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Next-Gen Gas Safety: IOT Innovations for Comprehensive Leak Management

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In today's rapidly advancing technological landscape, ensuring safety through innovative solutions has become more critical than ever. Our project is designed to transform traditional gas safety mechanisms by introducing a modern, interconnected system rooted in the Internet of Things (IoT). This project focuses on developing an intelligent gas leak detection and response system that can be seamlessly integrated into residential, commercial, and industrial settings. By utilizing smart sensors, wireless connectivity, and real-time monitoring, the system is capable of detecting gas leaks at an early stage and initiating timely alerts through mobile applications or automated safety responses, such as valve shutoffs or ventilation activation. The centralized IoT framework allows users to monitor multiple zones remotely, providing enhanced control and improved safety assurance. Our goal is to minimize the risk of gas-related accidents, protect lives and property, and offer users a reliable, user-friendly platform that prioritizes both safety and convenience. Through this project, we envision a future where technology and safety go hand in hand, delivering smarter solutions for everyday challenges.

Keywords: Gas leakage detection, real-time monitoring, mobile application development, user notifications, remote control, and automated gas shut-off mechanism.

1. Introduction

Gas safety is a paramount concern in both residential and industrial environments, where gas leaks can lead to catastrophic consequences, including explosions, fires, and toxic exposures. Traditional methods of gas leak detection, such as manual inspections and basic sensor systems, often fall short in providing timely and accurate alerts. As urbanization and industrial activities continue to expand, the need for more advanced and reliable gas safety solutions becomes increasingly critical.

The advent of the Internet of Things (IoT) has revolutionized various sectors by enabling real-time monitoring, data collection, and automated responses. In the context of gas safety, IoT innovations offer a transformative approach to leak management. By integrating smart sensors, wireless communication, and advanced analytics, IoT-based systems can provide comprehensive and continuous monitoring of gas pipelines, storage facilities, and distribution networks.

The integration of IoT in gas safety not only enhances the detection and prevention of leaks but also contributes to overall operational efficiency and cost savings. By adopting these next-generation technologies, industries and households can significantly mitigate the risks associated with gas leaks, ensuring a safer and more secure environment.

This capstone project aims to develop and evaluate an IoT-based gas leak management system, demonstrating its effectiveness in real-world scenarios. Through rigorous testing and analysis, the project will highlight the benefits and challenges of implementing IoT innovations in gas safety, paving the way for future advancements in this critical field.

2. Literature Survey

The capstone project titled "Next-Gen Gas Safety: IoT Innovations for Comprehensive Leak Management" aims to address critical issues in gas safety through the integration of IoT technologies. This literature survey explores existing research and developments in the field of gas leak detection, gas quantity measurement, and IoT-based safety systems, providing a foundation for the proposed innovations.

Khan, M. M. [1] suggested a low-cost, low-power, lightweight, portable, safe, user-friendly, effective, and straightforward system for detecting gas leaks that is based on an Arduino UNO R3 and MQ-6 gas sensor.

In order to transfer data to the open IoT API service Thing Speak, Zafar S, Miraj G, and others [2] created a system that consists of an Arduino UNO board, DHT11 sensor, and ESP8266 Wi- Fi module. They created application makes use of the cloud and employs a REST API web service to show results to end users.

A system for identifying and removing gas spills using a GSM module to transmit alarm messages when gas leaks occur was proposed by Shreya P and Raghavendra R [3].

Tina Babu and others[4], proposed a gas leakage detection system with Gas sensors, Methane sensor, Carbon monoxide Sensor, MQ2 Sensor, Communication module. The system processes data and sends it to cloud using internet and monitors real-time ensures that any gas leaks detected through automated alerts.

P. Kalpana and others[5], designed a model with microcontroller with Wi-Fi module for communication. Arduino IDE pass command to microcontroller, then microcontroller analyze data and gives output.

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Bader Farhan and Muhammad Tajammal[6], proposed a industrial monitoring system design using IOT. The gas sensor(MQ5) captures and post data in cloud. Based on the atmospheric conditions the sensor detects the leakage of gas. The alert is displayed by an LCD with location of leakage.

