A REVIEW PAPER ON SMART CONTROL SYSTEM FOR COMMERICAL CHIMNEY

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Abstract: This paper presents the design and implementation of a Smart Monitoring and Control System for a Split Chimney aimed at enhancing indoor air quality, energy efficiency, and user safety in modern kitchens. Conventional chimneys rely on manual operation and fail to adapt to varying cooking conditions, resulting in inefficient ventilation and increased power consumption. The proposed system overcomes these limitations by integrating multiple sensors to monitor temperature and smoke levels in real time. An Arduino Uno microcontroller processes sensor data and controls the chimney blower using a relay module for automatic ON/OFF operation. The system also incorporates gesture-based control for touch-free interaction, Bluetooth connectivity for remote operation via a mobile application, and an LCD display for continuous user feedback. Experimental evaluation demonstrates accurate sensing, rapid response to environmental changes, and reliable system performance. The intelligent control strategy ensures that the chimney operates only when required, thereby reducing energy consumption and improving safety. The proposed system is cost-effective, scalable, and suitable for future integration with IoT-based smart home technologies.

Keywords: Smart Monitoring, Relay Control, IoT, Kitchen Automation, Air Quality, Sensors

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I. INTRODUCTION

Indoor Air Quality (IAQ) in kitchens is a critical concern due to the continuous generation of pollutants during various cooking activities. Processes such as frying, grilling, roasting, and boiling release a significant amount of smoke, heat, moisture, and harmful gases including carbon monoxide (CO), nitrogen oxides (NOx), and volatile organic compounds (VOCs). In addition to gaseous pollutants, fine particulate matter (PM2.5) is produced, which is particularly hazardous as it can penetrate deep into the respiratory system and lead to serious long-term health issues such as asthma, cardiovascular diseases, and reduced lung function. Poor ventilation in kitchens further aggravates the problem, especially in residential environments where air circulation is limited.

Traditional kitchen chimneys have been widely used to remove smoke and airborne pollutants; however, these systems operate at fixed speeds and rely entirely on manual intervention. Such conventional systems lack the ability to adapt to dynamic cooking conditions, resulting in inefficient performance. In many cases, users either forget to switch ON the chimney during heavy smoke generation or leave it running unnecessarily even when not required. This leads to increased energy consumption, reduced equipment efficiency, and inconvenience for users. Moreover, fixed-speed operation does not account for varying pollutant levels, making these systems less effective in maintaining optimal indoor air quality.

With the advancement of embedded systems and sensor technologies, there has been a growing interest in developing smart and automated kitchen ventilation systems. Modern approaches focus on integrating sensors such as temperature sensors, gas sensors (MQ series), and smoke detectors to monitor environmental conditions in real time. These sensors provide continuous feedback, enabling the system to make intelligent decisions without human intervention. Automation not only improves efficiency but also enhances safety by ensuring timely activation of ventilation systems during hazardous conditions.

Among various control strategies, relay-based ON/OFF control systems have gained significant attention due to their simplicity, reliability, and cost-effectiveness. Unlike complex speed control mechanisms that require advanced hardware and control algorithms, relay-based systems provide a straightforward solution for activating or deactivating the chimney based on predefined threshold values. These systems are easy to implement, require minimal maintenance, and are suitable for both residential and small-scale commercial applications. Additionally, ON/OFF control reduces system complexity while maintaining effective pollutant removal performance.

Recent research in this domain has focused on improving sensor accuracy, response time, and system reliability to ensure efficient operation under varying environmental conditions. Integration with wireless communication technologies such as Bluetooth and IoT platforms has further enhanced user interaction by enabling remote monitoring and control. Furthermore, advancements in sensor calibration and data processing techniques have improved the precision of detection systems, reducing false triggering and ensuring consistent performance.

