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SAFEPATHIQ: NAVIGATING SAFETY THROUGHUNIFIED IOT-DRIVEN PREVENTING FIRES ANDINTELLIGENT EVACUATION: A SURVEY

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Abstract—In the realm of fire safety for expansive public spaces like malls and shopping areas, our project introduces an advanced fire and smoke detection system. Employing a network of strategically positioned sensors, the system continuously monitors air quality in real-time. A sophisticated algorithm for deep learning processes sensor data, effectively distinguishing between normal environmental variations and potential fire or smoke incidents.

Upon detection of anomalies, the system triggers immediate alerts, communicates with a central monitoring unit, and activates rapid response mechanisms, including automated alerts to emergency services and the deployment of fire suppression systems. This scalable solution ensures comprehensive coverage of large areas, prioritizing the safety of occupants and minimizing property damage in the face of fire emergencies.

Keywords— Fire Detection, Smoke Detection, Sensor Networks, Deep Learning, Emergency Response, Public Safety, Large-scale Environments, Rapid Alert System, Fire Suppression.

I. INTRODUCTION

In the wake of advancing science and technology, modern architecture has witnessed a surge in the design of large-scale public buildings, including shopping malls, office complexes, research centers, and educational institutions. However, with the increasing complexity of these structures, the potential for unforeseen disasters, particularly fire hazards, becomes a critical concern. Sudden events, This survey delves into the innovative project presented in the paper "An Intelligent IoT-Based People Evacuation Guidance Model for Fire Hazard," the project introduces a dynamic and intelligent IoT-based system aimed at guiding people through evacuation paths tailored in real-time to the prevailing fire hazards inlarge public buildings.

A. The Evolving Landscape of Public Buildings:

The complexity of modern public buildings, combined with the unpredictability of human behavior during stressful events, necessitates a robust evacuation system. Traditional methods often fall short in providing effective guidance, leading to inefficient evacuations in the face of disasters like fires, gas leakages, or earthquakes. In recent times, the expansion of large-scale public buildings—spanning shopping malls, office complexes, research hubs, and educational institutions—has become synonymous with progress. However, the escalating intricacies of these architectural marvels also amplify the potential risks associated with fire incidents, underscoring the imperative for proactive safety measures. The allure of creative and innovative architectural ideas, while shaping mesmerizing structures, simultaneously amplifies the challenges associated with disaster management.

B. Challenges in Evacuation Dynamics:

The proposed system utilizes IoT technology, integrating a network of sensors, including temperature sensors, to detect the presence of fire in different floors of a building. The information is processed in real-time, allowing for the creation of optimal evacuation paths dynamically. The system communicates with users through Personal Digital Assistants, such as mobile phones and tablets, providing timely alerts and guiding individuals to safety exits. Traditional evacuation methods often falter in the face of dynamic and unpredictable emergency scenarios. Inefficient evacuation guidance and the unpredictable behaviors of individuals under stress contribute to the complexity of ensuring a swift and organized evacuation during events like fires, gas leaks, or earthquakes. Recognizing these challenges, the proposed project seeks to revolutionize evacuation dynamics through the integration of cutting-edge technologies.

C. Targets and Framework:

The primary objectives of the project encompass the proposal of an intelligent Model for guiding people to evacuate in the event of a fire hazards in large buildings, ensuring the safety of lives and property. The system aims to construct optimal paths dynamically based on real-time situations, utilizing personal devices for efficient and rapidevacuation.

This survey paper aims to comprehensively examine the methodologies, technologies, and outcomes presented in the original paper, shedding light on advancements in IoT-driven fire safety systems for large public spaces. Concentrating on the objectives of proposing an intelligent people evacuation guidance model, safeguarding lives and property, and constructing optimal paths dynamically, the survey serves as a comprehensive guide to the innovative strides made in the realm of fire safety technology.

II. PRECEDING RESEARCH OVERVIEW

The review of the literature done for this investigation is summarized in a tabular format, providing a comprehensive overview of relevant research works. The table encompasses crucial details such as the name of the study, author(s), publication year, research objectives, and key advantages and disadvantages identified in each work

