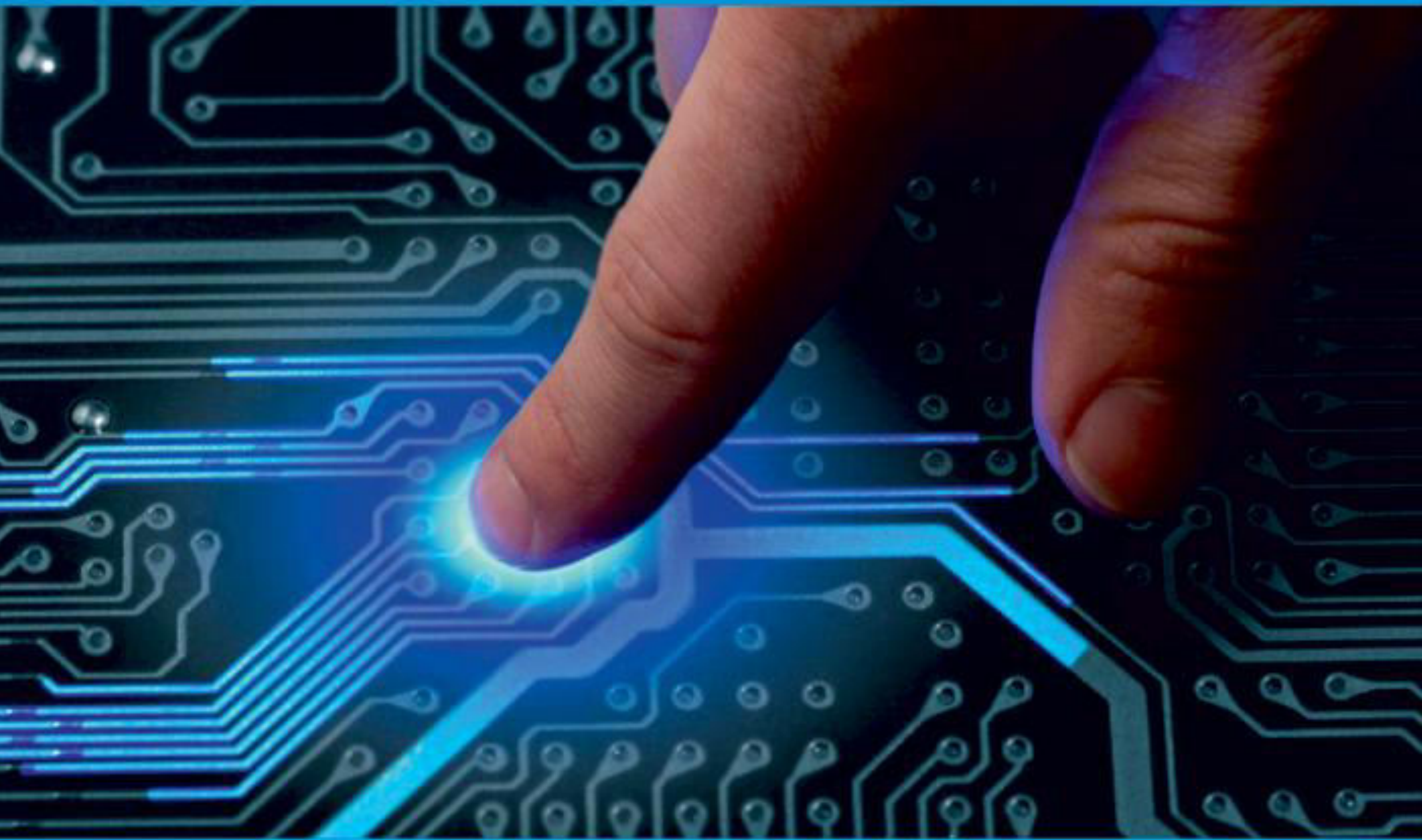
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 9, Issue 9, September 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.542

International Journal of Innovative Research in Computer and Communication Engineering

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 7.542

|| Volume 9, Issue 9, September 2021 ||

| DOI: 10.15680/IJIRCCE.2021.0909010 |

Survey of Fire Detection and Localization Approaches in Video Surveillance Applications

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ABSTRACT: Video based fire detection technology is becoming the focal point of research with its advantages of high intuitive, speed and anti-jamming capability. This paper reviewed the fire detection methods based on video images in recent years. Through the review, it is clear to see that video based fire detection technology can be divided into two main areas: the characteristics detection of flame and smoke. This fire detection method can improve the accuracy of the fire alarm, real-time and robustness. If the optimal algorithms can be adopted for each part of detecting motion area and extracting fire characteristics, the system performance will be further improved.

