AI-Powered Secure LPG Monitoring and Control System for Smart Kitchens

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Keywords: Smart LPG Stove, STM32F103C8T6 Microcontroller, Gas Leakage Detection, AI, ML Integration, Kitchen Safety System, Automated Safety Measures, PIR Sensor, Intelligent Decision-Making, Motion Deduction Control.

Abstract: This project presents an advanced safety mechanism to extend kitchen safety through automated monitoring and controlling using the STM32F103C8T6 microcontroller and the "AI-Powered Secure LPG Monitoring and Control System." It brings together multiple sensors to sense possible hazardous conditions and react preventively. use gas sensor which detect LPG leakage, it uses flame sensor to ensure flame present in utensil, and use ultrasonic sensor to check whether utensil is placed correctly. These features also aid in detecting and addressing dangers like gas leaks, unattended flames and improper stove use. Using AI & ML algorithms in conjunction with a PIR sensor camera, the system identifies whether the motion is from a human or an animal. Doing so increases accuracy of detection and reduces false alarms. The system will also automatically close cylinder valve and power supply in case of a gas leak. This prevents gas from flowing unless a flame or a utensil is detected. Furthermore, in the event of a fire, the system instantly notifies emergency services, facilitating a swift response. SMART LPG STOVE: Integrating advanced sensing technology with AI-driven decision-making, the Smart LPG Stove offers a revolutionary solution that not only increases kitchen safety but also effectively reduces accidents and promotes energy efficiency. This cutting-edge solution is a significant leap forward in the realm of contemporary kitchen appliances, providing a cooking experience that is both safer and more intelligent.

1 INTRODUCTION

Liquefied Petroleum Gas (LPG) is used as a domestic energy in many countries and is a major source of home cooking. Though LPG has improved cooking efficiency and convenience, it comes with fire risks. Gas leak and other type of kitchen accidents are common and hence, can bring serious injuries or even fatalities. Hence, it is crucial to prevent gas leak and other items in Kitchen to ensure Kitchen safety. To mitigate this problem, we proposed the "AI-Powered Secure LPG Monitoring and Control System for Smart Kitchens"

Advanced sensors, AI, ML and IOT technology can be integrated with a kitchen safety system to track potential hazards and act against them in real-time. Its aim for the cooking space specifically will likely zero in on core safety concerns, like gas leaks, unattended flame, and spontaneous combustions.

1.1 System Functionality

The system includes several sensors for full hazard detection:

If there is no flame or utensil detected at the cooking platform, the system will automatically turn off the gas regulator, thereby preventing gas wastage. If there is an LPG leak, the device instantly shuts the cylinder valve and disconnects the power supply, which lowers the probability of an explosion. In case of fire detection, the system sends emergency messages through GSM module, for quick response to users and nearest safety department providers.

An AI-powered camera, integrated with a passive infrared (PIR) sensor, differentiates between human and animal motion, improving motion detection accuracy and reducing false alarms. This intelligent decision-making capability enhances the system's efficiency and reliability.

S., K., B., A., S., N., R., S., M., I. N. and V., P.
AI-Powered Secure LPG Monitoring and Control System for Smart Kitchens.
DOI: 10.5220/0013899200004919

In *Proceedings of the 1st International Conference on Research and Development in Information, Communication, and Computing Technologies (ICRDICCT'25 2025) - Volume 3*, pages 407-413
ISBN: 978-989-758-777-1

1.2 The Growing Concern over LPG-Related Accidents

According to the National Crime Records Bureau (NCRB), recent statistics highlight the severity of LPG-related accidents. In Tamil Nadu, 586 people lost their lives due to gas cylinder explosions, while Gujarat recorded 735 fatalities. Among the southern states, Tamil Nadu reported the highest number of casualties, surpassing Andhra Pradesh (426), Karnataka (386), and Kerala (52). On average, gas cylinder explosions in Tamil Nadu claim around 10 lives per week. In the previous year, there were 632 reported incidents related to LPG explosions (Rohan Chandra Pandey). Another report reveals a significant rise in gas leakage accidents, increasing from 0.72% to 10.74% of all cooking-related mishaps.

