste status around the city. This paper aims to encourage further research in waste management [1-6]. In the existing method of the Smart Dust Management project, traditional dustbins are used without any IoT-based monitoring or automation system. These conventional dustbins lack thecapability to provide real-time data on their fill levels, gas emissions, or lid status. Waste management authorities rely on manual inspections and schedules to empty the bins, leading toinefficiencies and potential issues such as overflowing bins and uncollected waste. Moreover, there is no mechanism in place to detect and alert authorities in case of gas emissions from thebins or instances of unauthorized opening of the bin lids. As a result, effective management ofwaste disposal and sanitation in urban areas is hindered, leading to environmental and health concerns.

2. Proposed Methodology

The proposed method integrates advanced IoT technologies to improve dust management efficiency. Arduino acts as the central controller, coordinating the functions of various sensors and actuators. Ultrasonic sensors placed in dustbins accurately measure dust levels, providing real-time fill status data. Gas sensors detect harmful emissions from bins, ensuring environmental safety. An IR sensor monitors bin lid movements, providing insights into usage patterns.
Node MCU devices establish connectivity with the cloud server, enabling seamless data transmission and remote monitoring. This allows continuous uploading of sensor data for monitoring and management. Additionally, a motor automates bin door operations based on fill level, enhancing operational efficiency. Overall, the proposed method aims to revolutionize dust management with improved accuracy, real-time monitoring, and automated operations.

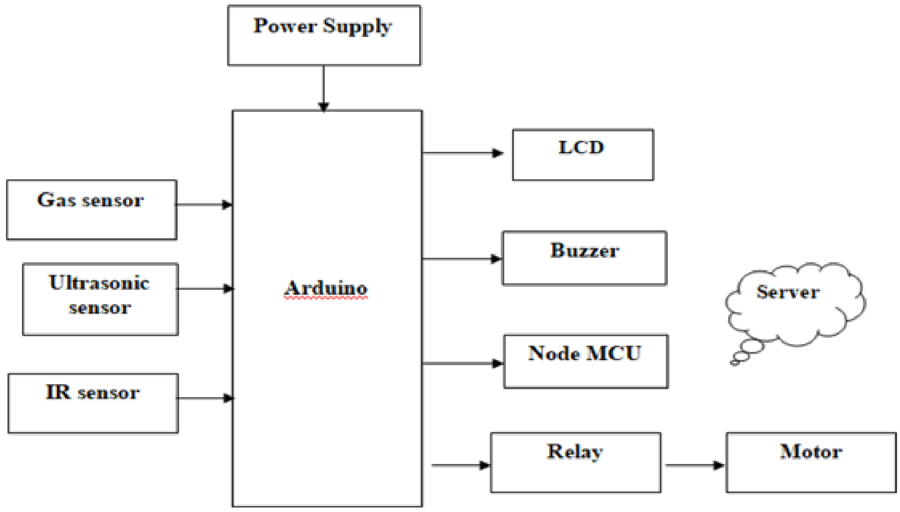

Figure.1Block diagram

2.1 Hardware description

2.1.1 Introduction to Aurdino

Arduino is an open-source electronics platform based on easy-to-use hardware and software. It consists of a microcontroller that can be programmed to sense and control objects in the physical world. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. They are used for a variety of purposes, including creating interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Arduino boards come in various shapes and sizes, each with its own set of features and capabilities. Some of the most popular Arduino boards include:
Arduino Uno: The Uno is one of the most popular Arduino boards. It features a microcontroller, digital and analog input/output pins, USB connection, and a power jack.
Arduino Mega: The Mega is similar to the Uno but with more digital and analog input/output pins, making it suitable for larger projects that require more I/O.