KEYWORDS: Fire, Detection, Machine Learning, CNN, Alarm, Localization.

I. INTRODUCTION

A fire detector is a sensor designed to detect and respond to the presence of a fire or fire, allowing fire detection. Responses to a detected fire depend on the installation, but can include sounding an alarm, deactivating a fuel line (such as a propane or a natural gas line), and activating a fire suppression system. When used in applications such as industrial furnaces, their role is to provide confirmation that the furnace is working properly; it can be used to turn off the ignition system though in many cases they take no direct action beyond notifying the operator or control system. A fire detector can often respond faster and more accurately than a smoke or heat detector due to the mechanisms it uses to detect the fire.

There are many fire detection systems which are based on video imaging that are implemented in different research works, with excluding some of detection which uses video sequencing. The fire detection research is generally based on video sequences and is divided into two following categories: fire flame detection and fire smoke detection [1]. Proposed system connected to fire flame detection technique; therefore it is discussed in this section. Two broad categories of approach can be identified for fire detection: 1) traditional fire alarms and 2) vision sensor assisted fire detection. Traditional fire alarm systems are based on sensors that require close proximity for activation, such as infrared and optical sensors. These sensors are not well suited to critical environments and need human involvement to confirm a fire in the case of an alarm, involving a visit to the location of the fire. Furthermore, such systems cannot usually provide information about the size, location, and burning degree of the fire. To overcome these limitations, numerous vision sensor-based methods have been explored by researchers in this field; these have the advantages of less human interference, faster response, affordable cost, and larger surveillance coverage. In addition, such systems can confirm a fire without requiring a visit to the fire’s location, and can provide detailed information about the fire including its location, size, degree, etc. Despite these advantages, there are still some issues with these systems, e.g., the complexity of the scenes under observation, irregular lighting, and low-quality frames; researchers have made several efforts to address these aspects, taking into consideration both color and motion features.

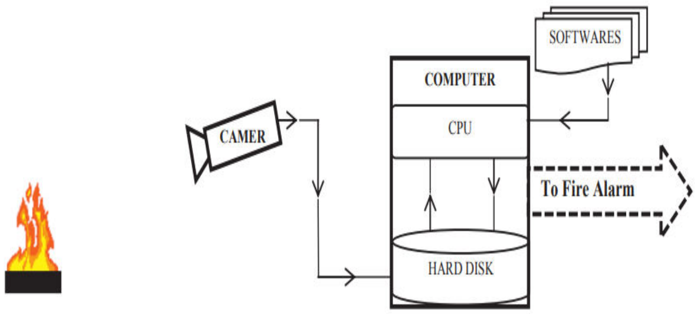

Figure 1: Fire Detection Conventional Approach

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The hardware includes camera lens, image sensors, a central processing unit (CPU) and a hard disk. Fire and smoke, if detected at an early incipient fire stage, can be easily be controlled by fire fighters making escape by others to safety, not difficult. The traditional detection methods, however, have many significant drawbacks, including time delays especially in large spaces with high ceilings (such as atria, hanger and warehouses). Video fire detection systems can also be applied to detect forest fires. In addition, in order to protect historical buildings from fire damage and so maintain the historical characteristics of their architectural design, some video fire detection systems can be combined with existing closed – circuit television (CCTV) video surveillance system. As a consequence, use of a video flame detection system can be useful in complementing the protection of large spaces, forest and historical buildings both day and night.

II. RELATED WORK

K. Muhammad et al.,[1] propose an original, energy-friendly, and computationally efficient CNN architecture, inspired by the SqueezeNet architecture for fire detection, localization, and semantic understanding of the scene of the fire. It uses smaller convolutional kernels and contains no dense, fully connected layers, which helps keep the computational requirements to a minimum. Despite its low computational needs, the experimental results demonstrate that our proposed solution achieves accuracies that are comparable to other, more complex models, mainly due to its increased depth. Moreover, this work shows how a tradeoff can be reached between fire detection accuracy and efficiency, by considering the specific characteristics of the problem of interest and the variety of fire data.