1.3 The Role of LPG in a Sustainable Energy Future

LPG has over 1,000 applications, serving hundreds of millions worldwide across industries such as commerce, agriculture, transportation, electricity generation, heating, and cooking. It is recognized for its environmental benefits, immediate availability, versatility, and ease of transportation. As the world transitions toward a more sustainable and secure energy economy, LPG remains a crucial energy source, particularly for clean cooking solutions in various countries.

1.4 A Smarter and Safer Kitchen Solution

By integrating IoT, AI, and automation, the Smart LPG Stove represents a breakthrough in modern kitchen technology. It enhances safety, reduces household risks, and improves energy efficiency, making it a transformative solution for smarter and safer cooking environments.

2 OBJECTIVES

- Develop an AI-powered automated system that can accurately detect gas leaks, flame presence, utensil placement, and abnormal heat levels to prevent LPG-related kitchen accidents.
- Implement an intelligent safety mechanism that automatically shuts off the gas regulator, cylinder valve, and power supply in the event of a gas leak, unattended flame, or absence of a utensil, minimizing fire risks.
- Integrate IoT and AI-driven monitoring to provide real-time gas and flame status updates, alert users and nearby safety authorities through a GSM module anenable remote monitoring via a smart interface.
- Enhance motion detection accuracy using an AI-powered camera with a PIR sensor, differentiating between human and animal movement to reduce false alarms and improve system reliability.
- Ensure user-friendly operation by offering an intuitive interface that allows households and commercial kitchens to easily configure and operate the system with minimal effort.
- Promote safer, more energy-efficient, and cost-effective LPG usage by minimizing gas wastage, reducing accident risks, and optimizing energy consumption for both residential and commercial kitchens.

3 LITERATURE SURVEY

The increasing realization of the hazards linked to the use of LPG has resulted in an increased demand for the creation of automated intelligent solutions for gas safety at home featuring smart home technology. The field has progressed through research and projects working on sensor and IoT technologies that would prevent things like gas leaks, unattended flame, and explosions. The Automatic Smart LPG Stove using IOT was designed and developed based on some significant researches and developments as cited below. Most research has addressed devices for detecting gas leaks to prevent explosions triggered by undiscovered leaks. MQ series gas sensors, especially the MQ4 and the MQ6 models, are commonly used to detect the methane and the LPG gases. Studies like those from Suryawanshi et al. (2018) have also pointed out that the detection of gas concentrations in the environment and the start of the alert with the combination of gas sensor and microcontrollers. These devices help prevent emergencies but often just serve as an alarm without controlling the gas supply. Many research efforts have studied integrated systems that consist of gas sensors with flame sensors and use Internet of Things. Rao et al. sensors to detect temperature changes, gas leakage and flames. In the case of an anomaly, IoT-enabled alarms would alert users. While this system is focused more on commercial use, it utilizes many of the same

aspects and ideas as the design of the Smart LPG Stove and provides automatic shut-off as well as notifications in real-time. With these concepts in mind, the use of IoT with gas, flame and ultrasonic sensors using IoT features gives us the Automated Smart LPG Stove, which is fully automated and easy to use. This approach not only helps to learn about potential risks, but also proactively responds in managing to avoid an accident, making cooking a far safer environment to be in.

4 PROBLEM STATEMENT

Liquefied petroleum gas (LPG) that is commonly used in homes for cooking is a highly flammable gas and poses a serious safety risk. Gas leaks, flames left unattended and forgetting to place utensils on a burner are leading causes in kitchen disaster that can lead to death, major injuries and property destruction. Gas leak detectors and flame monitoring equipment are already on the market; however, the majority of existing systems are either manual or a combination of manual and automatic, which are not fast enough to prevent incidents in the real time. In addition, there is a lack of sensor integration in the utensils presence detection system, which helps eliminate unnecessary gas and potential dangers if used accordingly.