Arduino Nano: The Nano is a compact board with similar features to the Uno but in a smaller form factor, making it ideal for projects with space constraints.
Arduino Due: The Due is based on a more powerful microcontroller than the Uno, making it suitable for projects that require more processing power.
Arduino Leonardo: The Leonardo is similar to the Uno but with built-in USB communication, making it easier to interface with computers.
In addition to the hardware, Arduino also provides a software development environment that allows users to write, compile, and upload code to their Arduino boards. The Arduino IDE (Integrated Development Environment) is a simple yet powerful tool that is used to write code in the Arduino programming language, which is based on Wiring, and upload it to the board.
Overall, Arduino is a versatile platform that is used by hobbyists, students, and professionals alike to create a wide range of projects, from simple blinking LED lights to complex robotics projects. Its ease of use, coupled with its affordability and flexibility, has made it one of the most popular platforms for electronics prototyping and experimentation.**2.1.2 Features of the Arduino**
Arduino boards come with a variety of features that make them suitable for a wide range of projects. Some of the key features of Arduino boards include:
Microcontroller: Arduino boards are equipped with a microcontroller, which is the brain of the board. The microcontroller is responsible for executing the program and controlling the inputs and outputs of the board.
Digital Input/Output Pins: Arduino boards come with a number of digital input/output (I/O) pins that can be used to connect the board to external devices such as sensors, LEDs, and motors. These pins can be configured as either inputs or outputs, allowing the board to read data from sensors or control external devices.
Analog Input Pins: In addition to digital I/O pins, Arduino boards also feature analog input pins that can be used to read analog signals from sensors. These pins allow the board to measure variables such as light intensity, temperature, and sound level.
PWM (Pulse Width Modulation) Pins: Some Arduino boards come with PWM pins, which can be used to generate analog-like signals. PWM is often used to control the brightness of LEDs or the speed of motors.
USB Connection: Arduino boards feature a USB connection, which allows them to be connected to a computer for programming and serial communication. The USB connection also provides power to the board, eliminating the need for an external power source.
Power Jack: Arduino boards come with a power jack that can be used to connect an external power source, such as a battery or a wall adapter. This allows the board to be powered independently of the USB connection.
Reset Button: Arduino boards feature a reset button that can be used to restart the board and re-run the program.
Integrated Development Environment (IDE): Arduino boards are programmed using the Arduino IDE, which provides a simple and intuitive interface for writing, compiling, and uploading code to the board.
Open-Source: Arduino is an open-source platform, which means that the hardware designs and software libraries are freely available for anyone to use and modify. This has led to a large community of Arduino users who share their projects and collaborate on new ideas.
Overall, Arduino boards are versatile and easy-to-use platforms that are ideal for beginners and experienced makers alike. Their combination of features, affordability, and flexibility make them a popular choice for a wide range of projects, from simple blinking LED lights to complex robotics applications.

2.1.3 Arduino Pinout

• Arduino Uno is based on an AVR microcontroller called Atmega328. This controller comes with 2KB SRAM, 32KB of flash memory, and 1KB of EEPROM. The Arduino Board comes with 14 digital pins and 6 analog pins. ON-chip ADC is used to sample these pins. A 16 MHz frequency crystal oscillator is equipped on the board. The following figure shows the pinout of the Arduino Uno Board

