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IoT BASED HEALTHY TOILET

Advaith P. K
Department of Computer Science and Engineering
College of Engineering, Thalassery
Kannur, Kerala

Sourav Govindadas
Department of Computer Science and Engineering
College of Engineering, Thalassery
Kannur, Kerala

Akhil A
Department of Computer Science and Engineering
College of Engineering, Thalassery
Kannur, Kerala

Yadhukrishna Sreekumar
Department of Computer Science and Engineering
College of Engineering, Thalassery
Kannur, Kerala

Asha Vijayan
Prof., Department of Computer Science and Engineering
College of Engineering, Thalassery
Kannur, Kerala

Abstract:- Toilets are an essential amenity for maintaining good hygiene and sanitation, but the build-up of unclean emissions and frequent use can lead to poor indoor air quality. This project aims to develop an IoT-based toilet system that uses sensors to detect air quality and alert cleaners or owners when it is time for cleaning. The system consists of a microcontroller connected to air quality and motion sensors. A cloud-based algorithm analyzes the data to determine when cleaning is needed, while an exhaust fan maintains a comfortable environment and energy efficiency. The system can also integrate with a mobile app to check occupancy and air quality. By improving cleanliness and air quality in public/private toilets, this project can enhance user experience and reduce the spread of infections.

Keywords:- *IoT, Sensors, Air Quality, Microcontroller, Infection Control.*

I. INTRODUCTION

In today's world, maintaining proper hygiene and sanita- tion in public toilets is of utmost importance to prevent the spread of diseases and ensure a safe and healthy environment. However, it can be challenging to maintain good indoor air quality in toilets due to frequent use and unclean emissions. To address this issue, a new IoT-based toilet system is being developed, which uses sensors to detect the air quality inside the toilet and alert the toilet attendants or owners when it is time for cleaning.

The IoT-based toilet system comprises a microcontroller that is connected to a set of sensors, including air quality sensors(MQ-7 and MQ-135), and motion sensor. The mi- crocontroller uses a cloud-based algorithm to analyze the sensor data and determine when the toilet needs cleaning. Additionally, the system operates an exhaust fan based on the air quality data, maintaining a comfortable environment inside the toilet while keeping energy consumption to a minimum. The system is integrated with a mobile app that allows the owners/cleaners to check occupancy and air quality .

The project has significant implications for maintaining the cleanliness and excellent air quality in public/private toilets, improving the user experience, and reducing the spread of infections. This project is also expected to have a positive impact on the environment by reducing the use of cleaning chemicals and minimizing energy consumption.

II. MOTIVATION

The motivation for developing an IoT-based toilet system is primarily driven by the need to maintain good hygiene and sanitation in public and private toilets. Public toilets are commonly used in densely populated areas, workplaces, and public spaces. However, public toilets can be sources of harmful gases and unpleasant odors, which can lead todiscomfort and health risks for users.

III. RELATED WORKS

Several studies have explored the use of IoT-based systems to improve sanitation and hygiene in public spaces. For example, the paper [3] developed an IoT-based smart toilet system that integrates sensors and data analytics to monitor and optimize water usage and quality, while also providing real-time feedback to users. Similarly, the paper [4] proposed an intelligent restroom system that uses sensors and machine learning algorithms to predict toilet occupancy and reduce waittimes for users.

Other researchers have focused on the use of gas sensors to monitor indoor air quality and detect hazardous pollutants. For instance, the paper [1] designed an IoT-based air quality monitoring system that uses multiple sensors to

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measure various indoor pollutants, including carbon monoxide and ni- trogen dioxide. Similarly, the paper [2] developed a gas sensor network that uses machine learning techniques to classify and identify different types of gas emissions in a variety of indoor environments.

While these studies provide valuable insights into the devel-opment and implementation of IoT-based systems for public spaces, they often focus on specific aspects of the problem, such as water usage or gas detection, and may not address the full range of challenges faced in public restrooms. In contrast, our proposed system aims to provide a comprehensive solution to improve the air quality and cleanliness of public and private toilets by integrating MQ-7 and MQ-135 gas sensors, a cloud- based server using Firebase, and a mobile app.

IV. HARDWARES AND SOFTWARES USED

In this section, we provide a brief overview of the hardwaresand softwares used our proposed system.

