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Safe Kitchen: An IoT-Enabled Microcontroller-Based Smart Kitchen Alert System

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A B S T R A C T

The purpose of this project is to design and implement an IoT-based Smart Kitchen Automation and Monitoring System that improves both safety and convenience in household kitchens. In today's modern lifestyle, kitchens are prone to hazards such as gas leakage, fire accidents, and equipment malfunctions, which can lead to severe consequences if not addressed quickly. To overcome these issues, this system integrates a microcontroller with various sensors including gas, temperature, humidity, and motion sensors to continuously monitor the kitchen environment. Real time data collected by the sensors is processed by the microcontroller, which then controls different appliances like exhaust fans, lights, and cooling systems through relay modules. Additionally, through an IoT platform the user can remotely monitor and control kitchen appliances using a smartphone. By combining hardware and IoT technology, this project ensures enhanced safety, energy efficiency, and automation, thereby transforming a traditional kitchen into a smart, secure, and user-friendly environment

Keywords: IoT-based Smart Kitchen, Gas Leakage Detection, LPG Cylinder Weight Monitoring, Real- time Monitoring, Microcontroller-Based System, Safety Automation, Multi-sensor Monitoring

INTRODUCTION

The kitchen is a critical, hazard-prone area in a home, facing constant risks like gas leakage, fire, and electrical short circuits due to continuous appliance use and the presence of flammable materials. Traditional reliance on ineffective manual supervision highlights the critical need for a modern safety solution. This project proposes an IoT-based Smart Kitchen Alert System to provide continuous, real-time monitoring of all critical parameters and ensure an instant, automated response. The core of the system is the ESP8266 microcontroller, which processes data from multi-sensors (MQ135 for gas, DHT11 for temperature, PIR for motion, and a sound sensor for the cooker whistle) and an integrated Load Cell for tracking LPG cylinder weight and consumption. Upon hazard detection, the system triggers safety automation (like activating exhaust fans/lights via a relay) and simultaneously uses the Blynk mobile application to send remote alerts and status updates, effectively bridging the gap between detection and user intervention to protect human life and property.

Insights and Innovations about the IoT Based Smart Kitchen

The core innovation across these projects lies in moving beyond simple hazard detection to provide comprehensive IoT-enabled safety automation and supply management in the kitchen. A key insight is the implementation of a dual-monitoring approach that integrates real-time gas leakage detection with LPG cylinder weight monitoring via a Load Cell; this not only ensures safety but also enables predictive refill notifications and consumption tracking, thus solving the common household problem of unexpected gas outages. Furthermore, the systems enhance safety through multi-sensor integration (including temperature, motion, and cooker whistle sound) and automated emergency response functionalities, where the ESP8266 microcontroller instantly triggers exhaust fans and alarms, while the Blynk application provides the user with remote status dashboards and instant alerts.

Problem Statement

Traditional LPG monitoring systems often fail to accurately track gas levels, resulting in delayed refilling and potential safety hazards. Manual observation further causes late detection of gas leaks or fire risks, increasing the chances of accidents. Additionally, the absence of automated real-time control, along with sensor errors and connectivity issues, can delay alerts and reduce the efficiency of emergency responses.