3. Methodology

Our Project outlines the systematic approach employed in designing and implementing the IoT-based gas safety system, titled "*Next Gen Gas Safety"*. The system integrates hardware components, such as gas sensors, microcontrollers (ESP32), and actuators, with advanced software solutions to enhance safety and convenience in managing LPG gas usage.

The methodology is divided into distinct phases, including the development of a Risk Detector Device for detecting gas leakage and automatically shutting off the gas supply, a Gas Quantity Measurement Device for monitoring LPG cylinder levels, and a mobile application for real-time alerts and control. Communication between devices is established through IoT protocols such as MQTT, while cloud-based infrastructure is utilized for data storage and analytics. The system is rigorously tested under various scenarios to ensure accuracy, reliability, and scalability.

Each stage of the development process incorporates user feedback to iteratively enhance the design and functionality.

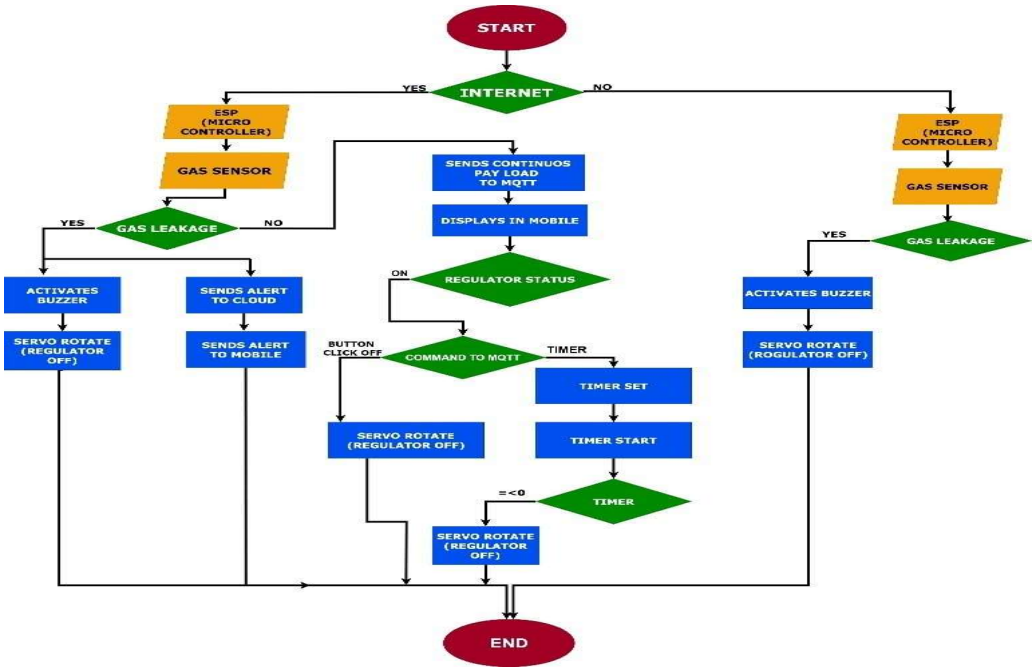

Fig.1: This Flowchart showcases the total project workflow and mechanism of how it start's and how it ends

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Main objective of our project is to build:

1. Risk Detector device if there is any gas leakage and automatically turns of the gas.
2. Device that measures the Gas quantity in the LPG gas cylinder.
3. An app that show cases above both in it, and through this a person can easily detect if there is any above mentioned risks and in further we include more features in the applications.

The first component of our system is the Risk Detector device. This device is equipped with advanced sensors capable of detecting even the slightest gas leakage. Upon detection, it automatically shuts off the gas supply, thereby preventing potential hazards and ensuring the safety of the occupants.

The second component is a Gas Quantity Measurement device. This device accurately measures the amount of gas remaining in the cylinder, providing users with real-time data. This feature eliminates the guesswork associated with gas usage and ensures that users are always aware of their gas levels, preventing unexpected shortages.
To unify these innovations, we have developed a comprehensive mobile application. This app serves as the central hub for monitoring and managing gas safety. It displays real-time data from both the Risk Detector and the Gas Quantity Measurement device, allowing users to easily detect any risks and manage their gas usage efficiently.