Current systems do not only cover utensil detection, causing excessive gas flow that causes energy waste and, moreover, a safety issue. Additionally, most solutions available today are not integrated with the IoT, meaning that they cannot send out emergency alerts, remote figure control, and monitor conditions in real-time. The challenge lies in designing an automated LPG stove system that can detect flames, gas leaks and utensils simultaneously, and is also able to shut off automatically to prevent dangerous situations. Besides, the notifications should be real time so that either the user or emergency services can act swiftly in case of critical event.

Existing systems combine the gas flow detection without any utensil detection leading to unnecessary gas flow which increases the energy consumption and introduces safety risks. Additionally, most implemented solutions are unable to integrate IoT technologies, which significantly limits their potential for real- time monitoring, remote control and emergency alerts. So, the task is to design automatic IoT-enabled LPG stove system based on the environment in order to detect gas leak, flame as well as utensil presence all at the same time with automatic shut off functionality in order to get rid of vulnerable conditions. And it should also be able to send alerts in real-time to the users or to emergency services so that action can be taken immediately when a critical event happens.

5 OPERATIONAL FRAMEWORKS

The AI-Powered Secure LPG Monitoring and Control System operates through three primary layers: sensing, processing, and control. These layers work together to detect hazards, analyze data, and take necessary actions to ensure kitchen safety.

The sensing layer consists of gas sensors, a flame sensor, an ultrasonic sensor, and an AI-powered camera with a PIR sensor to detect gas leaks, unattended flames, utensils, and human or animal presence.

The processing layer uses AI and ML to analyze sensor data, differentiate between human and animal movement, and make automated decisions to prevent accidents.

The control layer includes a motorized actuator to shut off the gas knob, a power cut-off mechanism for major leaks, and a GSM module for emergency alerts.

This system addresses the growing concern over LPG-related accidents by providing real-time monitoring, automatic gas shutoff, and emergency response, ensuring a safer kitchen environment. With its IoT and AI integration, it enhances safety, reduces risks, and promotes energy efficiency in modern kitchens.

6 EMERGING TECHNOLOGY

The development and application of the internet of things-based AI-Powered Secure LPG Monitoring and Control System for Smart Kitchens heavily relies on emerging technologies. Advancements in sensor technologies, microcontroller systems, and the internet of things have brought about the development of smart kitchen solutions that improve automation and safety.

Important developments in gas sensors, including the gas sensor, enable accurate detection of methane and LPG gas leaks, guaranteeing real-time monitoring of hazardous levels. The user's mobile phone received alert messages from our devised system with success. To get these messages on the user's phone, no application needs to be installed. The GSM technology is used to send these alert messages.

Furthermore, by lowering the possibility of an unsupervised gas flow, flame sensors improve stove safety by responding instantly to the presence or absence of a flame.

7 LPG SAFETY SYSTEM

Gas leaks are a severe issue that are currently seen in a lot of locations, including homes, businesses, cars, etc. LPG, also known as liquefied petroleum gas, is a combustible blend of hydrocarbon that can be used as fuel in a range of facilities, including homes, hotels, businesses, and automobiles. It also has a high temperature, low smoke and soot content, and little effect on the environment. Even when it is far from the source of the leak, LPG can quickly catch fire due to its high flame-retardant properties. LPG is mostly used for cooking in homes. They could blow up when the dumping gases combine with oxygen molecules and the amount of LPG in the atmosphere, or if there's a flame or an electric spark present.

In this work, the classic k-ε model describes the gas flow field. The k equation for turbulent dissipation and the 'k' equation for turbulent kinetic energy rate are computed using the two equations that make up the model. The variable 'k' denotes turbulent kinetic energy, which can be expressed as m2s−2. Additionally, ok represents the Plant-Schmidt constant of this energy, & denotes the turbulent kinetic energy dissipation, and C2 is the constant in the k-equation.