Literature review

The evolution of smart kitchen safety systems, as summarized from your literature review, demonstrates a significant shift from basic gas detection to comprehensive, IoT-based automation aimed at mitigating multiple hazards and improving household management. Early work by Prof. Ashwini Bagde et al. (2021) established the foundation by upgrading from the Arduino UNO to the more capable NodeMCU and replacing GSM modules with efficient relay modules for localized response. This technological shift was solidified by Bharthi S. et al. (2022) and Ananya Chandran et al. (2022), who further replaced costly boards like the Raspberry Pi with the NodeMCU and standardized the use of the Blynk application for remote monitoring. As the field matured in 2023, the focus broadened to component optimization and scope: Mohamed Vasim Hussain et al. (2023) adopted the DHT11 sensor for efficiency, while Kalpesh Gadhari et al. (2023) explored advanced safety by integrating Fire Extinguisher mechanisms. Simultaneously, Liang Wang (2023) introduced high-level concepts using AIoT Technology and the MQTT protocol, indicating a move toward sophisticated network architectures. Most recently, spanning 2024 to 2025, projects focused on comprehensive integration: Abdul Salam Shah et al. (2024) enhanced emergency response with an Exhaust Fan and OLED display, and Paresh Sagar et al. (2025) introduced intuitive voice command operation. Crucially, the work of Ashish Sunil Bonde et al. (2025) addressed the need for dual-functionality by combining the MQ-135 gas sensor with a Load Cell for cylinder weighing. Despite these diverse advancements, the current literature reveals a persistent challenge: the lack of a single, affordable, and fully integrated system that effectively combines this wide array of multi-sensor monitoring with accurate weight-based consumption tracking and automated safety controls for widespread residential deployment—a critical gap directly addressed by the present research.

Existing System

The existing system for kitchen safety is a fragmented, manual, and reactive approach that relies heavily on the user's presence and intervention, creating significant safety gaps. It is characterized by standalone, buzzer-based gas detectors which only provide localized, audio-visual alarms, offering no remote notification or automated mitigation. Furthermore, essential maintenance tasks, such as tracking gas supply, are relegated to inaccurate manual checks of the LPG cylinder's weight, leading to unexpected outages and a lack of proper consumption tracking.

Proposed System

The proposed system is an IoT-enabled Smart Kitchen Alert System designed to ensure both safety and convenience through continuous, real-time monitoring and automated response. The system's central processing unit is an ESP8266 Microcontroller, which acts as the brain by processing data from a comprehensive array of sensors, including the MQ135 Gas Sensor (for gas/smoke), DHT11 Sensor (for temperature and humidity), PIR Sensor (for motion), a Sound Sensor (to detect the cooker whistle), and a Load Cell (for LPG cylinder weight). The microcontroller constantly compares these readings against pre- set safe limits. When a hazard is detected (e.g., gas leakage or low cylinder weight), the system immediately performs two functions: first, it triggers automated safety responses like activating an LED alarm and a buzzer for on-site warning. Second, utilizing Wi-Fi and the Blynk mobile application, the system sends instant, remote notifications to the user and allows them to monitor the kitchen status or send manual commands from anywhere, effectively transforming a traditional kitchen into a secure and user- friendly smart environment.

Hardware and software Implementation

The project's implementation is founded on a blend of multi-functional hardware and robust IoT software tools, centered around the ESP8266 NodeMCU microcontroller, which serves as the system's brain and primary Wi-Fi connectivity module. The hardware stage involves continuous data collection from multiple sensors, including the MQ135 Gas Sensor (for leakage), DHT11 Sensor (for temperature and humidity), a PIR Sensor (for motion), a Sound Sensor (for whistle detection), and an HX711/Load Cell assembly for LPG cylinder weight measurement. For local and remote notification, output components such as an OLED Display and a Buzzer are used, alongside actuators like a Relay Module to control appliances like exhaust fans. The software development utilizes the Arduino IDE for writing and uploading the firmware, which is coded in Embedded C/C++. Finally, the system leverages the Blynk IoT Platform and the ESPDash Library to establish cloud monitoring and a local web dashboard, allowing users to view real-time data and receive instant mobile alerts from anywhere.

