IoT Based Autonomous Solution for the Maintenance of Public Toilet

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Keywords: Autocleaning, Monitors, Environmental Condition, Control System, Optimizing Water Usage, Hygiene System.

Abstract: Automated restroom system integrates IoT for water control and real-time occupancy detection to optimize resource usage efficiently. The system uses ultrasonic sensors for person detection and Ammonia sensors for detecting bad odors in restrooms. Water motor activates automatically when ultrasonic sensor detects a person, ensuring timely and efficient cleaning of the restroom. Fog maker dispenses sanitizing mist when hands are placed under it, enhancing hygiene and reducing manual intervention. LCD and IoT enable real-time monitoring of restroom conditions, providing data for efficient management and maintenance. UV light is incorporated for germ cleaning, ensuring a hygienic environment by eliminating harmful microorganisms in the restroom.

1 INTRODUCTION

The integration of the Internet of Things (IoT) in automated restroom systems has significantly improved hygiene, resource management, and user convenience.

The absence of proper sanitation facilities increases the spread of bacterial and viral infections such as diarrhea, urinary tract infections (UTIs), and skin diseases. heavy odor, it creates multiple problems like headaches, nausea, and respiratory discomfort. Environmental issues in public toilets stem from excessive water wastage due to leaking taps and inefficient flushing systems.

Traditional restroom maintenance relies on periodic cleaning schedules and manual intervention, often leading to inefficiencies in water usage, hygiene maintenance, and real-time monitoring. The development of smart restroom systems aims to address these challenges by incorporating advanced sensors and automation techniques to enhance efficiency and cleanliness. By utilizing IoT, these systems ensure optimal resource utilization while reducing the dependency on human effort for maintenance and monitoring.

A key component of the automated restroom system is real-time occupancy detection, which plays a crucial role in optimizing water and energy consumption. The system employs ultrasonic sensors to detect human presence and trigger necessary actions such as water flow control and sanitation processes. This feature ensures that water is used only when required, minimizing wastage while maintaining a clean and hygienic restroom environment. Additionally, an MQ6 gas sensor is integrated to detect unpleasant odors, allowing immediate corrective actions, such as activating ventilation or air-purification systems, to maintain fresh restroom conditions.

To further enhance hygiene, the system includes a fog maker that dispenses a sanitizing mist when hands are placed under it. This eliminates the need for physical contact with sanitation devices, reducing the risk of germ transmission. Moreover, an ultraviolet (UV) light sterilization mechanism is incorporated to disinfect restroom surfaces, effectively eliminating harmful microorganisms. These features work collectively to ensure a safer restroom environment, particularly in high-traffic public spaces where maintaining hygiene is crucial to preventing the spread of infections.

Real-time monitoring and data analytics further enhance the efficiency of automated restrooms. An LCD display and IoT connectivity enable facility managers to track restroom conditions remotely, allowing timely intervention and maintenance. By

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leveraging IoT-driven automation, these smart restroom systems not only promote hygiene but also contribute to sustainability by conserving water and reducing excessive cleaning resource consumption. With continuous advancements in sensor technology and automation, the implementation of such intelligent restroom systems is expected to become increasingly widespread, revolutionizing restroom management across various sectors, including public facilities, corporate spaces, and healthcare institutions.

2 RELATED WORKS

Explores the use of IoT-enabled smart toilets for elderly care, enabling health monitoring at home, particularly for infection tracking (K. Dheeraj, S. S. Kumar, and K. R. Singh). Smart restroom monitoring system for residential colleges, using IoT sensors to track restroom conditions and send alerts for maintenance, ensuring hygiene and user satisfaction (J. Smith, A. Brown, and L. Taylor).

Sensors monitor cleanliness and usage, alerting maintenance teams in real time via an IoT-enabled system aimed at maintaining public toilets in smart cities, reducing the risk of disease transmission (Wang Yunhe and Wang Bingbing). Smart public toilets within the context of a smart city, aiming for efficiency and sustainability (QIN Doudou, GUO Kairui, LI Yuhao et al.).

Focuses on how IoT can be applied in the design of public toilets, optimizing hygiene, maintenance, and user convenience (M. Patel and R. Sharma). Smart washroom cleaning system using hub technology to streamline cleaning operations. Sensors detect usage patterns and cleanliness levels, triggering alerts for cleaning staff, improving hygiene efficiency (Nayana B. Chide and Nilesh P. Bobad).