Generally, this equation reduces the combustion of propane and butane to a single, irreversible. In gas consumption, the combined effects of turbulence and the chemical reaction are considered using the finite rate/eddy current dissipation model. Figure 1 show the Block Diagram.

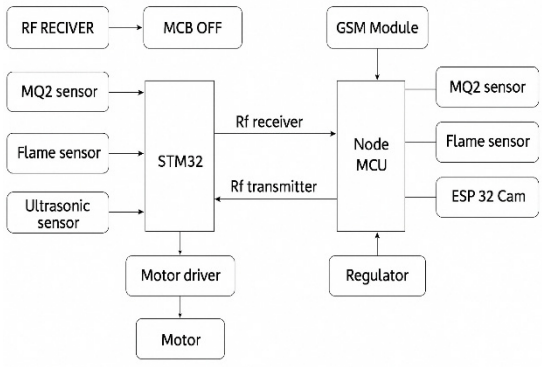

Figure 1: Block diagram.

8 DESIGN AND WORKING

The AI-Powered Secure LPG Monitoring and Control System for Smart Kitchens is designed to enhance kitchen safety by detecting gas leaks, monitoring flame presence, identifying utensil placement, and distinguishing between human and animal movement. Built around the STM32F103C8T6 microcontroller, the system integrates multiple sensors and AI-based automation to prevent hazards in real time. The gas sensor (MQ2) continuously monitors the environment for LPG leaks, and if a leak is detected, the system immediately shuts off the gas supply using a servo motor and cuts power to prevent ignition. Simultaneously, it triggers a buzzer alarm and sends real-time alerts via GSM and IoT to inform users and emergency responders. The flame sensor (KY-026) ensures the presence of a stable flame. If the flame goes out unintentionally, the system closes the regulator valve to prevent gas buildup. In case of a fire, it sends emergency alerts to nearby fire stations for a quick response.

An ultrasonic sensor (KY-050) detects if the utensil is present on the stove to improve energy efficiency. When no utensil is detected, gas supply is automatically turned off, saving gas from being wasted. Also, the PIR sensor and the ESP32 camera differentiate between humans and animals. In the case of unattended cooking, gas would continue to flow, but if no human presence was sensed near an active stove for a certain period of time, the system would cut the gas to avoid any hazards. In addition, it is enhanced with AI and ML algorithms that analyze motion data to reduce false alarms and process intelligent decisions. With GSM (SIM800L) through IoT connectivity gives users a mobile notification in real-time to monitor the kitchen appliances from a distance. In addition, AI not only detects early signs of potential hazards through predictive analytics but also suggests preventive safety measures.

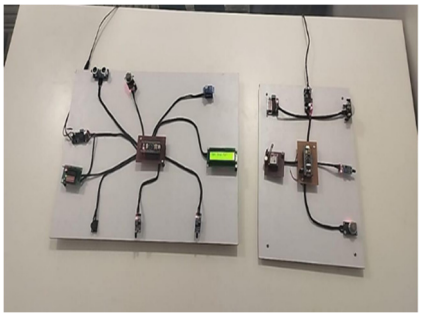

Figure 2: STM32F103C8T6 controller connection with sensors.

Figure 3: Testing setup with fire.

Figure 2 and 3 shows the STM32F103C8T6 controller connection with sensors and Testing setup with fire respectively.

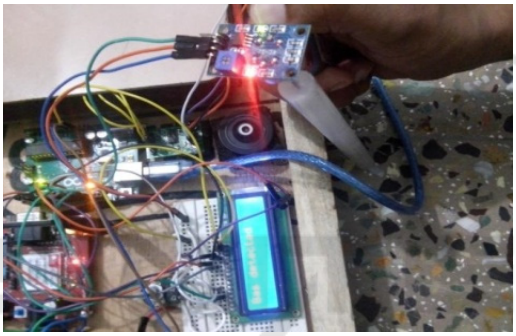

Figure 4: Testing gas detection.

Figure 5: Testing with no flame.