4. Software and Hardware

Here, Software and Hardware plays a major role in this IOT based project named "Next Gen Gas Safety".

i. Software Role:

The software in the "Next Gen Gas Safety" project plays a crucial role in facilitating real-time monitoring, communication, and user interaction. The Android Studio-based mobile application provides a user-friendly interface for accessing gas levels, leakage alerts, Auto timer cutoff, Gas Booking, Emergency Contacts, remote regulator control and AI voice assistant functionalities.

Fig.2: AI Voice Assistant has been integrated in this android application, that helps in assisting to the user and makes their work more easier

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Fig.3: Application Homepage

IoT protocols such as MQTT enable seamless data exchange between the hardware components, the cloud, and the mobile application. Cloud infrastructure is employed for storing sensor data, allowing for real-time tracking.

The microcontroller firmware, developed using platforms like Arduino IDE, processes sensor inputs, triggers alerts, and executes commands for actuator control. Together, these software elements ensure the system's functionality, reliability, and accessibility.

APP FUNCTIONALITY :

Flame Status Monitoring:

This feature detects whether the gas stove is currently ON or OFF. If the stove is on, the app will display "ON," allowing users to monitor flame usage. If the stove is off, it will display "OFF," ensuring users that no active flame is present.

Gas Leakage Detection:

Continuously monitors for any LPG gas leaks in the surroundings. If no leaks are detected, the app displays “Not Detected”. If a leak is detected, it immediately alerts the user and can trigger automatic safety actions.

Regulator control:

Enables remote control of the gas regulator through the app. Allows users to turn the gas supply ON or OFF without physically accessing the regulator.

Auto Timer Cutoff:

Auto Timer Cutoff automatically shuts off the gas supply if the stove is left on for an extended period.

Gas Booking :

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Gas booking assistance allows users to book a new LPG cylinder directly from the app. Saves time by providing a seamless gas refill request process.

Emergency Contacts:

Emergency Contacts Stores important contact numbers, such as emergency gas services, fire departments, or family members. Enables quick calling in case of a gas-related emergency.

ii. Hardware Role

The hardware serves as the backbone of the system, responsible for data acquisition, processing, and physical actuation. MQ-series gas sensors detect potential gas leaks and provide input to the ESP32 microcontroller, which acts as the central processing unit. Load cells are used to measure the LPG cylinder's weight, enabling accurate monitoring of remaining gas levels.

Fig.4: IOT Hardware Computers Set-up

The flame sensor continuously monitors the environment and sends signals to the ESP32 microcontroller upon detecting a flame. The system then triggers real-time alerts via the mobile application and can automatically shut off the gas supply using a servo motor to prevent further hazards. Additionally, the detection event is logged in the cloud for safety tracking. This integration enhances fire prevention, ensuring a more reliable and responsive gas safety mechanism. These hardware elements work in harmony with the software to create a robust, intelligent gas safety solution.

Fig.5: Servo Motor Integration to the LPG gas Cylinder

5. Conclusion

The "Next Gen Gas Safety" system exemplifies an innovative and comprehensive approach to enhancing LPG gas management and safety. By integrating advanced IoT technologies, such as gas sensors, load cells, ESP32 microcontrollers, and servo motors, the system provides real-time monitoring of gas levels and leakage status, along with remote manual control capabilities. The use of cloud-based storage and analytics ensures reliable data management, while the Android Studio -based mobile application delivers a seamless user experience across platforms.This project not only addresses critical safety concerns associated with LPG gas usage but also offers a scalable and user-friendly solution for modern households and industrial environments. The rigorous testing and optimization processes confirm its reliability, accuracy, and efficiency. With its robust design and intelligent functionalities, the "Next Gen Gas Safety" system sets a benchmark in gas safety technologies, promising a safer and more convenient future for users worldwide.

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