A. *Hardwares*

- *ESP-32:* ESP32 is a low-cost, low-power system on a chip (SoC) microcontroller with integrated Wi-Fi and Blue- tooth capabilities.Shown in Figure 1. It is widely used in IoT applications due to its versatility and compatibility with various sensors and modules. .
- *MQ-7 Carbon Monoxide Sensor:* The MQ-7 carbon monoxide sensor is a low-cost gas sensor that is widely used for indoor air quality monitoring. The sensor can detect carbonmonoxide (CO) concentrations in the range of 20 to 2000parts per million (ppm), with a response time of less than 10 seconds. The MQ-7 sensor is based on a metal oxide semiconductor (MOS) technology and operates on low power,making it an ideal choice for battery-powered IoT devices.

- *MQ-135 Gas Sensor:* In addition to the MQ-7 sensor, we also used the MQ-135 gas sensor in our system to detect the presence and concentration of other gases in the restroom environment. The MQ-135 sensor is a low-cost gas sensor that is commonly used for air quality monitoring in homes,

In this project, we used the ESP32 microcontroller to collect data from the gas sensors and transmit it to the Firebase database. We programmed the ESP32 using the Arduino Integrated Development Environment (IDE). The ESP32 was connected to the gas sensors using analog input pins, and the sensor data was processed and transmitted to the Firebase database using the ESP32 Wi-Fi module.

Fig. 1. ESP-32

Fig. 2. MQ-7

offices, and other indoor environments. The sensor can detect the presence of a wide range of gases, including ammonia, nitrogen oxides, and carbon dioxide, as well as other organic compounds.

The MQ-135 sensor operates on the principle of metal oxide semiconductor (MOS) technology, similar to the MQ-7 and MQ-136 sensors. When the sensor is exposed to a gas, the gas molecules interact with the MOS material, causing a change in the resistance of the sensor. This change in resistance isthen measured and converted into a voltage signal, which canbe processed by a microcontroller or other electronic device. The MQ-135 sensor has a detection range of 10 to 300 ppm for ammonia (NH_3) and a response time of less than 10 seconds. The sensor also has a high sensitivity to other gases, such as nitrogen oxides (NO_x), carbon monoxide (CO), and organic compounds, making it a versatile choice for indoor air quality monitoring.

In our system, we used the MQ-135 sensor to detect the presence of ammonia and other gases in the restroom environment. The sensor was connected to the ESP32 micro- controller, which processed the sensor data and transmitted it to the Firebase real-time database for storage and analysis. By monitoring the levels of ammonia and other gases in the restroom environment, our system can help to improve indoor air quality and ensure the safety and comfort of restroom users.

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B. Softwares

Fig. 3. MQ-135

- *Firebase:* Firebase is a mobile and web application development platform developed by Google. It provides a suite of services for building and managing mobile and web appli- cations, including real-time databases, authentication, hosting, and cloud storage. Firebase allows developers to build scalable and reliable applications quickly and easily, with minimal setup and configuration required.

In our project, we used Firebase to store and manage data from our IoT sensors. Specifically, we utilized Firebase Realtime Database to store the real-time sensor data and Firebase Cloud Functions to process the data and trigger alerts based on predefined thresholds. We also utilized Firebase Authentication to secure access to the data and Firebase Hosting to host our web-based dashboard for viewing andanalyzing the sensor data.

Firebase provided us with a robust and reliable platform for managing our sensor data, processing it in real-time, and visualizing it in a user-friendly dashboard. Its ease of use and integration with other Google services allowed us to quickly develop and deploy our IoT-based toilet monitoring system.

- *Flutter:* Flutter is an open-source mobile application development framework developed by Google. It allows de- velopers to build high-performance, natively compiled appli- cations for mobile, web, and desktop platforms from a single codebase. Flutter provides a rich set of pre-built widgets and tools, making it easy for developers to create beautiful and responsive user interfaces. Additionally, Flutter offers hot reload functionality, allowing developers to make changes to the code and see the results instantly, speeding up the development process. With its fast development cycle andability to target multiple platforms, Flutter is an ideal choice for building cross-platform IoT applications, including ourproposed toilet system.
- *Arduino IDE:* The Arduino IDE is an open-source soft- ware development environment used for writing, compiling, and uploading code to Arduino boards. It supports multiple programming languages, including C and C++, and provides a user-friendly interface for writing and debugging code. The IDE includes a code editor with features such as syntax highlighting, code completion, and error highlighting, making it easy to write and debug code.