Figure 4 and 5 shows the Testing gas detection and Testing with no flame respectively. The Smart LPG Stove System is a highly secure and energy-efficient appliance for today's kitchens, thanks to a mix of advanced sensors, AI-powered automation, and IoT integration. It provides real-time hazard alerts, automated shutoff solutions, and remote notifications, making cooking safer and more convenient.

The following components were used in the development of the "AI-Powered Secure LPG Monitoring and Control System for Smart Kitchens"

- STM32F103C8T6
- Flame sensor
- ESP 32 Cam
- Servo motor
- Gas sensor (MQ2)
- GSM module (SIM800L)
- Encoder (RF transmitter)
- Decoder (RF receiver)
- Display (optional, eg., LCD)
- Ultrasonic sensor
- IR sensor
- Buzzer

9 PROPOSED METHODOLOGY

This paper aims to provide a proposed design methodology of Automated Smart LPG Stove using IoT that assures kitchen safety through real time monitoring, automated control and notifications to users. It is a sensor, microcontroller, and actuator-based system to check for gas leakage, flame status and utensil presence on the stove. Gas sensors monitor the levels of LPG and methane, continuously checks the levels of the gas. A flame sensor is placed near the burners to check if the flame is on, and an ultrasonic sensor to see if utensils are being used.

The STM32F103C8T6 microcontroller receives real-time data from these sensors and executes predefined safety protocols. When the gas is not off when it should be, the system then has the ability to rely on sensor input and has the intelligence to turn off the gas knob by itself in times of crisis, such as gas leaks, no flame, or no utensil detected when the gas is on.

The IoT module will allow the user to connect their devices to the kitchen to remotely monitor whether the kitchen is safe. To make the system more usable, a smartphone application and web portal interface is developed that allows users to set alert thresholds and monitor the stove remotely. Finding such a smart solution would reduce the chances of gas accidents happening as it is a complete solution for automated kitchen safety.

10 RESULTS

Through the very successful IoT connection, an extinguished flame or gas leak could be detected remotely with the help of a smartphone app, and customers would receive immediate notifications in the face of any danger. At the system's core was a set of valves that could be opened and closed remotely, allowing users to manage the gas supply from a distance.

Testing demonstrated that the microprocessor responded accurately and quickly to sensor inputs, and that the system functioned reliably and consistently in a variety of conditions. The user interface also provided users with real-time data about gas concentrations, flame status, and utensil presence, which gave them full control and supervision over the system.

When we take all of these into account, the accuracy of detection, timely response and IoT-based remote monitoring of the system practically assured the kitchen safety. Best User Interface, User Experience for Device: The user interface was designed to put the users in full control and supervision of the device and to show real-time data about the concentration of gas, state of flame, and presence of the utensil. Conclusively, the system's accurate detection, early response, and Remote Monitoring based on Internet of Things and Secured, smart kitchen ensures Kitchen safety.

11 CONCLUSIONS

The Smart LPG Stove based on STM32F103C8T6 controller, on the other hand, aims to make the kitchen safe by protecting it from the effects of gas, flames, and utensils automatically, by recognizing the risk of leakage and turning off the gas knob. Customers may also feel more comfortable knowing that the device is simple to install and use, and it can help avoid disasters in the kitchen. In the system, there are 4 sensors used (STM32F103C8T6 controller board _ flame sensor _ gas sensor _ ultrasonic sensor original).

You can enhance the project to add voice control, multi-language, and mobile app compatibility features. Overall, the smart LPG stove project is an effective and useful of STM32F103C8T6 controller technology that can improve the safety of your kitchen significantly.

12 FUTURE SCOPE

The IoT- powered Automated Smart LPG Stove has an extensive scope to grow and adapt, and the way ahead can have a few suggestions for improvement in the future.

Integration with Smart Home Systems: As the Internet of Things evolves, the system can be integrated into broader smart home ecosystems, allowing seamless communication with other smart devices, smoke alarms, ventilation systems, and fire detectors.