Circuit Diagram Circuit Diagram Explained

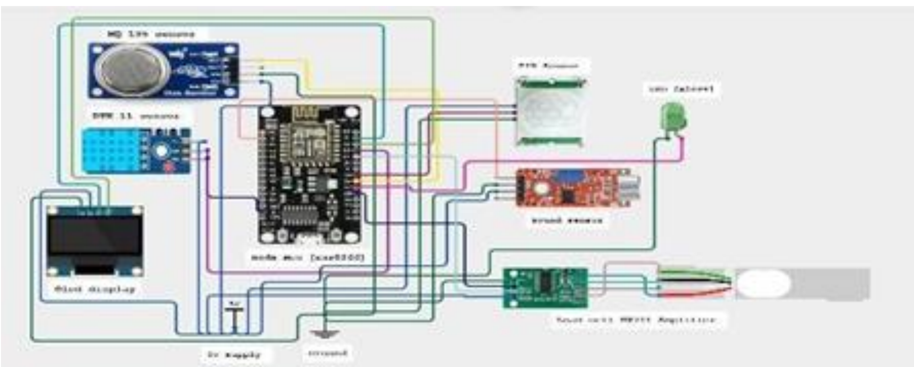


Figure 1: Circuit diagram

The circuit diagram (or Block Diagram) illustrates the architecture of your system, which is centered on the ESP8266 NodeMCU.

Component Roles:

1. **Microcontroller (The Brain):**
   - ESP8266 NodeMCU: This unit processes all sensor data, executes the programmed logic (Embedded C/C++), and manages the two-way communication over Wi-Fi, making the system an IoT-enabled device.
2. **Input Sensors (Data Collection):**
   - MQ135 Gas Sensor: Detects hazardous gases (LPG, smoke) and sends an analog signal corresponding to the gas concentration to the ESP8266.
   - Load Cell + HX711: Measures the precise weight of the LPG cylinder. The Load Cell creates a tiny electrical signal proportional to the weight, which the HX711 Amplifier digitizes before sending it to the microcontroller.
   - DHT11 Sensor: Collects environmental data: temperature and humidity to monitor heat and potential fire risk.
   - PIR Sensor (Passive Infrared): Detects motion in the kitchen area, which can be used for energy saving (light control) or security.
   - Sound Sensor: Specifically tuned to detect high-frequency sounds like a pressure cooker whistle.
3. **Output & Actuators (Response):**
   - OLED Display: Provides local visual feedback, showing real-time status (e.g., "SAFE," Gas Level, Weight).
   - Buzzer/LED: Provides an immediate audible and visual alarm on-site when a hazard is detected.
   - Relay Module: Acts as an electrical switch, controlled by the ESP8266, to turn high-power external appliances (like an exhaust fan or kitchen lights) ON or OFF automatically in response to sensor readings.
   - Blynk IoT Platform: The cloud service that receives all data from the ESP8266 and provides the remote interface **(mobile app) for user interaction and alerts.**

2. **Operational Scenarios**

The system’s functionality is defined by its ability to switch instantly between passive monitoring and an active, multi-channel response across various situations.

A. **A Typical Operating Situation (Passive Monitoring)**

The system continuously runs its main loop: the ESP8266 reads all sensor values and uploads them to the Blynk cloud via Wi-Fi. The OLED display shows the current safe status (e.g., "Safe Kitchen: Ready," current temperature, and cylinder weight). In this passive mode, no alarms or actuators are triggered, and the remote user can confirm the kitchen's safety status on the Blynk mobile app at any time.

B. **Gas Leak Detected (Critical Active Response)**

This is the primary emergency scenario:

- Trigger: The MQ135 Gas Sensor detects an LPG concentration level exceeding the safety threshold set in the code.
- Local Response: The ESP8266 immediately activates the Buzzer and LED alarm for instant occupant

warning. Simultaneously, it sends a high signal to the Relay Module to switch on the Exhaust Fan, initiating ventilation to disperse the leaked gas. The OLED Display shows a critical "GAS LEAK DETECTED!" message.

- Remote Response: The system utilizes the Wi-Fi connection to send an instant Push Notification Alert to the user’s smartphone via the Blynk app, notifying them of the precise hazard and allowing them to take further remote action if necessary.