This review paper focuses specifically on relay-based ON/OFF smart chimney systems, analyzing existing methodologies, technologies, and design approaches. It aims to evaluate the effectiveness of sensor-based automation in improving indoor air quality while maintaining simplicity and affordability. The paper also identifies key challenges, such as sensor limitations, environmental variability, and system optimization, and discusses potential improvements for real-world applications. By examining current research and technological trends, this study provides a comprehensive understanding of smart chimney systems and their role in modern kitchen environments.

II. LITERATURE REVIEW

Shubhangi Namdev Mule et al. (2025) [1] developed an IoT-based smart ventilation system integrating multiple environmental sensors such as MQ2 and temperature sensors for continuous monitoring of indoor air quality. Their system automatically activates ventilation mechanisms when pollutant levels exceed predefined thresholds. The study emphasizes real-time monitoring and adaptive control for improving indoor environments. Experimental results demonstrated enhanced pollutant removal efficiency and reduced energy consumption. The system architecture supports scalability for smart home applications. Their work highlights the effectiveness of sensor-based automation in ventilation systems. Overall, the research provides a strong foundation for intelligent chimney system design.

Guyot et al. (2025) [2] conducted a comprehensive analysis of smart ventilation systems focusing on demand-controlled airflow in residential environments. Their study revealed that intelligent ventilation systems can reduce energy consumption by up to 40% while maintaining indoor air quality. The research highlights the importance of integrating sensors and control algorithms for adaptive performance. They also discussed challenges in system standardization and performance evaluation. Their findings support the use of real-time monitoring systems in modern ventilation solutions. The study validates the role of automation in improving efficiency. It strongly supports the development of smart chimney systems.

Shubham More et al. (2021) [3] proposed an IoT-based smart kitchen system designed for safety and automation. Their system detects gas leakage and automatically activates exhaust systems to prevent hazardous conditions. The research emphasizes minimizing human intervention in safety-critical environments. Wireless communication enables remote monitoring and control. Experimental validation showed fast response time and reliable operation. The system is designed to be cost-effective and user-friendly. Their work demonstrates practical implementation of safety automation in kitchens. It directly supports smart chimney applications.

Ashish Sunil Bonde et al. (2024) [4] developed a smart kitchen automation system using IoT technologies to monitor temperature, gas concentration, and environmental parameters. The system provides real-time feedback to users and allows remote control through wireless communication. Their research focuses on enhancing efficiency and convenience in kitchen operations. The system architecture supports scalability and integration with smart home ecosystems. Experimental results showed stable performance under varying conditions. Their work highlights the importance of automation in reducing manual effort. It is highly relevant to intelligent chimney systems.

Liu et al. (2023) [5] investigated the effectiveness of IoT-enabled ventilation systems in controlling cooking emissions. Their system utilizes sensors to detect particulate matter and harmful gases, automatically adjusting airflow based on pollutant levels. The study demonstrated a significant reduction in indoor air pollution. They also analyzed energy consumption and found optimized performance. Their work emphasizes real-time control and adaptive ventilation strategies. The research supports the development of efficient air quality management systems. It provides strong validation for smart chimney technologies.

IoT and Machine Learning Kitchen Study (2023) [6] explored the integration of IoT and machine learning for smart kitchen monitoring. The system continuously analyzes environmental data to predict hazardous conditions. Their approach enhances decision-making capabilities using intelligent algorithms. The study emphasizes worker safety and operational efficiency. Results showed improved performance compared to traditional systems. The research highlights the potential of AI in automation systems. It supports future advancements in smart chimney systems. The work demonstrates the importance of predictive monitoring.

Wang et al. (2019) [7] reviewed smart sensing technologies used in indoor environmental monitoring systems. Their research focuses on integrating multiple sensors for comprehensive data collection. They emphasized the role of sensor networks in improving energy efficiency and air quality. The system processes real-time data for adaptive control. Challenges such as sensor accuracy and reliability were discussed. Their work supports the concept of multi-sensor systems. It is highly applicable to smart chimney design. The study highlights the importance of embedded systems in automation.

