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Sensor-Based Smart Gas Leak, Flame, Smoke and Human Presence Detection System with Automatic Shutoff for Biogas and LPG Stoves

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Abstract
Gas leakage and unattended stoves are main reasons for fire accidents and death of humans particularly in kitchens the use of LPG and biogas structures this studies affords a sensor-primarily based smart protection system able to detecting gasoline leakage flame smoke and human presence close to cooking areas the proposed gadget integrates multiple sensors with a microcontroller platform to constantly screen hazardous situations when ordinary situations which includes gas leakage or immoderate smoke are detected the machine robotically triggers an alarm and shuts off the gasoline supply the use of an electrically controlled valve a human presence sensor is integrated to perceive whether or not a person is close by thereby decreasing false alarms and allowing wise selection making the machine makes use of gas sensors for LPG and biogas detection a flame sensor to perceive open flames a smoke sensor to monitor combustion particles and a passive infrared sensor PIR to hit upon human presence all sensors are interfaced with an Arduino-primarily based manipulate unit that techniques sensor information in actual time when the fuel attention exceeds a safe threshold or fire hazards are detected the gadget turns on an alert mechanism and routinely stops gasoline flow to save you from accidents the system is designed to be fee-effective strength green and appropriate for domestic as well as small-scale business kitchens and as well as for agricultural kitchens experimental trying out suggests that the proposed system can come across hazardous situations quickly and reply routinely decreasing the danger of fireplace and gasoline-associated injuries the designed prototype demonstrates the feasibility of integrating a couple of protection sensors with computerized manage mechanisms for kitchen protection this smart tracking gadget contributes to stepped forward household safety protection and supports the improvement of wise cooking environments in the home rural and agricultural kitchens.

Keywords: *Gas Leakage Detection, Smart Kitchen Safety System, Arduino Microcontroller, LPG and Biogas Monitoring, Flame and Smoke Detection, PIR Human Presence Sensor, Automatic Gas Shut-off.*

1. Introduction
Gas-based cooking systems like LPG and biogas stoves are widely used around the world because they are efficient and easy to use. However, even though these systems have many benefits like very quick and convenient to the modern world instead of traditional wood stove but still gas leaks are be a big safety problem in homes and places like hotels and hostels where food is prepared. If gas leaks are not found quickly, they can cause fires, explosions, health problems and even loss of life. Older gas stoves don't have safety features that can automatically detect dangerous situations like unattended cooking, abnormal heating or burning and elder peoples are non-cautious to the LPG gas and biogas stoves. Because of this, there has been a lot of research into creating smart monitoring systems that use sensors and other technologies. These modern sensors can check things like how much gas is in the air, how much smoke there is, and whether a flame is present. This study aims to create a smart system that uses sensors to detect gas leaks, smoke, flames, and whether someone is near cooking equipment. The system also has an automatic shut-off feature for gas to stop accidents before they happen. The goal is to make kitchens safer by identifying dangers early and responding automatically.

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2. Methodology of the System

The system proposed includes multiple sensors which are connected to a microcontroller to identify dangerous situations and the main sensors in the system are a gas sensor, smoke sensor, flame sensor and a passive infrared sensor-PIR. The gas sensor is used to find leaks of LPG or biogas by checking the level of gas in the air, the smoke sensor detects smoke that comes from burning of the food product due to unattended cooking, flame sensor helps to identify if there is a fire or an unusual flame and the human presence sensor PIR checks if someone is close to the stove all the sensors send their data to an Arduino microcontroller which analyzes the signals and compares them with set safety limits assigned or trained. If it detects something unsafe the microcontroller turns on a buzzer to alert people and activates a relay module that connects to a solenoid valve this valve, then cuts off the gas supply to stop more leaks or prevent fire.

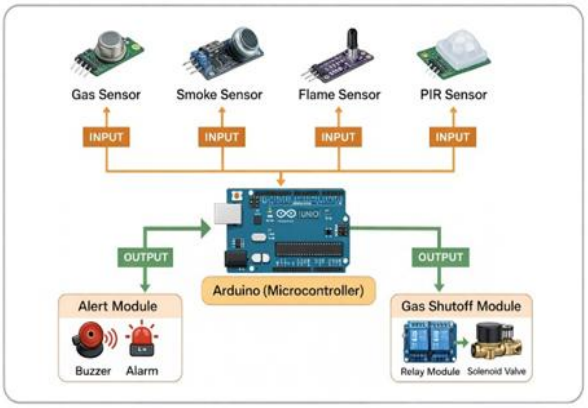

Figure 1 Block Diagram of the Proposed Smart Gas Safety System

3. Design of the System

The proposed system consists of four main modules:

3.1. Sensing Module

This part includes sensors for detecting or identifying gas, smoke, flame, and human presence. These sensors keeps monitoring the surrounding environment all time.

3.2. Control Module

The control module uses an Arduino UNO microcontroller. It gathers the signals from the sensors like LPG or smoke detected and acts according to the signal.

3.3. Alert Module

The Alert module consist of buzzer and LED indicator system or Display to indicate and to alert people if any dangerous situation is determined.

3.4. Gas shutoff Module

In this module there is solenoid valve that is controlled by a relay. If a risky situation is detected, this valve automatically turnoff the gas supply.