W. Thomson et al.,[2] presents different Convolutional Neural Network (CNN) architectures and their variants for the non-temporal real-time bounds detection of fire pixel regions in video (or still) imagery. Two reduced complexity compact CNN architectures (NasNet-A-OnFire and ShuffleNetV2-OnFire) are proposed through experimental analysis to optimise the computational efficiency for this task. The results improve upon the current state-of-the-art solution for fire detection, achieving an accuracy of 95% for full-frame binary classification and 97% for superpixel localisation.

K. Muhammad et al.,[3] proposed system is based on intelligent independent and subordinate agents, where each agent has a different task to report to the fire brigade and disaster management instantly. A deep yet efficient CNN is utilized in the system for feature extraction, classification, localization, and detection of fire in video frames. When the fire is detected in the frames, a fire alert is instantly sent to the emergency department and all agents immediately start their processing for checking the severity and growth rate of the fire, recognizing the scene and all objects on fire, and evacuation monitoring. It is believed that using such a system is the demand of the time to save humanity from massive fire disasters and can make the current surveillance networks more intelligent.

K. M. Akhil et al.,[4] proposed localization or positioning is an important aspect in wireless sensor network (WSN). In WSN sensor nodes are generally distributed randomly and to embed GPS module to all the nodes make the implementation more costly. But finding the position accurately is very much necessary in some of the cases like forest fire detection, animal monitoring etc. In this respect machine learning approach may play an important role. In this article a comprehensive literature review is done on machine learning techniques and a novel machine learning based self-localization technique is proposed.

A. Abiri et al.,[5] focuses on the designing of a system that deals with the sniper positioning based on using only bullet Shockwave signals. The first acquired Shockwave signal in the microphones' array is not from the fired bullet and specifies only the relevant point on the bullet trajectory. Hence, in this research, by utilizing the two least microphones count arrays in the 2-Dimensional real environment, first it is obtained the bullet trajectory, and then in an initiative, the reduction curve of the Mach number on this bullet trajectory, is devoted to locating the source of the fire. Also, the generalized cross-correlation phase transform method is used for calculating of the time delays between the microphones in an array.

J. Zhu et al.,[6] proposed and its effectiveness is verified by experiments. The application of sub-pixel detection method in calibrating stereo vision system can significantly improve the accuracy and stability of fire positioning. However, with the increase of fire distance, the positioning error would increase significantly, which is unavoidable. The experimental results show that the increase of the baseline distance can effectively suppress the increase of the positioning error under the baseline distances of 186mm, 249mm and 438mm. Therefore, after an appropriate baseline distance is matched, the variable baseline distance stereo vision system based on sub-pixel detection can be used for fire positioning of wider range.

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G. S. C.A et al.,[7] presents different Convolutional Neural Network (CNN) architectures and their variants for non-temporal binary fire detection and localization in video or still imagery. We consider the performance of experimentally defined, reduced complexity deep CNN architectures for this task and evaluate the effects of different optimization and normalization techniques applied to different CNN architectures (spanning the Inception, ResNet and EfficientNet architectural concepts). Contrary to contemporary trends in the field, our work illustrates a maximum overall accuracy of 0.96 for full frame binary fire detection and 0.94 for superpixel localization using an experimentally defined reduced CNN architecture based on the concept of InceptionV4.

M. Aktas et al.,[8] provides MIL relaxes the requirement of having accurate locations of fire patches in video frames, which are needed for patch level CNN training. Instead, only frame level labels indicating the presence of fire somewhere in a video frame are needed, substantially alleviating the annotation and training efforts. The resulting approach is tested on a new fire dataset obtained by extending some of the previously used fire datasets with video sequences collected from the web. Experimental results show that the proposed method improves fire detection performance upto 2.5%, while providing patch level localization without requiring patch level annotations.

X. Fan et al.,[9] presents the simulation results that the map boundary established by the SLAM algorithm is obvious, and the terrain environment is well reproduced, and the positioning of the robot is realized. The fire source identification algorithm accurately identifies the area and contour of the flame, and realizes the intelligent detection of the fire source point. In addition, the fusion of the two algorithms enables the fire-fighting robot to independently detect the fire source in the indoor environment, effectively preventing the occurrence of fire accidents.