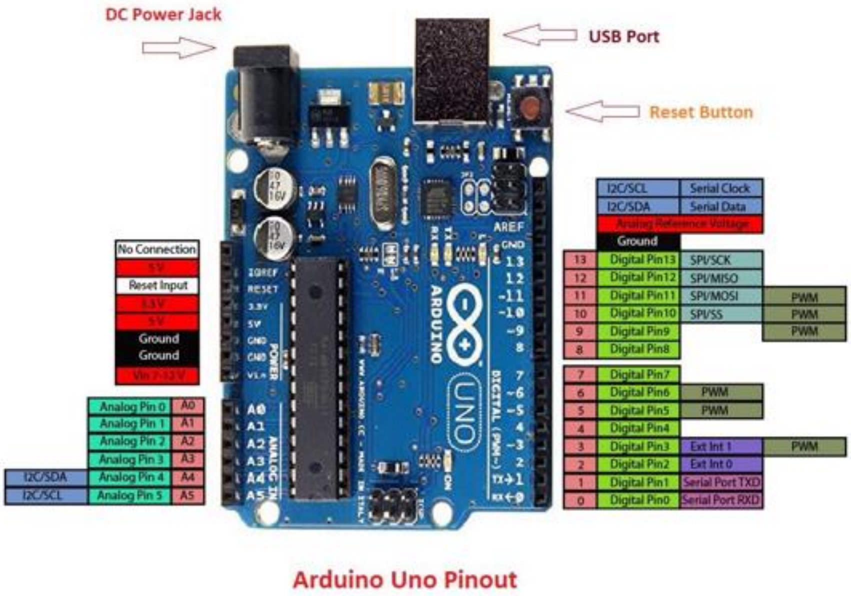

Figure.2. Arduino UNO Pinout diagram

3. Results and Discussion

3.1 Code

File Edit Sketch Tools Help

Select Board

smartcity_ard.ino

```
#include <SoftwareSerial.h>
SoftwareSerial espSerial(9,10);
#include <LiquidCrystal.h>
LiquidCrystal lcd(A5,A4,A3,A2,A1,A0);
String str;
int trig=4;
int echo=5;
int gas=11;
int buz=12;
//ULTRA SONIC SENSOR PARAMETERS
int duration;
int distance;

void setup()
{
  // put your setup code here, to run once:
  Serial.begin (9600);
  espSerial.begin(9600);
  pinMode(trig,OUTPUT);
  pinMode (echo,INPUT);
  pinMode(gas,INPUT);
  pinMode(buz,OUTPUT);
  lcd.begin(16,2);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("SMART CITY WASTE");
  lcd.setCursor(0,1);
  lcd.print("MANAGEMENT");
  delay(2000);
}

void loop()
{
  // put your main code here, to run repeatedly:
  digitalWrite(trig,LOW);
 delayMicroseconds(2);
 // Sets the trigPin on HIGH state for 10 micro seconds
 digitalWrite(trig,HIGH);
```

Figure.3. Proposed design code execution

3.2 Advantages and Applications

6.1 ADVANTAGES

1. Real-time Monitoring
2. Remote Accessibility
3. Timely Alerts
4. Data-driven Optimization
5. Enhanced Environmental Management

6.2 APPLICATIONS

1. Optimized Waste Collection Routes: Utilizing real-time data from IoT sensors placed in waste bins and collection vehicles, the system optimizes collection routes to maximize efficiency and reduce fuel consumption.
2. Fill-Level Monitoring: Sensors installed in waste bins monitor fill-levels in real-time, enabling timely collections and preventing overflow situations, thus improving operational efficiency.

3. Environmental Monitoring: The system incorporates sensors to monitor environmental parameters such as temperature, humidity, and air quality, allowing authorities to assess the impact of waste management activities on the environment.
4. Fire Detection and Prevention: Gas sensors deployed in waste bins detect flammable gases, helping to prevent fires caused by spontaneous combustion or improper disposal of hazardous materials.
5. Recycling and Segregation Management: Smart bins equipped with RFID or barcode scanners facilitate efficient waste segregation and recycling, streamlining the recycling process.
6. Public Health Monitoring: Monitoring waste decomposition rates and pathogen levels help assess potential risks to public health and take preventive measures to mitigate the spread of diseases.
7. Smart Bin Maintenance: The system enables predictive maintenance of smart bins by monitoring their operational status and detecting any malfunctions or damage, ensuring continuous functionality.
8. Educational Outreach and Awareness: Educational initiatives raise awareness about waste management best practices and environmental conservation, empowering citizens to make informed decisions.
9. Data Analytics for Decision-Making: Collecting and analyzing data on waste generation, collection activities, and environmental conditions facilitates informed decision-making and strategic planning.
10. Community Engagement and Participation: Initiatives such as community clean-up drives, waste reduction campaigns, and participatory budgeting processes engage citizens in decision-making and problem-solving, fostering a sense of ownership and responsibility for waste management outcomes.

4. Conclusion

In conclusion, the implementation of an IoT-based smart dust management system marks a significant advancement in waste management methodologies. By leveraging advanced sensors, microcontrollers, and cloud connectivity, this project offers a comprehensive solution to the challenges posed by conventional waste management approaches. Integrating ultrasonic, gas, and IR sensors enables real-time monitoring of dustbin fill levels, detection of harmful emissions, and monitoring of bin lid status, enhancing operational efficiency and environmental sustainability. The use of Arduino microcontrollers as central processing units provides intelligence and autonomy to the system, enabling automated responses to detected events and seamless communication with the cloud for data transmission and analysis. This streamlines waste collection processes and facilitates data-driven decision-making, enabling stakeholders to optimize resource allocation, reduce operational costs, and mitigate environmental risks. Additionally, the adoption of Node MCU for server connectivity ensures smooth integration with existing infrastructure and scalability for future expansion, making it a versatile and adaptable solution for diverse urban environments. In summary, the smart dust management system represents a significant shift in waste management practices, offering a glimpse into the future of smart cities and sustainable development. By harnessing IoT technology to monitor, analyze, and optimize waste collection processes, the project contributes to the creation of cleaner, healthier, and more efficient urban environments. Continued advancements in sensor technology, communication protocols, and data analytics hold immense potential for further improvements in smart dust management systems, paving the way for smarter, greener, and more livable cities in the future.

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