Smart toilet capable of analyzing excreta for real-time, personalized health monitoring. Highlights its potential in early disease detection through non-invasive methods (Seung-min Park, Daeyoun Won, Jung Ho Yu, Sanjiv Gambhir, Brian Lee, Andre Esteva, et al.). IoT-enabled smart washrooms, focusing on user convenience, water conservation, and maintenance optimization (R. Sujeetha, D. Abhinav, R. Rithik, and S. Abishek).

Toilet system for monitoring health by analyzing excreta, offering personalized health feedback (Cristina Balaceanu, Ioana Marcu, George Suciu, Carina Dantas, and Peter Mayer). Washrooms in general and lacks integration with advanced healthcare or personalized services (K. Nakamura, S. Takahashi, and Y. Honda).

IoT-based toilet management system, emphasizing automated maintenance and real-time monitoring to ensure cleanliness and efficiency (R. Gupta, S. Mehta, and V. Deshmukh). Smart toilet system designed for elderly individuals and people with disabilities, emphasizing usability, health monitoring, and enhanced accessibility (D. Lopez and J. Garcia).

IoT sensors to detect human presence in smart toilets. It discusses potential improvements and strategies to enhance sensor accuracy and reliability (F. Rossi, L. Bianchi, and P. Conti). Smart toilet system for optimizing resource usage like water and energy. Sensors collect usage data to help manage resources more efficiently (C. Lee and M. Park).

Public toilets as either potential health facilitators or pathogen transmitters, emphasizing design and hygiene management for public health (Clara Greed).

3 EXISTING SYSTEM

Existing research on IoT-enabled smart toilets has significantly evolved, focusing on hygiene, maintenance, health monitoring, and resource optimization. Early studies examined public toilets as potential health facilitators or pathogen transmitters, emphasizing hygiene management and design considerations. With technological advancements, IoT integration became a key focus, leading to the development of smart toilet systems that optimize resource usage, such as water and energy, through sensor-driven data collection.

Research has also introduced IoT-based toilet management systems aimed at automated maintenance and real-time cleanliness monitoring, ensuring efficient restroom operations. Additionally, studies have explored the challenges of using IoT sensors for human presence detection in smart toilets, highlighting concerns related to accuracy and security.

In recent years, smart toilets have been increasingly explored for healthcare applications. Some advancements in this field have introduced smart toilets capable of analyzing excreta for real-time, personalized health monitoring, with potential applications in early disease detection. Similarly, research has focused on the use of IoT-enabled smart toilets for elderly care, particularly in infection tracking, allowing health monitoring at home.

Other studies have proposed smart restroom monitoring systems for residential colleges to ensure cleanliness and user satisfaction. Additionally, IoT-enabled systems have been developed to maintain public toilets in smart cities, reducing disease transmission risks. These studies highlight the growing integration of IoT in sanitation and healthcare, paving the way for future innovations in smart toilet technology.

4 PROPOSED SYSTEM

The proposed system integrates IoT for real-time monitoring and control, optimizing water usage and improving restroom hygiene. Ultrasonic sensors detect human presence and Water level from tank, triggering automated cleaning mechanisms like water motors to ensure timely restroom maintenance.MQ6 sensors monitor air quality, detecting bad odors and initiating cleaning processes to maintain a pleasant restroom environment with Spryer. Fog makers dispense sanitizing mist when hands are placed under them, enhancing hygiene and reducing the spread of germs. LCD and IoT enable real-time monitoring of restroom conditions, providing data for efficient management and maintenance. UV lights are integrated for germ cleaning, ensuring a sanitized restroom environment by eliminating harmful microorganisms effectively. Figure 1 shows the IoT-Based Smart Sanitization and Environmental Monitoring System Using Arduino.

- User Detection & Monitoring Module
- Air Quality & Odor Detection Module
- Automated Cleaning & Water Management Module
- Sanitization & Hygiene Enhancement Module
- IoT-Based Remote Monitoring & Control Module
- Power Supply & Connectivity Module

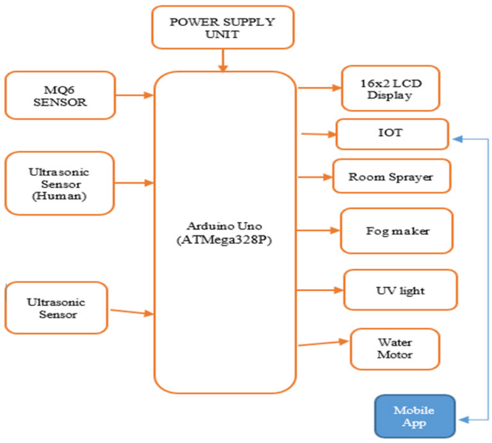

Figure 1: IoT-based smart sanitization and environmental monitoring system using Arduino.

