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Intelligent Kitchen Safety and Emergency Response System using IoT

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Abstract

The potential dangers stemming from inadequate safety measures in kitchens, including gas leaks and temperature fluctuations, can lead to severe consequences such as explosions, fires, and health hazards. To counteract these risks, an innovative research centered around a dual-purpose sensor system is proposed. This system effectively detects both gas leaks and temperature anomalies using a single sensor, optimizing efficiency and affordability. Notably, an added feature involves a low-cost camera module that captures images during critical situations like gas leaks or extreme temperature changes. These images are then transmitted via IoT technology to a designated Telegram channel, providing an additional layer of visual data to aid in emergency responses. The research stands out for its cost-effective design, focusing on low energy consumption and practical usage, making it an ideal solution for elevating kitchen safety standards.

Keywords: Smart Kitchen, BME680, IoT, Kitchen Safety, Environment Detection.

1. Introduction

Kitchens are essential to every day functioning in the fast-paced world of today, acting as centres of culinary innovation and nutrition. But in the midst of all the activity, maintaining these areas' safety often falls short. Changing temperatures and gas leaks can provide serious problems, including fire hazards and health issues. To address these potential threats, an innovative research that employs cutting-edge technology to revolutionize kitchen safety is

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presented. l For this purpose the BME680 sensor, that offers offers extremely accurate measurements of ambient air temperature, barometric pressure, relative humidity, and interior air quality is utilized. are Its dual-purpose functionality not only provides the solution but also optimizes the cost. To further improvise the system's effectiveness, we've incorporated the ESP32 camera module, a compact yet high-quality visual capture device. This module ensures real-time image capture during critical events, such as gas leaks or extreme temperature changes. Seamlessly synced with the main controller, the ESP8266 NodeMCU, these images are promptly relayed to a designated Telegram bot through IoT connectivity. The ESP8266 NodeMCU serves as the research's central controller, orchestrating the cohesive functioning of the BME680 sensor, ESP32 camera module, and Telegram bot integration. This nodal coordination ensures swift and accurate responses in emergency situations, equipping users with valuable visual insights to guide their actions.

2. Related Work

[1] Rezwan et al. present an IoT-based Smart Inventory Management System (SIMS) using sensors, Arduino, and Wi-Fi, enabling real-time tracking, automated reordering, and manual orders through app. The system offers comprehensive order history and expenditure analysis through its website interface. [2] Balaji et al. propose an IoT-based Smart Kitchen Wardrobe System, employing wireless networks and Live Video Analysis via Arduino for real-time grocery product monitoring, complemented by a userfriendly Android app interface. [3] Harika Pudugosula's research presents an IoT-based Smart and Safety Monitoring System for kitchens, integrating sensors like DHT11, IR flame, and MQ-3 for real-time fire and gas leakage detection. The system utilizes Arduino UNO, relay, LEDs, and a WiFi module to enable remote monitoring and control. [4] R. Pavithra et al. introduced a Cloud-based Smart Pantry System via IoT, employing sensors to monitor container item levels stored in the cloud for remote access. The system enables real-time monitoring, alerts for low stock, and automated ordering notifications to shopkeepers. [5-10]] Mrutyunjaya Sahani et al. propose an integrated system for real-time kitchen monitoring, utilizing GSM, WSN, and embedded web server architecture. The solution enables remote control, alerts via GSM, and web-based monitoring through sensors and mobile devices, showcasing its accuracy and efficiency [11,12].

3. Proposed Work

The Kitchen Safety Enhancement research introduces cutting-edge technology to elevate kitchen safety. By seamlessly integrating the versatile BME680 sensor, the system achieves precise detection of gas leaks and temperature fluctuations, enhanced by its ability to assess humidity and air quality. The ESP32 camera module further enhances the system by capturing high-resolution real-time images during critical situations, working in tandem with the ESP8266 NodeMCU central controller. This controller facilitates communication with a Telegram bot via MQTT protocol, enabling swift response and coordination in emergencies. One of the research's key advantages lie in its ability to not only prevent potential hazards but also significantly reduce the risk of gas leakage related explosions, fires, and health risks. The incorporation of real time image capture during gas leaks provides responders with visual insights to make informed decisions promptly. This innovation not only ensures quicker response times but also minimizes the potential for extensive damage or injury. Additionally, the integration of the BME680 sensor's multi-sensory capabilities offers comprehensive monitoring, preventing dangerous temperature fluctuations and fostering a safer environment for both individuals and food items. By leveraging technology to its fullest potential, the research emphasizes its commitment in introducing a new era of kitchen safety and efficiency

3.1 Components

(i) BME680 Sensor: environmental sensor used for measuring gas, temperature, humidity, and air pressure. Accurate gas detection including VOCs (Volatile organic compounds) and hazardous gases. The sensor provides temperature, humidity, and air quality readings for optimal conditions.