Title	Authors	Year	Objectives	Advantages	Disadvantages
Efficient Smart Emergency Response System for Fire Hazards using IoT. [1]	Tumma Srinivasarao , R. Ragupathy, Maganti Syamala, Nalini N.J	2018	1. Utilize IoT sensors to identify a fire risks in the early stages. 2. Implement a mechanism that is capable of monitor environmental conditions continuously in real-time.	1. The system enables faster response to fire emergencies, potentially reducing damage and saving lives. 2. Automated emergency response reduces reliance on human intervention, especially in critical situations.	1. The system relies heavily on the proper functioning of IoT devices and connectivity; any failure could compromise effectiveness. 2. Continuous monitoring raises privacy concerns, and addressing these concerns is essential for public acceptance.
An IoT Based Intelligent Fire Evacuation System. [2]	Afsana Khan, Afrida Anzum Aesha, Juthi Sarker Aka, S.M. Faisal Rahman, Md. Jamil-Ur Rahema	2019	1. Improve the safety of individuals during fire emergencies by providing intelligent guidance for evacuation through the shortest safe paths. 2. Implementthe search algorithm known as A* to calculate and guide evacuees along the most efficient and safe evacuation routes, considering real-time conditions.	1. The system leverages IoT and the A* search algorithm to provide quick and intelligent guidance to evacuees, minimizing The amount of time needed to leave the building safely. 2. Dynamic path adjustments based on real-time conditions and crowd density enhance adaptability, ensuring that the system remains effective in varying scenarios.	1. The effectiveness within the system is contingent on the proper functioning of technology components, and any technical failure could compromise its reliability. 2. The integration of an IoT-based system with a comprehensive sensor network may entail significant costs for installation and maintenance.
An Intelligent Iot Based People Evacuation Guidance Model For Fire Hazard. [3]	Faritha Banu J, Yuvarani K, Suvetha B, Nyle S, Srilekha A	2020	1. Provide real-time guidance to individuals in large public buildings during fire hazards to dynamically construct optimized evacuation paths based on the current situation. 2. Enable occupants to reach safety exits swiftly by utilizing their Personal Digital Assistants (PDAs) such as mobile phones and tablets for personalized and dynamic evacuation guidance.	1. Utilizing PDAs allows for personalized evacuation guidance, considering the real-time situation and providing occupants with the most relevant and efficient paths to safety. 2. The system leverages IoT to continuously monitor the environment, ensuring that evacuation paths are dynamically adjusted based on the current situation, enhancing overall safety.	1. The system's effectiveness relies on the reliability of IoT technology, and any technical glitches or failures may compromise its performance. 2. Implementing an Intelligent IoT-based system may involve initial setup costs and ongoing maintenance expenses, potentially limiting its adoption in certain scenarios.

Title	Authors	Year	Objectives	Advantages	Disadvantages
Convolutional neural network based early fire detection. [4]	F. Saeed, A. Paul, P. Karthigaikumar and A. Nayyar	2020	1. Develop a fire detection mechanism capable of recognizing potential fire incidents at an early stage, minimizing response time and reducing the severity of damages. 2. Integrate data from both wireless sensors and images captured by surveillance cameras to create a comprehensive and accurate fire prevention model.	1. The application of machine learning and deep learning techniques enables the early prediction of potential fire incidents, providing valuable time for evacuation and emergency response. 2. By utilizing both sensor data and image data, the model can leverage multiple sources of information, enhancing The precision and reliability of fire detection.	1. Deep neural network training can be complicated and time-consuming. computational resources and time, making the initial setup challenging. 2. The utilization of surveillance camera images raises privacy concerns, and careful consideration must be given to ensure compliance with privacy regulations.
DeepFireNet: A real-time video fire detection method based on multi-feature fusion. [5]	B. Zhang, L. Sun, Y. Song, W. Shao, Y. and Guo and F. Yuan	2020	1. Develop a framework capable of detecting fires in real-time from video streams collected by monitoring equipment. 2. Utilize static and dynamic features of fire to filter out A substantial amount of non-fire images, focusing computational resources on potential fire instances.	1. DeepFireNet is designed for real-time video detection, allowing for timely response to fire incidents. 2. The framework efficiently filters out non-fire images, focusing computational resources on potential fire instances for improved efficiency.	1. Implementing and fine-tuning Deep learning models might need expertise and computational resources, potentially limiting accessibility. 2. The performance of the algorithm may be highly dependent on the quality and diversity of the training data, requiring careful consideration during model development.
IoT based Safety System: LPG/CNG Detection and Alert. [6]	Avita Katal, Kavin Sharma and Vitesh Sethi	2021	1. Improve emergency response by leveraging IoT to detect and communicate incidents such as fires in real-time. 2. Support the growth of a smart city by utilizing IoT technology to add services for citizens and enhance city administration.	1. The system enables real-time identification of fire incidents, allowing for immediate response and minimizing the potential damage. 2. Leveraging IoT improves communication between authorities, citizens, and emergency response teams, enhancing overall efficiency.	1. The efficiency of the system relies heavily on the availability and proper functioning of IoT devices and communication networks. 2. Implementing surveillance and notification systems raises privacy concerns, necessitating careful consideration and adherence to privacy regulations.

