NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY
[IJIERT] ISSN: 2394-3696 Website: ijiert.org
VOLUME 11, ISSUE 01, January -2024

A REVIEW PAPER ON AUTOMATED FIRE DETECTION

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Article History: *Received on: 28/10/2023*
Accepted on: 01/01/2024

DOI: *https://doi.org/10.26662/ijiert.v11i1.pp10-13*

Abstract:
Automated fire detection and localization systems play a pivotal role in enhancing early response mechanisms and minimizing the devastating impact of fires. This review explores recent advancements in technologies and methodologies related to automated fire detection and localization. The study encompasses a comprehensive analysis of various sensing technologies, including infrared, image processing, and machine learning-based approaches. The effectiveness of these systems in diverse environments, such as industrial facilities, residential spaces, and outdoor areas, is evaluated. The review delves into the challenges faced by existing systems, addressing issues related to false alarms, scalability, and real-time response. Additionally, advancements in the integration of Internet of Things (IoT) and artificial intelligence (AI) techniques for more robust fire detection and localization are discussed. The aim is to provide a thorough understanding of the current state of automated fire detection systems, their limitations, and the potential avenues for future research and development in this critical field.

Introduction:
Despite the widespread implementation of fire-detection methods in both residential and industrial settings, fires persistently result in numerous fatalities, accidents, and substantial financial losses. According to the International Association of Fire and Rescue Services (CTIF), the annual average death toll from fire accidents and hazards in India was approximately 16,714 between 2014 and 2018. Recent technological advancements in sensing methods, information technology, and telecommunication have significantly improved fire detection methods in recent years.

Fire Incidents and Technological Progress:
Prompt identification of emerging fire incidents and timely warnings to building residents and emergency services are crucial aspects of fire safety. This progress has given rise to modern fire sensing and detection technologies, paving the way for the development of smart buildings.

Common Causes of Fires:

In residential environments, cooking, smoking, and electrical issues are the most frequent sources of fires. Electrical fire hazards deserve particular attention as they contribute significantly to fire fatalities globally. Causes include faulty sockets, appliances, extension leads, portable heaters, outdated wiring systems, overload, loose contacts, and short circuits.

Detection Mechanisms:

Several occurrences precede a fire, and their physical or chemical manifestations can be measured to trigger an alert. While phenomena like the characteristic scent of smoke are used in fire detection systems, none consistently offer accurate detection. Early warning, either human or automatic, followed by a swift response by trained fire emergency personnel, is crucial to controlling fires before they cause substantial damage.

Key Alarming Signs:

The key signs of a fire include heat in the environment, visible flames, smoke, and changes in the surrounding air quality. Real-time measurement of physical quantities is vital for effective fire sensing.

Challenges in Fire Sensing Methods:

Despite advancements, fire sensing methods still face challenges, including minimizing false alerts and improving sensitivity and dynamic response. This paper focuses on reviewing various fire-sensing methods in the literature, emphasizing their application in confined environments.

Literature Review:

M. J. Hurley et al stated that Smoke becomes apparent much earlier than other fire indicators. The early detection of smoke plays a critical role in enhancing the likelihood of effective fire control and survival. The production of smoke results from the combustion of materials, impacting the air quality in the surrounding environment

B. J. Meacham et al indicated that the extent of incident light scattering by an element is predominantly influenced by factors such as the particle's size, shape, incident light wavelength, scattering angle, and refractive index

T. Deng et Al introduces a smoke detection method that integrates dual-polarized channels to fine-tune the sensitivity for both white and black smoke. The sum is differentiated based on the polarization degree of the channel, and sensitivity is modified using a correction factor.