Chen et al. (2018) [8] analyzed demand-controlled ventilation systems with a focus on adaptive airflow management. Their research demonstrated energy savings up to 60% using sensor-based control strategies. The study highlights the importance of dynamic ventilation systems. They discussed issues related to sensor calibration and accuracy. Experimental results showed improved efficiency and performance. Their work validates the use of intelligent control systems. It supports energy-efficient chimney designs. The study contributes to smart ventilation technologies.

Damien Bouchabou et al. (2021) [9] studied smart home systems using sensor-based automation and activity recognition. Their research demonstrates how sensor data can be used to understand environmental conditions. The system processes real-time data for intelligent decision-making. They emphasized improving user convenience and system responsiveness. The study supports integration of IoT technologies in smart environments. Their work contributes to automation in household systems. It is relevant to smart kitchen applications. The research highlights advanced control mechanisms.

Maryam Nikpour et al. (2023) [10] focused on IoT-based energy management systems for smart buildings. Their research aims to reduce energy consumption using intelligent monitoring and control. Sensor networks are used for continuous data collection and analysis. The system optimizes energy usage based on real-time conditions. Their study emphasizes sustainability and efficiency. Experimental results showed significant energy savings. The research supports automation in ventilation systems. It is applicable to energy-efficient chimney designs

Erhan et al. (2020) [11] worked on anomaly detection in sensor-based systems to improve reliability and safety in automated environments. Their research primarily focuses on identifying abnormal patterns in sensor data using statistical and computational techniques. They proposed methods to enhance detection accuracy while minimizing false alarms in real-time systems. The study highlights the importance of continuous monitoring and intelligent data analysis in automation. They also discussed challenges such as noise interference, sensor drift, and data inconsistency. Their system improves fault detection capabilities in embedded applications. The research emphasizes the need for robust algorithms in safety-critical environments. Experimental results showed improved system reliability under varying conditions. Their approach contributes to enhancing system stability and operational safety. The findings are highly relevant to smart chimney systems where early detection of abnormal smoke or temperature is essential. Overall, their work strengthens the foundation for intelligent monitoring systems.

Dr. K. Srinivas (2023) [12] developed a real-time environmental monitoring system using temperature and gas sensors integrated with microcontroller platforms. His system continuously monitors environmental conditions and activates ventilation systems automatically when predefined thresholds are exceeded. The research emphasizes the importance of sensor calibration to ensure accuracy and reliability. He demonstrated that real-time monitoring significantly improves response time in hazardous situations. The system reduces the need for manual intervention and enhances operational safety. His study also focused on optimizing sensor placement for better performance. Experimental results showed stable operation under different environmental conditions. The system is designed to be cost-effective and scalable. His work supports automation in industrial and domestic environments. It is highly applicable to smart chimney systems where temperature and smoke monitoring are critical. The research highlights the importance of integrating sensing and control mechanisms. Overall, it contributes to efficient and safe automation systems.

Anjali Verma (2022) [13] proposed a Bluetooth-based automation system for wireless control of electrical devices using embedded systems. Her research focuses on enabling real-time communication between mobile applications and microcontrollers. The system allows users to remotely control appliances through simple commands. She emphasized reducing communication latency and improving signal reliability. The study also addressed issues such as pairing stability and interference in wireless communication. Her system provides a user-friendly interface for device control. Experimental results showed consistent performance within a limited range. The design is simple, cost-effective, and easy to implement. Her work enhances user convenience and flexibility in automation systems. It supports smart home applications and IoT integration. The system is particularly useful in controlling chimney operations remotely. Overall, her research contributes to wireless automation technologies.

S. Karthik (2021) [14] developed a smoke detection system using MQ-series sensors for monitoring indoor air quality. His system continuously detects harmful gases and triggers alarms or exhaust systems automatically. The research emphasizes early detection of hazardous conditions to prevent accidents. He studied sensor sensitivity under different environmental conditions. The system demonstrated rapid response time in detecting smoke. Noise filtering techniques were implemented to improve accuracy. His work highlights the importance of reliable sensing in safety systems. The design is suitable for both residential and industrial applications.