Title	Authors	Year	Objectives	Advantages	Disadvantages
Building Fire Evacuation: An IoT-Aided Perspective in the 5G Era. [7]	Hongqiang Fang, Siuming Lo, Jacqueline T. Y. Lo	2021	1. Utilize the capabilities of 5G to provide high-speed and low-latency communication for improved connectivity. 2.Implement IoT Devices for real-time Monitoring of environmental Conditions and fire incidents.	1. 5G provides high-speed and low-latency communication, enabling rapid data transmission for real-time monitoring. 2. The combination of IoT and 5G facilitates efficient data processing and analysis for better decision-making.	1.Implementing 5G infrastructure and advanced IoT devices may incur high initial costs. 2.The use of IoT and 5G raises security concerns, Particularly regarding data privacy and the Potential for cyber attacks.
Research on Fire Risk Level Prediction Based on XGBoost Algorithm. [8]	Shufeng Yang, He li, Yufeng Fan	2022	1. Fire Risk Level Assessment: The primary objective is to address the issue of fire risk level assessment, particularly in the context of rural and residential building fires in a northern city. 2. The paper aims to analyze annual fire information from the northern city. This analysis likely involves understanding patterns, trends, and factors contributing to fire incidents in the specified region.	1. The experimental findings show that the XGBoost algorithm predicts fire risk levels with a high degree of accuracy. This shows how well the model works to produce precise predictions based on the variables that were examined. 2. XGBoost is renowned for having a high degree of predicting accuracy and handling intricate relationships in data. This benefit is especially useful in situations like fire risk assessment where a number of variables affect the result.	1. Tuning Complexity: Achieving optimal performance with XGBoost often requires careful parameter tuning. Determining the right combination of hyper parameters can function as a time-consuming process and may require domain expertise. 2.The way in which the XGBoost algorithm is heavily based on the caliber and Representative among the input data. If the dataset used for training is biased or lacks diversity, the model's predictions may be limited in their generalizability.

Title	Authors	Year	Objectives	Advantages	Disadvantages
A Fire Evacuation and Control System in Smart Buildings Based on the Internet of Things and a Hybrid Intelligent Algorithm Evacuation and Control System in Smart Buildings Based on the Internet of Things and a Hybrid. [9]	Ali Mohammadiou un otikandi, Hassan Falah Fakhruldeen, Maytham N. Meqdad, Banar Fareed	2023	1. Implement sensors and IoT devices for early detection of fire incidents. 2. Develop a system for automated and efficient evacuation processes based on real-time data. 3. Establish reliable communication channels between devices and systems for seamless coordination.	1. Enables faster response to fire incidents, minimizing damage and enhancing safety. 2. The hybrid intelligent algorithm enhances decision-making for efficient evacuation strategies. continuous monitoring through IoT devices provides real-time data for informed decision-making.	1. Integrating IoT and hybrid intelligent algorithms can be complex and may require specialized knowledge. 2. The implementation and maintenance costs of such systems can be relatively high. 3. Reliability is contingent on the proper functioning of technology, which may fail or be vulnerable to cyber threats.
Fire Surveillance System Using Wi-Fi. [10]	Ria Khandelwal, H S Gore, Aman Yadav, Shivratna Ghante	2023	1.Improve the efficiency and speed of emergency Response by Utilizing wireless sensor networks to detect dangers and guide evacuees to safety. 2.Integrate Wireless sensor networks into smart buildings to create an intelligent and responsive Environment that prioritizes occupant Safety during emergencies.	1. Wireless sensors enable real-time detection of dangers, allowing for immediate response and evacuation guidance. 2. The incorporation of wireless sensor networks contributes to the development of intelligent and responsive buildings, enhancing overall safety.	1.The effectiveness of the system based on how trustworthy the wireless sensor is networks, and any technical failures may compromise the evacuation process. 2. Implementing a comprehensive wireless sensor network within buildings may involve significant initial costs for installation and maintenance.

III. COMPARATIVE STUDY OF FIRE SAFETY ALGORITHMS IN SMART ENVIRONMENTS

A. An IoT Based Intelligent Fire Evacuation System: Algorithm Used:A* algorithm for searching is utilized to manage the central module for guiding people through the shortest safe path in the midst of a fire incident. Sensor Integration: The system incorporates a wireless sensor network, including PIR sensors, smoke sensors, and heat sensors,for detecting fires in real time and evacuation guidance.

B. DeepFireNet: A real-time video fire detection method based on multi-feature fusion: Algorithm Used: DeepFireNet combines fire features and neural network using convolutionss for real-time video fire detection. The network architecture involvesreplacing 5×5 convolution kernels with two 3×3 convolution kernels, reducing network parameters. Sensor Integration: The paper focuses on video-based fire detection and proposes a method to filter non-fire images, extract suspected fire areas, and apply a neural networkwith convolution for the detection of fire.

IV. CONCLUSION

The presented survey paper explores an Intelligent IoT-based Model of Person Evacuation Guidance for Fire Hazard, proposing a comprehensive system to enhance safety in large public buildings.The integration of IoT devices, deep learning algorithms, and various sensors allows for real-time monitoring, early fire detection, and optimized evacuation paths. The system aims to minimize danger and economic losses by providing timely alerts and guiding individuals to safety exits. The research highlights the importance of leveraging advancements in technology to improve fire safety measures in complex and densely populated environments, contributing to the overall well-being of occupants and property protection.

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