C. **Low Gas/Consumption Tracking**

This scenario addresses convenience and supply management:

- Trigger: The Load Cell senses that the LPG cylinder's weight has dropped below a pre-programmed low threshold (e.g., 2 kg).
- Remote Response: The system sends a "LOW GAS: Time to Reorder" notification to the user via the Blynk app, preventing unexpected service interruption.
- Local Response: The OLED Display shows the remaining weight and a warning message.

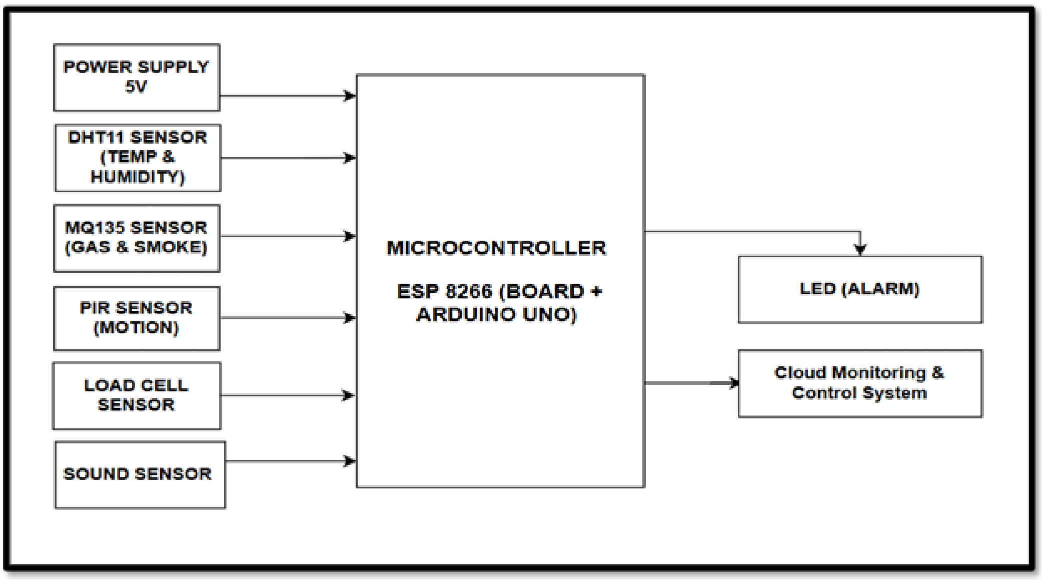
D. **Multi-Hazard and Automation Scenarios**

The unique multi-sensor array allows for expanded automation:

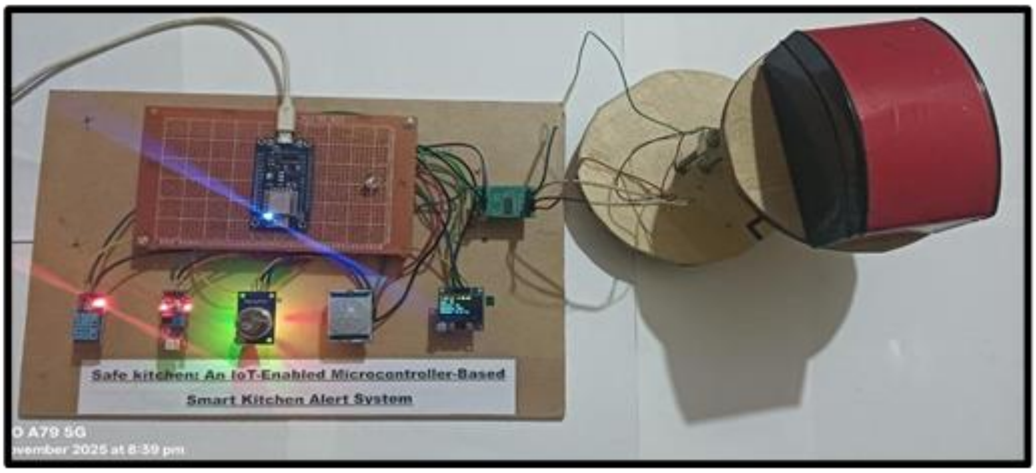
- Heat/Fire Risk: If the DHT11 Sensor detects dangerously high temperatures, a specific "High Temperature Warning" is sent via Blynk, alerting the user to a potential fire risk.

