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Arduino-Based Safety System for Gas Flame Monitoring, Leakage Detection, and Utensil Presence Using Sensor Integration and SMS Alerts

Vinay Sapkal, Nidhi Karkera, Nidhish Wakodikar, Ashish Nikam, Mrunal Nikam, Shreyash Nikhare
Department of Engineering, Sciences and Humanities (DESH), Vishwakarma Institute of Technology, Pune, 411037, Maharashtra, India

Abstract: ***In this research project, we present an innovative Arduino-based safety system designed to enhance household gas safety by monitoring gas flame, detecting gas leakage, and ensuring the presence of utensils in the cooking area. By integrating various sensors such as a flame sensor, gas leakage sensor, and ultrasonic sensor, coupled with servo motor control and GSM technology, our system provides real-time monitoring and proactive response to potential hazards. This project showcases the integration of hardware components and intelligent control algorithms, enabling an efficient and reliable safety system. The use of Arduino as the central control unit provides a flexible and cost-effective solution for gas safety applications. Experimental results demonstrate the effectiveness of our system in detecting potential hazards, triggering appropriate actions, and notifying users via SMS alerts.***

Keywords: Arduino, gas safety, flame sensor, gas leakage sensor, ultrasonic sensor, servo motor, GSM, SMS alerts.

I. INTRODUCTION

Ensuring the safety of household gas usage is of paramount importance to prevent accidents and protect lives and property. Gas-related incidents, such as unattended flames, gas leakage, and improper usage of cooking appliances, can pose significant risks in residential environments. To address these safety concerns, we present an innovative Arduino-based safety system that integrates various sensors, servo motor control, and GSM technology to monitor gas flame, detect gas leakage, and ensure the presence of utensils in the cooking area. The objective of this project is to develop a comprehensive safety system that actively monitors gas-related hazards and provides timely alerts to users. By employing Arduino as the central control unit, we leverage its flexibility, accessibility, and ease of integration with sensors and actuators. Through sensor integration and intelligent control algorithms, our system enables real-time monitoring and proactive response to potential risks, ultimately enhancing gas safety in residential settings.

II. LITERATURE REVIEW

The paper titled "Development of a Low-Cost Low-Energy Intelligent Reminder System for Unextinguished Gas Stoves" presents a solution to improve kitchen safety by addressing the issue of unattended gas stoves during cooking. The proposed system aims to provide timely alerts to the user without interrupting the cooking process. Instead of immediately extinguishing the flame, the system monitors the user's presence and generates periodic alerts to remind them to return to the stove. The system utilizes various sensors and low-power modules to operate efficiently. The authors constructed a prototype of the system and conducted experiments to evaluate its effectiveness and practicality. The results confirm the system's applicability in enhancing kitchen safety without disrupting cooking tasks. [1]

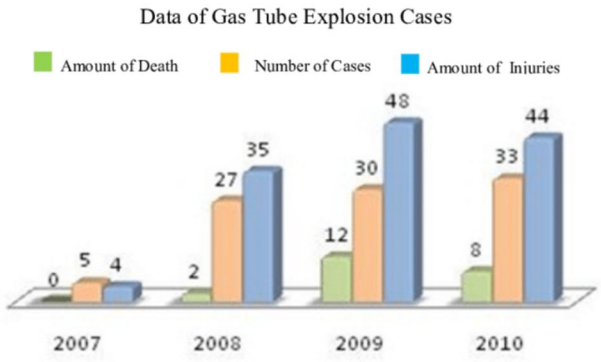
The paper titled “Smart Gas Stove for Kitchen Employing Safety and Reduction of Gas Wastage” introduces a system designed to enhance kitchen safety and reduce gas wastage by providing additional protection. The proposed system utilizes an ATmega328p microcontroller to control the kitchen gas valve mechanism and automatically turn off the gas supply when the stove is not in use for cooking. A solenoid valve is employed to control the gas flow. The system ensures that the gas burner only ignites when there is a flame and a cooking pot on the burner. Additionally, it incorporates features such as automatic activation of the exhaust fan when smoke is detected, high temperature monitoring, and gas leakage detection. The system also includes a timer function for cooking at specific times and Bluetooth connectivity for voice control of the burner. In case of gas leakage, the system triggers an alarm and notifies the homeowner via phone call and text message. Various modes are available to further enhance kitchen safety. Overall, this system provides effective safety measures and enhances the convenience of using a gas stove. [2]