L. B. Freund et al showed bimetallic sensing as an alternative form of static heat detection, employing two distinct metals with disparate expansion rates fused to create a unified metal strip. The strip is electrically activated using a low-voltage current. In the event of a fire in the surroundings, the strip heats up, causing the metal with a higher expansion rate to bend toward the electrical contact, thereby initiating the alarm. The specific temperature at which the alarm is triggered is determined by the gap between the contacts. Flame detectors are specifically crafted to detect the existence of flames and hold significant importance across various industries, including chemical plants, hydrogen stations, drilling and construction sites, industrial gas turbines, industrial heating and drying systems, and printing and paper manufacturing industries. Flames, the visible and gaseous components of a fire arising from the interaction between oxygen and fuel, are the focal point of detection for this type of fire detector, often referred to as a light detector. Fire detection employs two types of CO sensors: non-dispersive infrared (IR) and electrochemical. Non-dispersive IR sensors operate on an optical method of fire detection, while electrochemical gas sensors rely on the electrochemical reaction of the sensing material. In a study referenced as, the authors conducted an extensive survey on diverse gas sensing technologies, with sensitivity and selectivity identified as the primary performance indicators. Their investigation also highlighted additional performance criteria, including response time (the duration for the sensor to issue an alert upon gas detection), energy consumption, reversibility (whether the sensing material returns to its original state after detection), fabrication cost, lifetime, and more.

Thanigaivel M et al implemented through Image Processing, a technique employed to execute operations on an image using an algorithm for extracting valuable information. Image processing involves two main methods: analog image processing and digital image processing. Digital image processing offers distinct advantages over analog processing, providing a broader range of algorithms as input data and mitigating issues like noise and distortion during processing. The core concept revolves around Color Detection. Once the system learns to identify fire through trained image processing, it gains the ability to autonomously detect fires and activate preventive measures. The system assesses the volume intensity of the fire outbreak and automatically sends alerts to the receiver.

Prof. Amit Hatekar et al introduces a system designed for the automatic detection of fire based on the subsequently described algorithm. The RGB color model is applied to the frame, followed by the conversion of the resulting RGB frame to an HSV frame. This frame is then subjected to thresholding and median blurring, with the outcomes of these processes combined using the Bitwise AND operation. The project puts forth a fire detection algorithm that operates without sensors, a departure from conventional fire detection systems. Real-time image capture is facilitated through the use of OpenCV.

Md. Mahamudul Hasan et al designed to detect fires by leveraging knowledge of the physical behavior of fire, issuing automatic warnings to individuals before reaching a hazardous state. The system primarily alerts registered users via a GSM Modem that sends SMS notifications. The control actions of the system are managed by Arduino UNO R3, with a Huawei GSM modem utilized for internet connection and SMS transmission. A Liquid Crystal Display (LCD) panel is incorporated to provide a visual representation of the system's status. In the event of fire data being detected in a video image stream, the warning component activates a fire alarm through a siren.

Athul Satheesh et al determined that the initial step involves creating a neural network model utilizing various datasets of fire (Positive) and non-fire (Negative) images and videos to accurately detect fires. The project employs the CNN (Convolutional Neural Network) concept, with Python used to control the neural network. Specifically, a Fire Net, similar to Google Net, is created, and it is trained and identified using fire and non-fire data. OpenCV and Tensor Flow serve as the libraries for training and identification. The system incorporates various sensors, including temperature sensors, to monitor temperature levels.

G. Sathyakala employed a webcam as an alternative to surveillance cameras, continuously monitoring the interiors of buildings. The video feed is processed using OpenCV and Raspberry Pi, incorporating fire detection algorithms. If a fire is detected, an alarm is activated to alert individuals in the specific area. Additionally, a brief segment of the live video is transmitted to the building's security or the remote fire station via wireless LAN. This enables the fire station to take immediate action, dispatching rescuers based on the assessment of the number of individuals affected in the fire-stricken area. The detection of fire in the system is accomplished using the Hue, Saturation, Value (HSV) algorithm.

Gap Identification:

The review of literature has shown some gaps in the existing systems and technologies used. By using those gaps we have identified the problem statement and the main objective of study has been decided and the objective is to is to develop an automated fire detection and localization system using a surveillance camera equipped with Haar algorithm and Twilio API The system will analyze video streams in real-time to detect the presence of fire and will send alert messages via the Twilio API to relevant personnel for prompt response. Additionally, the system will utilize the camera's position and angle to accurately determine the location of the fire, aiding in the efficient deployment of firefighting resources.

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