4. Working Principle of the System

The working principle of the proposed system is based on as many sensors monitoring environmental conditions in real time. Each sensor is designed to detect, specifically, a kitchen safety parameter. The function of gas sensor it continuously detects the concentration of lpg or biogas in air. So, when the gas concentration went above or below a predefined threshold value, it produced an analog signal and sent the same to the microcontroller for processing. The smoke sensor works in the same way that it detects cigarette particles from incomplete combustion. A flame sensor recognizes the infrared radiation emitted by fire, indicating an open flame. The passive infrared (PIR) sensor detects human activities based on changes in infrared levels. A microcontroller processes all sensor data and compares the values against preset safety thresholds. The system raises an alarm and automatically turns off the gas supply via a relay mechanism if any abnormal condition is detected. This guarantees immediate response and minimizes the risk of accidents.

5. Hardware Components

The System consist of several hardware components and they are listed below

5.1. Gas sensors (MQ-2/MQ-5)

This sensors are used to detect the leakage of LPG-liquefied petroleum gas and Biogas.

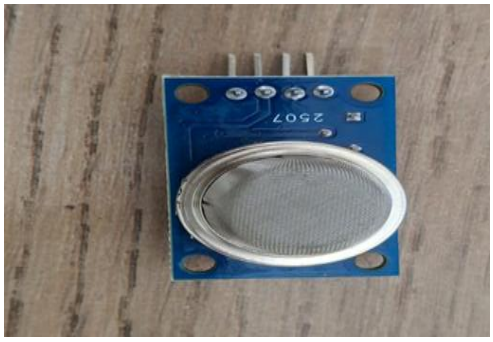

Figure 2 Figure of Gas sensor

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5.2. Smoke sensor (MQ-135)

This sensor is used to detect smoke particles present in the air.

5.3. Flame sensor

Flame sensor is used to detect flame or fire by sensing infrared light.

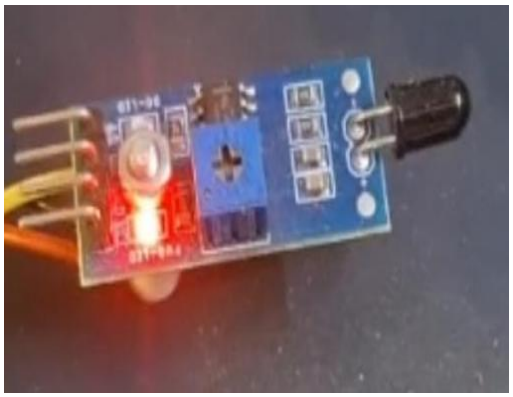

Figure 3 Figure of Flame sensor

5.4. PIR sensor

It is used to detect motion and human presence near the stove area.

Figure 4 Figure of PIR sensor

5.5. Arduino Microcontroller

It acts as the brain of the system while it processes the signal received from the sensors and control the buzzer and solenoid valve.

5.6. Relay module

It is used to control the solenoid valve to shut off the gas supply when receiving the signal from the Arduino microcontroller.

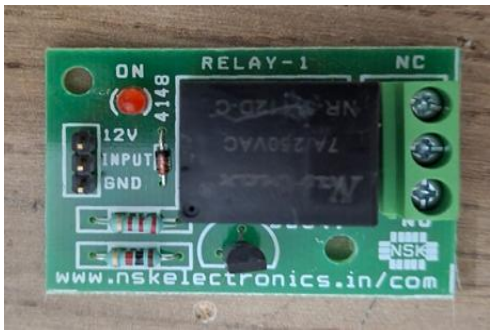

Figure 5 Figure of Relay Module

5.7. Solenoid valve

It is a type of valve which is controlled by relay module and it automatically shut off.

Figure 6 Figure of Solenoid Valve

5.8. Buzzer

Generate audible sound for alerting people by receiving signal from Arduino.

Figure 7 Figure of Buzzer

6. Result and Discussion

A prototype of the proposed system was created and tested with various simulated conditions. A quick response time traces LPG leakage by gas sensor. The smoke sensor positioned inside the furnace was found

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to precisely measure increased levels of smoke generated from controlled combustion fire tests. The flame sensor was able to detect open flames and the human presence sensor detected activity near the stove. The moment it detects hazardous conditions, an alarm is activated and the gas supply is turned off using a relay-controlled valve. At last the result of the system indicates by integrating multiple sensors improves the accuracy of the detection and reduces the false alarm and shutoff gas supply.

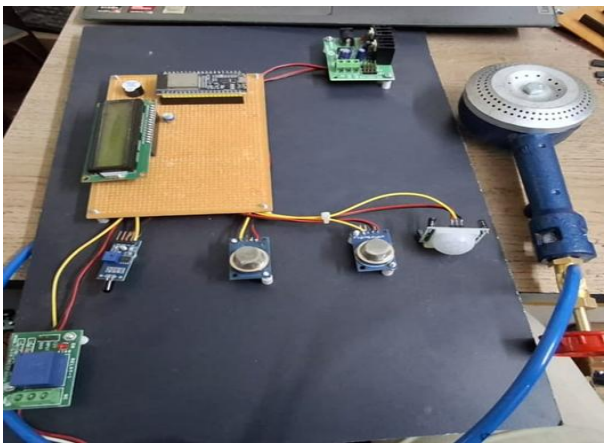

Figure 8 Prototype of the Proposed System

Conclusion

This study introduced a sensor-oriented intelligent supervisory system for identifying gas leakages, fire, smoke, and human presence in kitchen surroundings. It works very well by correctly implementing and embedding multiple sensors into a microcontroller to ensure real-time monitoring and automated safety responses. Tests demonstrated that the system is capable of rapidly identifying dangerous conditions and automatically turning off the gas supply. The proposed system provides a low-cost, dependable solution that can be effectively adapted for both household kitchens and small-prep commercial cooking environments.

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