G. Laneve et al.,[10] The limitations related to the sensitivity of the geostationary sensor to fire sizes have been, at least in part, overcome by introducing specific algorithms. However, the reduced accuracy in the geographic localization of the fire, which can, in principle, occupy any position in an area of about 16 km 2 (at Mediterranean latitudes), makes this information not very interesting for the institutions involved in firefighting. This work analyzes the feasibility of improving the localization of the thermal anomalies (hotspots) by combining images acquired simultaneously from different MSG satellites located at different longitudes. In particular, we combine the images acquired by MSG-9 located at long. 9.0°, MSG-10 located at 0.0° and MSG-8 located at long. 41.5°.

K. Muhammad et al.,[11] propose an original, energy-friendly, and computationally efficient CNN architecture, inspired by the SqueezeNet architecture for fire detection, localization, and semantic understanding of the scene of the fire. It uses smaller convolutional kernels and contains no dense, fully connected layers, which helps keep the computational requirements to a minimum. Despite its low computational needs, the experimental results demonstrate that our proposed solution achieves accuracies that are comparable to other, more complex models, mainly due to its increased depth. Moreover, this work shows how a tradeoff can be reached between fire detection accuracy and efficiency, by considering the specific characteristics of the problem of interest and the variety of fire data.

S. S. Esfahlani et al.,[12] presents a system that combines robotic operating system (ROS) and computer vision techniques for fire detection in a mixed reality environment. We have collected video streams from a mini camera on an Unmanned Aerial Vehicle (UAV), where the navigation data relied on state-of-the-art Simultaneous Localization and Mapping (SLAM) system. The data collected onboard are communicated to the ground station and processed through the robotic operating system. A robust and efficient re-localization SLAM was performed to recover from tracking failure and frame lost in the received data. The fire detection algorithm was developed based on the colour, movement attributes, temporal variation of fire intensity and its accumulation around a point.

III. CHALLENGES

False alarms- False alarms incorrect installation, lost connections, faulty or aging equipment, and improper maintenance are the most common problems we come across in monitoring commercial and residential fire alarm systems. As the monitoring company, we don't have the luxury of coming on site to inspect equipment and make sure everything is functioning correctly.

Equipment & Connection Problems- Individual smoke detector sensitivity adjustment, drift compensation, and maintenance-needed indicators are a just few of the most recent tech advances helping to improve fire detection equipment. Unfortunately, electronic devices also age, which could cause equipment to malfunction just as a result of time. Another problem could be that the equipment was never installed correctly from the start, which could lead to a host of problems down the road. Any number of things could also break the connection between the alarm system and

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the monitoring station, which is why we recommend installing at least one backup connection in every monitoring scenario.

Maintenance- The best way to make sure an alarm system stays in good working order is with tests, inspections, and regular maintenance. We recommend inspecting commercial systems annually and residential systems no less than every two to three years. Regular maintenance will help identify problems before they cause issues and keep your customers' systems in good working order.

The issues within a hospital are not the same as they are in a warehouse. In a facility where life safety is the major concern, such as hospitals where patients may not be able to evacuate on their own, early warning is essential. Dormitories, hotels, and other facilities where occupants may be sleeping when a fire starts also require that a system provide more rapid notification.

In a warehouse, where the occupants will be awake and aware and there will most often be fewer of them, the alarm system often does not need to provide notice as early. In a generally unoccupied structure where life safety is not a major issue, detection of a fire can be slower without significantly increasing risk. When selecting a system, we must consider the ongoing commitment that will be required over the life of the system. Inspection, testing, and maintenance requirements for these systems are extensive. Meeting these requirements over the life of a system usually will cost more than the original installation.

IV. CONCLUSION

The Location determination is an important problem for almost all WSN applications. However, obviously becomes an important target in the case of surveillance systems for fires do not have to support real-time monitoring of each point of an area at any time location early threat of fire. Solutions applying wireless sensor networks, on the other hand, can gather sensorial data values, like temperature and humidity, from all points of a area incessantly, day and night, and allow for fresh and precise data to the fire-fighting center rapidly. This paper presents the review of fire detection and localization techniques in video surveillance applications.

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