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The paper titled "Home Automation System using Internet of Things (IoT)" presents a home automation system based on the Internet of Things (IoT) technology. The proposed system aims to provide convenience and control to homeowners by allowing them to remotely monitor and control various devices and appliances in their homes. The proposed approach involves the use of an SMS-based security box, which significantly reduces the risk of crime and protects valuable assets. The security box is designed to send an SMS notification to the owner's mobile device via a GSM module when someone other than the owner attempts to open it. The primary objective of this paper is to develop a cost-effective security solution that provides substantial benefits in terms of asset protection. [3]

The paper titled “LPG Leakage Detector with Smart SMS Alert using Microcontroller” is based on a minimal gadget that consolidates a MQ-6 sensor. This sensor is equipped for recognizing any spillage of LPG gas in its area, setting off a signal sound to caution the encompassing region. It likewise sends a SMS warning to the client, giving prompt data about the gas spillage in their home. This gadget isn't restricted to homegrown use however can likewise be utilized in assembling ventures where LPG gas is used for huge scope creation to distinguish any gas spills. To forestall gas drainage mishaps, introducing a LPG spillage marker in a very much ventilated location is suggested. The GSM module is utilized to send SMS cautions to the client, while a ringer is enacted at the same time. The SMS message is shown on a predefined versatile number utilizing the Microcontroller. In the event that the gas level surpasses the typical reach, a prompt alert is produced with the profoundly precise and touchy MQ-6 sensor, offering fast reaction time and exact identification. [4]

The paper titled ‘LPG Leakage and Flame Detection with SMS Notification and Alarm System: Rule-Based Method’ was published on 8 August 2020. The paper focuses on developing a rule-based system for detecting and notifying the owner of a house about gas leakage, smoke, and flame from an LPG cylinder. The system utilizes sensors such as a flame sensor and a gas MQ2 sensor to detect fire, gas leaks, and smoke. When any of these are detected, the system triggers an alarm, displays warning messages on an LCD, and sends text messages to the owner's cellphone. The researchers conducted functionality testing and achieved 100% accuracy. The proposed system aims to enhance the safety and security of LPG consumers by providing timely notifications and alarms in case of potential hazards. [5]



III. METHODOLOGY/EXPERIMENTAL

A. System Architecture Design

Determine the required components for the safety system, including a flame sensor, gas leakage sensor, ultrasonic sensor, servo motor, GSM module, and exhaust fan.

Design the architecture of the system, outlining the connections between the Arduino board and the various components.

Identify the appropriate pins on the Arduino board for connecting the sensors, servo motor, GSM module, and exhaust fan.

B. Hardware Setup

Gather the necessary components and ensure their compatibility with the Arduino board.

Connect the flame sensor, gas leakage sensor, and ultrasonic sensor to the designated digital pins on the Arduino board.

Connect the servo motor to a PWM pin on the Arduino board.

Connect the GSM module to the Arduino board using the appropriate communication interface.

Connect the exhaust fan to a digital pin on the Arduino board.

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C. Arduino Programming

Set up the Arduino Integrated Development Environment (IDE) and ensure the correct board and port are selected.
Import any required libraries for the sensors, servo motor, and GSM module.
Initialize the pins and variables used in the program.
Implement a continuous loop that monitors the sensors and controls the servo motor and exhaust fan based on sensor readings.
Use appropriate conditional statements and algorithms to detect flame presence, gas leakage, and utensil presence.
Write code to turn off the gas knob using the servo motor and activate the exhaust fan when necessary.
Incorporate the GSM module to send SMS alerts to the user when specific events occur.

D. Testing and Debugging

Upload the Arduino program to the board.
Conduct thorough testing to ensure proper functionality of the system.
Simulate different scenarios to verify the system's response to flame presence, gas leakage, and utensil presence.
Monitor the SMS alerts sent by the GSM module to confirm their accuracy and timeliness.
Debug and refine the code as needed to address any issues or anomalies.

E. Performance Evaluation

Evaluate the performance of the safety system by conducting a series of experiments and tests.
Measure the system's accuracy in detecting flame presence, gas leakage, and utensil presence.
Assess the response time of the system in activating the servo motor and exhaust fan, as well as sending SMS alerts.
Compare the system's performance with established safety standards and guidelines.
Analyze the results and identify areas for improvement or optimization.

IV. METHODS TO WRITE ARDUINO CODE

1) setup()

- The setup() function is executed once when the Arduino board is powered on or reset.
- It is used to initialize variables, set pin modes, and configure any necessary settings.

2) loop()

- The loop() function is continuously executed after the setup() function.
- It contains the main program logic and runs repeatedly as long as the Arduino is powered on.
- It is responsible for monitoring inputs, processing data, and controlling outputs.

3) pinMode()

- The pinMode() function sets the mode of a specific pin as input or output.
- It takes two arguments: the pin number and the mode (INPUT or OUTPUT).