Improved User Interface and Analytics: Additionally, this information could be used to develop more sophisticated online or mobile applications with full data, allowing users to contribute to monitoring safety events, reviewing gas consumption over time and receiving guidelines for improving energy efficiency.

REFERENCES

A. Gupta," Economical and Optimal Gas Leakage Detection and Alert System," International Journal of Scientific and Research Publication, vol. 7. no. 11, pp. 260-263,2017.

A.Shrivastava, R. Prabhakar, R. Kumar, and R. Verma, "Gsm Based Gas Leakage Detection System," International Journal of Emerging Trends in Electrical and Electronics, vol. 1, no. 2, pp. 42–45, 2013.

B. SakthiKumar, M. I. Niranjana, M. Abinath, I. G. Prasath, K. Jugasri and S. Kailash, "Survey on Smart Agriculture Using Iot," 2023 International Conference on Computer Communication and Informatics (ICCCI), Coimbatore, India, 2023, pp. 1-5, doi: 10.1109/ICCCI56745.2023.10128531.

C.O.Folorunso, W.A. Raheem, L.A. Akinyemi, and A.A. Raji, "Development of a Liquified Petroleum Gas Leakage Detector, Level Indicator, and Automatic Shutdown System," Covenant Journal of Engineering Technology (CJET), Vol.3, No.2, 2019.

K. Krishnadas, N. P. Prajith, P. Sidharthan, S. Mariyam, and V.H. Arul," Automatic Gas Controller Unit," International Journal of Engineering Research & Technology (IJERT), Vol. 8, no. 05,2019.

K.Manoj Senthil, R. Karthick, M.Kavin, S.I.Musthakahamed," Gsm Based Automation Of Gas Stove," International Journal Of Scientific & Technology Research, vol. 9, no. 3, 2020.

M. I. Niranjana, V. Parthipan, J. Dhanasekar, M. Jesheer, M. G. Giridaran and K. L. Harishankar, "An Innovative IoT Based Surveillance Robot for Smart Applications," 2023 7th International Conference on Electronics, Communication and Aerospace Technology (ICECA), Coimbatore, India, 2023, pp. 377-382, doi: 10.1109/ICECA58529.2023.10395527.

Mohammed Khalafalla, Prof. Zhang Jun, "Automatic Gas Cooking Control System based on Microcontroller," International Journal of Engineering Research & Technology, vol. 5, no. 2, pp. 2278-0181, 2016.

Neha R. Shahapurkar, Shubham P. Deshpande, M. R. Rajput, "A novel technique for LPG gas leakage detection and control for safety," International Journal for Research & Development in Technology, vol. 7, no. 3, 2017.

Rohan Chandra Pandey, "Internet of Things (IoT) Based Gas Leakage Monitoring and Alerting System with MQ-2 Sensor," International Journal of Development Research, vol. 5, no. 2, pp. 2321-9939,2017.

S. P. S. Selvapriya C, A. M, and A. K. C, "LPG Leakage Monitoring and Multilevel Alerting System," Int. J. Eng. Sci. Res. Technol., vol. 2, no. 11, pp. 1–4, 2013.

S. Jahan, S. Talukdar, M. M. Islam, M. M. Azmir, and A. M. Saleque," Development of Smart Cooking Stove: Harvesting Energy from the Heat, Gas Leakage Detection and IoT Based Notification System," International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST), Dhaka,2019.

S. S. K. S. Senthilkumar, "A Wireless Gas Leakage & Level Detection with Auto Renewal System," IJAREEIE, pp. 2095– 2100, 2015.

V. Abishek and M. Aierselvam, "Wireless Auto Power Trip during Gas Leakage," Advance in Electronic and Electric Engineering, Vol.3, no.3, pp.327-332, 2013.

V. Abishek, and M. Aierselvam, "Wireless Auto Power Trip during Gas Leakage," Advance in Electronic and Electric Engineering, Vol. 3, no. 3, pp. 327-332,2013.