- Cooker Whistle/Cooking Complete: The Sound Sensor detects the unique frequency of the cooker whistle. The system can then be programmed to send a notification (e.g., "Whistle Detected: Cooking May Be Complete") or automatically trigger the exhaust fan to clear steam/odors.
- Motion Control: The PIR Sensor can be used to automatically turn on the kitchen lights when motion is detected and turn them off after a period of inactivity, improving energy efficiency.

Block Diagram



RESULT



CONCLUSION

The project successfully achieved its aim by designing and implementing a functional "Safe kitchen: An IoT-Enabled Microcontroller-Based Smart Kitchen Alert System." The developed system, centered on the ESP8266 NodeMCU, effectively addresses the critical safety and management shortcomings of traditional kitchens by providing continuous, multi-sensor monitoring. We demonstrated the seamless integration of gas leakage detection (MQ135), LPG cylinder weight tracking (Load Cell), and environmental sensing (DHT11, PIR, Sound Sensor) into a single, cohesive platform. By leveraging the Blynk IoT application, the system provides instant, remote alerts and enables automated safety responses (via the Relay Module) and user control, thereby eliminating the reliance on manual supervision. In conclusion, the prototype is an affordable, reliable, and user-friendly solution that significantly enhances household safety, optimizes gas consumption management, and ultimately contributes to a safer and smarter living environment.

FUTURE ENHANCEMENT

1. **Automated Gas Shut-Off Valve Integration:** Implement an automatic motorized gas valve connected to the Relay Module. Upon detecting a severe gas leak, the system should immediately and physically shut off the main gas line, offering the highest level of safety automation.

2. **Machine Learning for Predictive Analysis:** Integrate a Machine Learning (ML) algorithm to analyze historical gas consumption patterns, temperature fluctuations, and environmental data. This would allow for highly accurate predictive refill ordering and intelligent anomaly detection (e.g., distinguishing a fast leak from a normal usage drop).
3. **Advanced Communication Redundancy (GSM/SMS):** Add a GSM Module or integrate an SMS gateway service. This ensures the system can send critical text message alerts to the user even if the home's Wi-Fi network or internet connection is completely down.
4. **Voice Control Integration:** Integrate with popular voice assistants (like Amazon Alexa or Google Home). This would allow users to use voice commands to check the kitchen status ("What is the current gas level?") or manually control appliances ("Turn on the kitchen fan").
5. **Long-Term Power Optimization:** Focus on hardware and software redesign to utilize the ESP8266's Deep Sleep mode effectively. This will minimize power consumption, enabling the system to run reliably on a small, rechargeable battery backup for extended periods during power outages.
6. **Fault Detection and Self-Diagnosis:** Implement a feature to continuously monitor the health of the sensors (e.g., checking gas sensor stability or Load Cell calibration). The system should automatically send an alert if a sensor is failing or malfunctioning.
7. **Fire Extinguisher Actuation:** Incorporate a small, automated fire extinguishing mechanism (e.g., a solenoid-controlled extinguisher) that the Relay Module can trigger if the temperature spike and smoke level pass a critical fire threshold.
8. **Appliance Health Monitoring:** Integrate current sensors to monitor the power consumption of kitchen appliances (like the refrigerator or microwave). This allows for anomaly detection (e.g., a spike in refrigerator usage indicating a fault) and provides users with energy usage statistics.
9. **Advanced Data Logging and Reporting:** Migrate the backend data processing to a dedicated cloud platform (like AWS IoT or Google Cloud). This would allow for robust, secure data logging, professional reporting, and scalable data analytics.
10. **Enhanced User Interface (Web and Mobile):** Develop a more sophisticated and user-friendly mobile application and web dashboard, offering advanced data visualization, customized alert settings, and multi-user access control.

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