UNO (ATMega328P) – Acts as the main Arduino controller, processing sensor inputs and controlling output devices such as the water motor, fog maker, and display.
NodeMCU (ESP8266) – Provides Wi-Fi connectivity for remote monitoring and control, allowing users to access data or send commands wirelessly.
Water Motor – Operates based on sensor readings, turning on or off to regulate water flow as needed, controlled by the Arduino.
Fog Maker – Uses ultrasonic vibrations to convert water into mist, controlled by the microcontroller for humidity control or visual effects.
16x2 LCD – Displays real-time sensor readings, system status, or any necessary information processed by the Arduino.
UV Light – Turns on for sterilization or specific applications, controlled via relays or transistors based on programmed conditions.
MQ6 Sensor – Continuously detects gas leaks (LPG, propane, butane) and sends signals to the Arduino, which can trigger alerts or safety actions.
Ultrasonic Sensor – Measures distances or levels by emitting ultrasonic waves and detecting reflections, useful for obstacle detection or liquid level monitoring.
Power Supply Unit – Provides regulated power to all components, ensuring stable operation of microcontrollers, sensors, and output devices.
Jumper Wires – Facilitate electrical connections between components, enabling communication and power distribution within the system.

5 IMPLEMENTATIONS

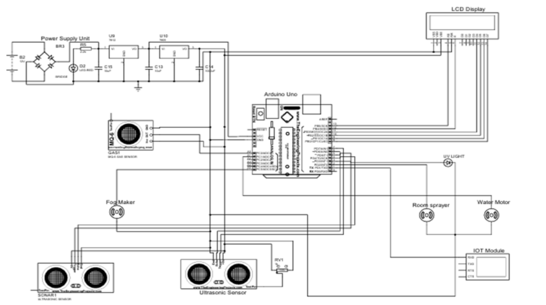

Figure 2: Smart waste management system using Arduino and IoT.

Figure 2 gives the smart waste management system using Arduino and IoT.

These are the algorithms we are using in this process.

- **Event-Driven Algorithm:** The system continuously listens for inputs from ultrasonic sensors (person detection), MQ6 sensors (odor detection), and hand detection for the fog maker. Whenever an event (sensor trigger) occurs, corresponding actions (water motor activation, sanitation, etc.) are executed.
- **State Machine Algorithm:** The system transitions between different states (Idle, Occupied, Cleaning, Ventilation, Disinfection) based on sensor data.
- **Loop-Based Control Algorithm:** A continuous loop runs to check sensor inputs and update restroom conditions in real-time, ensuring efficient monitoring.
- **IoT-Based Monitoring Algorithm:** Data from sensors is sent to an IoT dashboard, enabling remote tracking and maintenance alerts.

5.1 User Detection & Monitoring

Utilizes ultrasonic sensors to detect human presence in the restroom. Activates water motor only when a user is detected, reducing water wastage. Tracks water level in the storage tank to ensure optimal water availability.

- **Air Quality & Odor Detection**
  Uses MQ6 gas sensors to detect bad Odors and monitor air quality. Triggers automatic cleaning mechanisms when Odor levels exceed a threshold. Ensures a pleasant restroom environment by eliminating foul smells efficiently.
- **Automated Cleaning & Water Management**
  Controls water motor to spray and clean surfaces based on sensor inputs. Reduces manual intervention and ensures consistent hygiene levels. Monitors and optimizes water usage, preventing unnecessary wastage.
- **Sanitization & Hygiene Enhancement**
  Integrates fog makers to dispense sanitizing mist when a user places hands under them. UV light system eliminates harmful microorganisms, ensuring germ-free restrooms. Enhances user hygiene and reduces the risk of infections.
- **IoT-Based Remote Monitoring & Control**
  Utilizes NodeMCU (ESP8266) for cloud-based real-time monitoring of restroom conditions. Displays restroom status and sensor data on an LCD screen. Sends data to Arduino IoT Cloud for remote management and maintenance alerts.
- **Power Supply & Connectivity**
  Ensures uninterrupted power for components like Arduino UNO, sensors, and actuators. Uses jumper wires for connectivity between hardware components. Manages power distribution to optimize energy efficiency.