Experimental validation showed consistent performance. The system reduces human dependency in emergency situations. It supports automated chimney activation during smoke detection. Overall, his research strengthens safety mechanisms in smart environments.

Neha Sharma (2020) [15] designed a temperature-based automation system for controlling ventilation and cooling devices. Her system uses digital temperature sensors to monitor environmental heat levels continuously. When the temperature exceeds a predefined threshold, the system activates ventilation automatically. The study focuses on improving safety and comfort in indoor environments. She demonstrated that temperature-based control can act as an early warning system before smoke formation. The system also helps in reducing unnecessary energy consumption. Experimental results showed stable and reliable performance. Her research emphasizes simplicity and efficiency in design. The system is cost-effective and easy to implement. It reduces manual intervention significantly. The work supports smart chimney systems where temperature plays a key role. Overall, it contributes to energy-efficient automation.

Rahul Mehta (2019) [16] worked on relay-based control systems for managing high-power electrical devices using microcontrollers. His research focuses on ensuring safe operation through electrical isolation between low-voltage and high-voltage circuits. The system uses relays to switch devices ON and OFF based on control signals. He emphasized proper relay selection and protection circuits for reliability. The design reduces circuit complexity and improves durability. Experimental results showed efficient switching without overheating. His work highlights the importance of safety in automation systems. The system is simple, robust, and cost-effective. It is widely applicable in industrial and domestic automation. His research supports embedded system design. It is particularly relevant for chimney blower control. Overall, it ensures safe and reliable operation of high-power devices.

Pooja Nair (2022) [17] developed a gesture-based control system using IR sensors for touchless operation of electrical devices. Her system detects hand movements and translates them into control commands. The research focuses on improving gesture recognition accuracy. Filtering techniques were used to reduce false triggering. The system enhances hygiene by eliminating physical contact. It is particularly useful in environments like kitchens where surfaces may be greasy. Experimental results showed reliable performance under controlled conditions. The system is simple and user-friendly. Her work improves user interaction with automation systems. It supports modern smart home technologies. The system is applicable to chimney control systems. Overall, it enhances convenience and usability.

Arvind Kumar (2021) [18] designed a multi-sensor embedded system combining temperature, gas, and motion sensors. His research focuses on improving decision-making accuracy through sensor fusion. The system processes data from multiple sensors simultaneously. It reduces false alarms compared to single-sensor systems. Real-time processing ensures quick response to environmental changes. He emphasized modular system design for flexibility. Experimental results showed improved reliability and performance. The system is scalable and adaptable. His work supports advanced automation systems. It is highly relevant to smart chimney systems. The research highlights the importance of integrated sensing. Overall, it enhances system efficiency and robustness.

Kavya Reddy (2020) [19] developed an LCD-based monitoring system for displaying real-time sensor data. Her system provides clear and continuous feedback to users. The research focuses on improving readability and reducing display flickering. Efficient updating techniques were implemented for smooth operation. The system enhances user interaction with automation devices. It allows users to monitor system status easily. Experimental results showed stable display performance. Her work emphasizes the importance of user interfaces. The system is simple and cost-effective. It supports monitoring applications in embedded systems. It is useful for smart chimney displays. Overall, it improves usability and system transparency.

Imran Shaikh (2018) [20] worked on improving Bluetooth communication in embedded systems. His research focuses on enhancing data transmission stability and reducing communication delays. The system ensures reliable wireless connectivity between devices. He addressed issues such as signal interference and pairing errors. Efficient communication protocols were implemented. Experimental results showed improved responsiveness. The system supports real-time control applications. His work enhances user experience in automation systems. It is relevant to smart home technologies. The research supports wireless control of chimney systems. Overall, it improves communication efficiency.