(ii) ESP32 Camera Module: Equipped with a high-resolution camera for real-time image capture. Enables visual documentation during emergencies such as gas leaks. High-quality images enhance response effectiveness.

(iii) ESP8266 NodeMCU: Powerful microcontroller with integrated Wi-Fi capabilities. Central controller coordinating communication, data processing, and decision-making. Facilitates real-time alerts and image transmission via MQTT protocol.

(iv)Exhaust Fan and Buzzer: Exhaust fan vents hazardous gases to enhance safety. Buzzer serves as an audible alert for gas leaks and temperature fluctuations. Combined action improves detection and emergency response.

3.2 Methodology

The system initiation commences with the power-on process, activating the ESP8266 microcontroller. The integrated libraries are initialized, enabling seamless data communication and processing. Following initialization, the ESP8266 establishes a connection to the Wi-Fi network, confirming its readiness for data transmission and reception. This state of readiness is indicated by a distinct status signal, validating the operational status and successful connectivity. The pivotal aspect of real-time monitoring depends on the BME680 sensor, continuously gauging gas concentrations and temperature levels. This BME680 sensor utilizes specialized gas-sensitive materials, for detecting gas molecules that interact with its surface. These interactions influence the sensor's electrical conductivity, which is then quantified and converted into precise gas concentration values. For temperature assessment, the sensor uses a microheater to maintain a consistent temperature differential between its surface and the ambient surroundings. This temperature differential, governed by the applied power, provides insights into the prevailing temperature conditions.

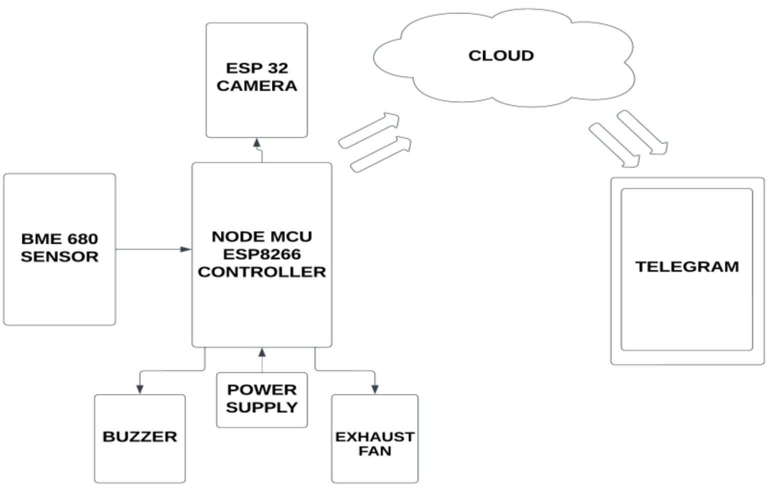

Figure 1. Block Diagram

Continuous monitoring of real-time gas and temperature parameters involves applying predetermined threshold values. Upon crossing these thresholds—an indication of potentially perilous gas levels or critical temperature variations—the ESP8266 initiates an emergency protocol. This protocol activates the ESP32 camera module, capturing an instantaneous image of the kitchen's ongoing state, thereby affording contextual visual data during the emergency. Concurrently, an emergency alert is dispatched to a designated Telegram bot via the Internet, transmitting the captured image and promptly notifying intended recipients of the unfolding emergency scenario. For immediate responsiveness, the emergency signal concurrently triggers the exhaust fan and buzzer. The exhaust fan swiftly expels accumulated hazardous gases from the kitchen area, enhancing safety. Simultaneously, the buzzer produces an audible alarm to alert occupants to the imminent emergency. Both the fan and buzzer operate until gas and temperature levels revert to safe parameters, signifying containment of the situation

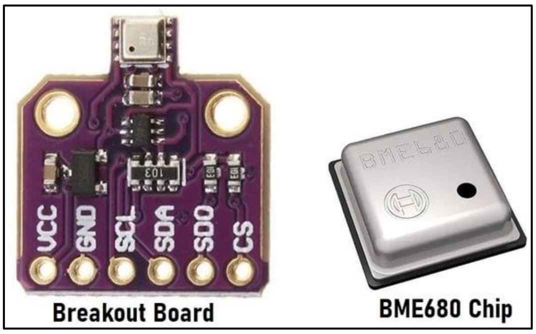

Figure 2. BME680 Sensor

The orchestrated methodology unfolds gradually, encompassing power-on sequencing, library setup, Wi-Fi establishment, and confirmation of ESP8266 readiness. The pivotal role played by the BME680 sensor in real-time monitoring through innovative mechanisms ensures the rapid detection of gas and temperature anomalies. Upon exceeding emergency thresholds, the ESP8266 orchestrates image capture through the ESP32 camera, prompt alerting of the fan and buzzer, and expeditious notification via the Telegram bot. These interwoven steps facilitate immediate, decisive responses and offer comprehensive visual insights for effective emergency management within a kitchen environment.