6 SAMPLE OUTPUT

The system comprises an Arduino-based smart safety circuit integrating IR, ultrasonic, and gas sensors for real-time environmental monitoring. As shown in Figure 3, the sensors detect obstacles, distance, and toxic gases, with data processed by Arduino to trigger appropriate actions like exhaust fan activation. In Figure 4, the circuit identifies motion and hazardous gas presence, displaying alerts on the LCD and activating safety mechanisms through relays. Figure 5 highlights the regulated power supply and relay-driven control for managing detected risks. Together, these configurations ensure a responsive and automated safety solution for hazardous environments.

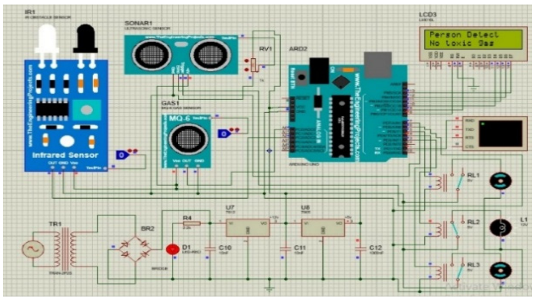

Figure 3: Sensor (IR, Ultrasonic, gas) detect obstacles, distance, and toxic gases, sending data to Arduino. Arduino processes signal, display status on LCD, activates relays to trigger exhaust fan or alert system.

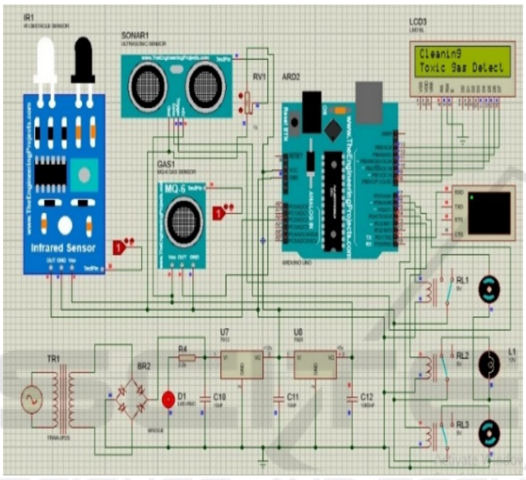

Figure 4: Sensor detect obstacle, motion and gas level, sending data to Arduino which processes and display status on LCD. Based on the input, Arduino activates relays to trigger alarm or exhaust system for safety.

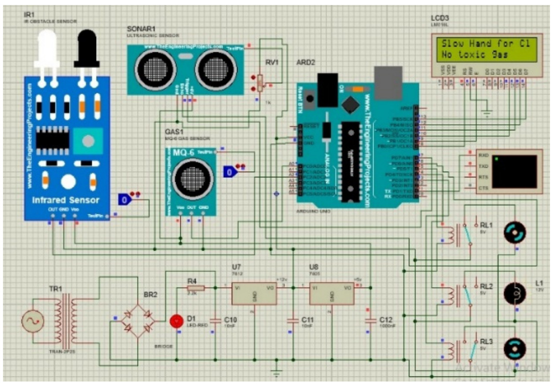

Figure 5: This circuit use Arduino to monitor gas, distance and obstacles via sensor, displaying status on an LCD and control devices through relays a regulated power supply to the entire system.

7 CONCLUSIONS

The automated restroom system optimizes water usage and improves hygiene through IoT-enabled real-time monitoring and control. Ultrasonic sensors ensure accurate person detection, triggering automated cleaning mechanisms and reducing manual intervention in restrooms.MQ6 sensors detect bad odors, initiating cleaning processes to maintain a pleasant and hygienic restroom environment. Fog makers enhance hygiene by dispensing sanitizing mist, reducing the spread of germs and improving user convenience. LCD and IoT enable real-time monitoring of restroom conditions, providing data for efficient management and maintenance. UV lights ensure germ-free restrooms by eliminating harmful microorganisms, providing a sanitized environment for users.

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