4) digitalRead()

- The digitalRead() function reads the value of a digital pin.
- It takes one argument: the pin number to be read.
- It returns either HIGH or LOW, depending on the voltage level at the pin.

5) digitalWrite()

- The digitalWrite() function writes a digital value (HIGH or LOW) to a specific pin.
- It takes two arguments: the pin number and the value to be written.

6) analogRead()

- The analogRead() function reads the value from an analog pin.
- It takes one argument: the analog pin number to be read.
- It returns an integer value between 0 and 1023, representing the voltage level.

7) analogWrite()

- The analogWrite() function writes a PWM (Pulse Width Modulation) value to a specific pin.
- It takes two arguments: the pin number and the PWM value (ranging from 0 to 255).

Serial communication functions:

1) Serial.begin(): Initializes the serial communication with a specified baud rate.
2) Serial.print(): Sends data as human-readable ASCII text.
3) Serial.println(): Sends data as human-readable ASCII text with a newline character.
4) Serial.available(): Returns the number of bytes available to read from the serial port.
5) Serial.read(): Reads incoming serial data.\

V. METHODS TO GET DELAY IN ARDUINO

1) *Using the delay() Function*
a) The delay() function is a built-in Arduino function that pauses the program execution for a specified number of milliseconds.
b) It takes one argument: the duration of the delay in milliseconds.
c) After the delay period elapses, the program continues executing the next line of code.

2) *Using millis() for non-blocking Delay*
a) millis() is a function that returns the number of milliseconds that have elapsed since the Arduino board was powered on or reset.
b) By comparing the current value of millis() with a desired time interval, you can implement a non-blocking delay.

VI. TYPE OF PROGRAMMING USED

A. *Functions*
1) Functions in Arduino programming are blocks of code that perform specific tasks.
2) Functions can be built-in (like setup() and loop()) or user-defined.
3) User-defined functions allow you to create custom functionality and can be called from other parts of the code.
4) Functions can have parameters (input values) and return values.

B. *Variables and Data Types*
1) Variables in Arduino programming are used to store and manipulate data.
2) Arduino supports various data types, including integers (int), floating-point numbers (float), characters (char), and Booleans (bool).
3) Variables can be declared and initialized with values.
4) Constants can be defined using the const keyword.

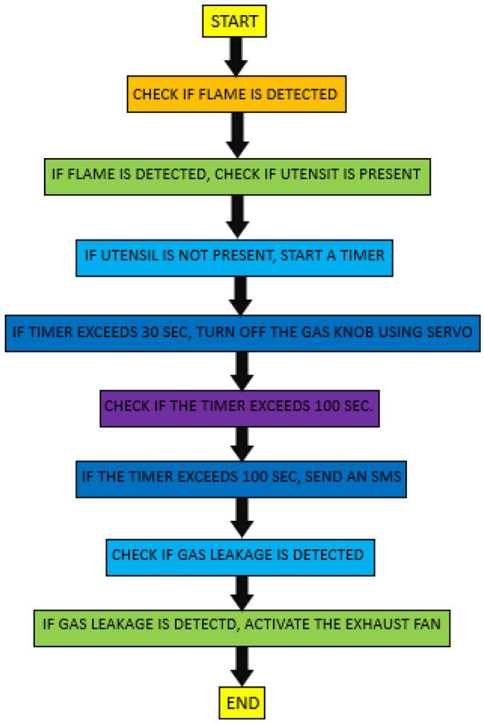
C. *Control Structures*
1) Control structures enable the flow and execution of code based on specific conditions.
2) Examples of control structures include if statements, for loops, while loops, and switch statements.
3) if statements allow you to perform conditional checks and execute specific code blocks based on the result.
4) Loops (for and while) enable repetitive execution of code until a specific condition is met.
5) Switch statements provide a way to select one of many code blocks to execute based on a given expression.

D. *Libraries*
1) Arduino libraries are pre-written code modules that provide additional functionality and simplify complex tasks.
2) Libraries provide functions and constants specific to certain sensors, actuators, communication modules, and more.
3) Libraries can be included in your Arduino sketch using the #include directive.

E. *Serial Communication*
1) Arduino boards often communicate with other devices or computers via serial communication.
2) The Serial object in Arduino allows you to send and receive data over the serial port.
3) Functions such as Serial.begin(), Serial.print(), and Serial.read() are used to configure and interact with the serial port.

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VII. FLOW CHART OF OUR PROJECT



VIII. FUTURE SCOPE

To date the model is fulfilled for use in homes but still, if permits we would first implement the system to book LPG gas automatically by sending an SMS/call to the respected authority through the GSM module. For that purpose, we would also implement a model that would keep track of the level of gas inside the LPG. This can be done in two ways: I) Either interfacing the Load sensor. II) the Interfacing gas pressure sensor so that we could access the amount of gas present in the LPG. Secondly, we could interface Voice Recognition Module to control the flame as well as to switch on/off the gas knob through voice command.