In addition to the code editor, the IDE includes a serial monitor that allows the user to communicate with the Arduino board via the serial port. This is useful for debugging purposes and for sending and receiving data to and from the board.

The IDE also includes a library manager that allows the user to easily download and install libraries, which are pre- written code that can be used to extend the functionality of the Arduino board. These libraries can be searched and downloaded from a centralized repository within the IDE, making it easy to find and use them in a project.

Overall, the Arduino IDE provides a simple and powerful development environment for programming Arduino boards, making it accessible to both beginners and experts alike.

V. PROPOSED METHODOLOGY

In this section, we describe the proposed methodology for the system. Our system uses two gas sensors, MQ-7 and MQ-135, to measure carbon monoxide and ammonia, respectively. These sensors were chosen because they are low-cost, small in size, and provide accurate readings for the target gases.

A. Sensor Calibration

Before deploying the sensors, they were calibrated using a gas calibration chamber to ensure accurate and consis- tent readings. The calibration process involved exposing the sensors to known concentrations of carbon monoxide and ammonia gases, and recording the output voltage from the sensors. These calibration data were used to develop a linear regression model for converting sensor output voltage to gas concentration.

B. System Architecture

Our proposed system architecture is shown in Figure 4. The system consists of the two gas sensors, an ESP32 mi- crocontroller, and a Firebase database and web application for data storage and visualization. The ESP32 microcontroller is responsible for reading the sensor data and transmitting it to the Firebase database via Wi-Fi.

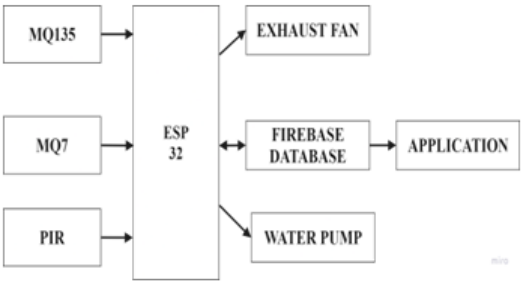

Fig. 4. Proposed System Architecture

C. Features of the Proposed System

Our proposed system is designed to continuously monitor the air quality inside a toilet and maintain a comfortable and healthy environment for the users. The

system includes several features that work together to achieve this goal:

- *Wireless Control of Exhaust Fan:* The system analyzes air quality data collected from multiple sensors and wirelessly controls the exhaust fan to maintain a comfortable and healthy environment inside the toilet. This approach is very efficient and consumes minimum energy.
- *Machine Learning-Based Data Analysis:* Using machine learning algorithms, the system further analyzes the air qualitydata to continuously monitor the ability of the exhaust fanand ventilation system to maintain a healthy environment. If the pollution level goes above a certain threshold and theexhaust fan and ventilation system fail to maintain a healthy environment, a manual cleaning request is sent to the email of the cleaning person or authority.
- *Color-Coded Status Indicators:* Based on the condition of the inside air, the system produces a color signal to inform the user whether the toilet is safe to use or not. A green light means that the toilet environment is safe and comfortable to use. A yellow light means that the air quality is not good enough, and the user should wait until the exhaust fan returns it back to a better condition. A red light means that the toiletis not usable until a person cleans it.

In summary, our proposed system provides a comprehensivesolution for monitoring and maintaining the air quality inside a toilet. With its wireless control of the exhaust fan, machine learning-based data analysis, and color-coded status indicators, it ensures a comfortable and healthy environment for the users while minimizing energy consumption.

VI. CONCLUSION

In this paper, we proposed an IoT-based system for mon- itoring indoor air quality using low-cost gas sensors and a Firebase database and android application. Our experiments showed that the system was able to accurately measure the concentrations of carbon monoxide and ammonia gases and detect changes in gas concentration levels over time. The system has the potential to provide real-time monitoring of indoor air quality, which is critical for ensuring the health and safety of occupants in indoor environments.

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