Ritu Agarwal (2021) [21] developed sensor-based safety systems for detecting hazardous environmental conditions. Her system continuously monitors parameters such as gas levels and temperature. It automatically activates safety mechanisms when abnormal conditions are detected. The research emphasizes reducing human intervention in critical situations. The system improves response time and reliability. Experimental results showed effective hazard detection. Her work enhances safety in automation systems. It supports real-time monitoring and control. The system is applicable to industrial and domestic environments. It is highly relevant to chimney safety systems. Overall, it reduces risk and improves protection.

Manoj Kulkarni (2019) [22] studied motor control techniques using relay-based switching methods. His research compares traditional control systems with automated relay-based systems. He emphasized reliability, simplicity, and cost-effectiveness. The system reduces complexity and improves durability. Experimental results showed stable motor operation. His work supports fixed-speed motor applications. It ensures efficient control of electrical devices. The research highlights the importance of proper switching mechanisms. It is relevant to chimney motor control systems. Overall, it improves system performance and reliability.

Sneha Joshi (2022) [23] developed a dual-mode control system supporting both manual and automatic operation. Her system allows users to switch between modes based on requirements. In automatic mode, sensors control the system, while manual mode provides user control. The research focuses on flexibility and usability. Smooth transition between modes was achieved. Experimental results showed improved user interaction. The system enhances convenience and reliability. Her work supports adaptive automation systems. It is applicable to smart chimney designs. Overall, it improves system versatility.

Rakesh Yadav (2021) [24] developed real-time monitoring systems for continuous data collection and analysis. His system ensures accurate and consistent data acquisition. The research focuses on improving system stability and reducing data lag. Real-time processing enhances responsiveness. Experimental results showed reliable long-term performance. The system supports embedded automation systems. His work emphasizes efficient data handling. It is relevant to smart chimney monitoring systems. Overall, it improves performance and reliability.

Priyanka Singh (2020) [25] focused on sensor calibration techniques to improve accuracy and reliability. Her research addresses issues such as environmental variations and sensor drift. She proposed methods to reduce measurement errors. The system provides stable and consistent readings. Experimental validation showed improved sensor performance. Her work emphasizes the importance of calibration in automation systems. It enhances overall system reliability. The research supports precise measurement applications. It is relevant to smart chimney sensors. Overall, it improves sensing accuracy and efficiency.

III. CONCLUSION

This review paper has examined various studies related to indoor air quality (IAQ) in kitchen environments and the evolution of chimney systems from conventional to smart automated designs. The literature clearly indicates that cooking activities are a major source of indoor pollution, releasing smoke, heat, and harmful gases such as CO, NOx, VOCs, and fine particulate matter (PM2.5). These pollutants pose serious health risks, thereby making efficient ventilation systems an essential requirement in modern kitchens. From the reviewed works, it is evident that traditional chimney systems suffer from limitations such as manual operation, lack of adaptability, and inefficient energy usage. These drawbacks have motivated researchers to explore intelligent and sensor-based automation systems. Various studies highlight the effectiveness of integrating temperature sensors, gas sensors, and smoke detectors for real-time monitoring and control of ventilation systems.

The literature further shows that automation significantly improves system performance by enabling timely activation of chimneys under varying cooking conditions. Among different control techniques, relay-based ON/OFF control has been widely recognized for its simplicity, reliability, and cost-effectiveness. Several authors have demonstrated that such systems can achieve satisfactory performance without the complexity associated with variable speed control mechanisms.

However, the review also identifies certain challenges, including sensor inaccuracies, environmental interference, and false triggering, which can affect system reliability. Many researchers emphasize the need for proper calibration, filtering techniques, and robust system design to overcome these issues. Additionally, integration with wireless technologies such as Bluetooth and IoT platforms has been explored to enhance user interaction and system flexibility.

Overall, the reviewed literature confirms that sensor-based smart chimney systems provide a practical and efficient solution for improving indoor air quality in kitchens. While significant progress has been made, there is still scope for improvement in terms of system accuracy, adaptability, and long-term reliability. Future research should focus on developing more robust, energy-efficient, and scalable solutions that can be easily implemented in real-world applications.

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