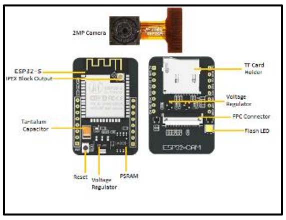

Figure 3. ESP32 Cam Module

3.3 Flowchart

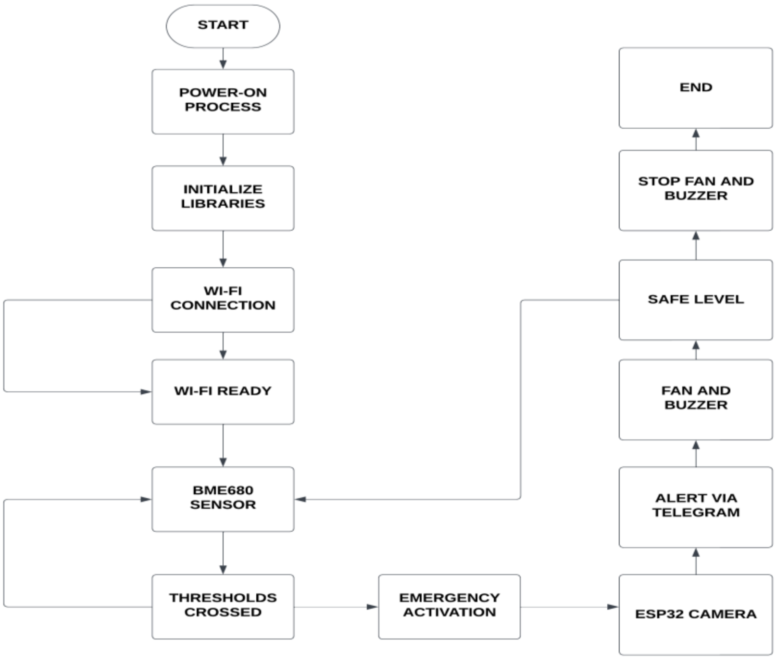

Figure 4. Flow Diagram of the Proposed

4. Discussion and Future work

The Kitchen Safety Enhancement research put forth is a potential solution to significantly enhance kitchen safety through the integration of advanced technology. The research successfully created a comprehensive safety system that effectively detects gas leaks and critical temperature fluctuations using the BME680 sensor. This multi-sensory sensor accurately measured gas concentrations and temperature changes, enabling rapid identification of potential hazards and the prevention of dangerous situations such as gas leaks and extreme temperature shifts

The incorporation of the ESP32 camera module facilitated real-time image capture during emergencies, providing vital visual context for responders and aiding in informed decision-making. The ESP8266 NodeMCU acts as the central controller, ensuring seamless communication between components and enabling timely alerts through IoT-based communication to a designated Telegram bot. Although challenges arose during calibration and communication optimization, the research's overall outcomes underline its capacity to significantly elevate kitchen safety. Further development of the model, implementation and real-world testing are essential to refine the system for practical implementation and broader use.

5. Conclusion

The Kitchen Safety Enhancement Research has successfully integrated advanced technology, uniting the BME680 sensor for gas leak and temperature detection with the ESP32 camera module for real-time image capture, all orchestrated by the ESP8266 NodeMCU for seamless communication through IoT channels to a designated Telegram bot. This achievement demonstrates the potential to revolutionize kitchen safety by swiftly identifying hazards, preventing risks, and offering visual guidance during emergencies. Challenges encountered underscored the intricacies of implementation. In conclusion, this research's success highlights technology's pivotal role in enhancing kitchen safety, and further model development, implementation and real-world testing that are to be carried out in the future works hold the promise of a safer kitchen environment for all.

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Author's biography

Charu Ahamed S, born on May 11, 2003, in Trichy, is a dedicated individual with a passion for Electronics and Communication Engineering (ECE). In 2018, Charu accomplished a notable academic feat, completing a diploma in ECE with a commendable first-class distinction, securing 73%. This achievement demonstrates Charu's commitment to the field and sets a strong foundation for further academic pursuits. With a keen interest in ECE, Charu is poised to make meaningful contributions in this domain.

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