IX. CONCLUSION

Analyzing the circumstances of today's desire for automation in all facets of creating a simple existence, our proposal would assist users in overcoming challenges caused by gas leakage concerns. When there is a gas leak, our project will immediately turn off the gas. This will help to avoid any mishaps and decrease the amount of gasoline waste caused by negligence. Second, if there is no such utensil on the gas for a while, as sensed by the ultrasonic sensor, the knob will still turn off. This will also notify the house owner to take measures if the owner is not at home in order to avoid mishaps.

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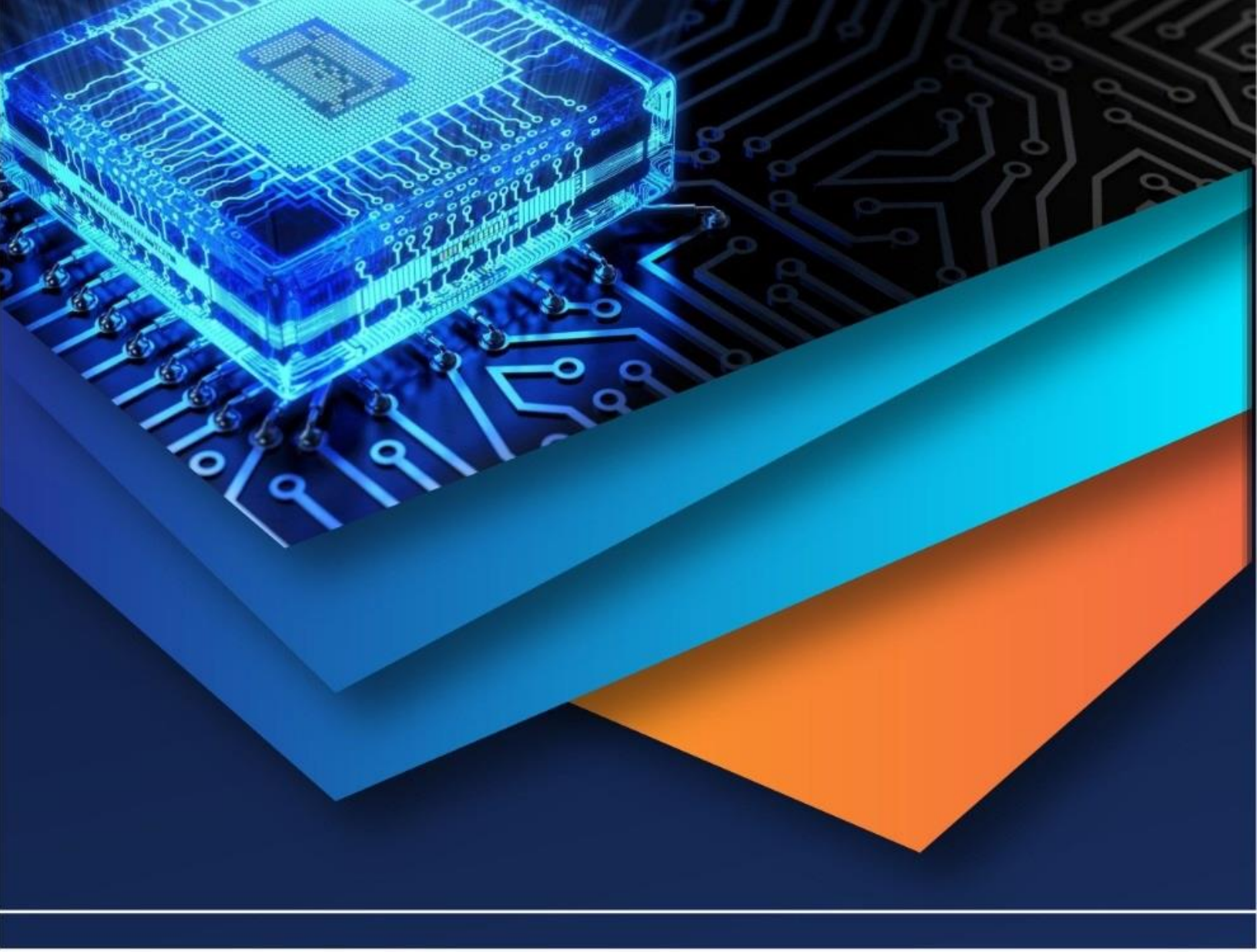
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