An In-depth Review on Smoke and Fire Detection System

Saiprasad Bhise
Rachika Waghmare
Shrutika Jaghdhane
Yash Deshmukh

Shobha Raskar
Jaya Mane

Modern Education Society's College of Engineering,
19, Late Principal V. K. Joag Path,
Wadia College Campus Pune-411001
Computer Department
Savitribai Phule Pune University

Abstract — Throughout the globe, there seems to be an increment in the number of fires and fire-related catastrophes. Globally, there has also been a surge in the frequency of wildfires. According to statistics, wildfires have become more intense and lethal in recent decades. The increased probability throughout the world necessitates the installation of an efficient fire mitigation strategy to counteract such phenomena. The identification of wildfire in an immediate and adequate way is the initial phase in the avoidance and intervention of such incidents. As a result, there is a requirement for a fire identification mechanism that is very precise and trustworthy. Traditional techniques to fire identification rely on sophisticated electronics that are inefficient and have a high identification uncertainty. This review report summarizes efficient fire identification approaches that have been employed in the past. The techniques were effectively analyzed in the formulation of our research design, which employs the concept of Convolutional Neural Networks and Decision Making. This technique will be developed further in future versions of this paper.

Key Words: Convolutional Neural Networks, Decision Making.

I INTRODUCTION

Prehistoric civilizations' discovery of fire was one of the major achievements of all mankind. This is because primitive humans were unable to comprehend the mechanics of combustion and how to control its force. When mankind discovered how to manage fire, the entire trajectory of history of mankind shifted dramatically. Humans have been consuming

healthy food ever since advent of fire. These cooked meals prepared them with significantly more nourishment, allowing them to maintain massive brain capacities. This was critical in exploring other hobbies and mastering the fire. Even nowadays, regulated incineration is employed efficiently in a broad array of applications. All around the world, combustion powers our cars and electrical generators.

If left unchecked, fire is a tremendously destructive force that can destroy practically anything in its path. The fire is also very vulnerable to outside factors and may swiftly spread to nearby places if conditions are favorable. This has resulted in massive wildfires, which occur every year in hot and dry places. When these flames approach the city, they consume vast swaths of forest and can cause widespread devastation. Because wildfires are so large, they are extremely difficult to manage. These flames should be noticed at an early stage, when they are manageable, in order to lessen any negative impacts of the fire and reduce devastation.

The traditional ways for detecting fires make considerable use of sensors and other associated devices. These sensors detect the presence of smoke or a rise in the temperature of the surrounding environment. These

technologies are costly due to the high cost of sensor arrays. These arrays are similarly restricted to a specific range after which they are rendered useless. The concept of fire detection using video monitoring. This method is suggested since video may cover broad regions and does not need complex sensor arrays to accomplish fire detection goals.

Along with the usage of an effective fire detection system, the survey is also looking into a smoke detection mechanism. The ancient saying "where there is smoke, there is fire" holds true since smoke is one of the most common methods to identify a fire. However, because smoke detection is one of the most difficult components, most standard techniques have proved unsatisfactory. This has been a troublesome occurrence since the smoke and its detecting systems are used for effective and practical smoke detection.

The fire and smoke detection mechanism that have been researched earlier have been studied in detail along with the current approaches that have been in implementation have also been analyzed in this survey paper. This has been crucial in determination of the various inconsistencies and other drawbacks in the paper to achieve the detection of smoke and fire accurately. The achieved methodology in this survey paper will be elaborated further in the upcoming research articles on this topic.

This literature survey paper segregates the section 2 for the evaluation of the past work in the configuration of a literature survey, and finally, section 3 provides the conclusion and the future work.

II RELATED WORKS

Zhentian Jiao [1] explains that there has been a considerable hazard due to the natural and artificial fires that are the reason for the immense catastrophe across the world. Through this study, the authors suggested a forest fire alarm system using a machine learning model with implementation in a conceived autonomous vehicle framework. To interpret the photos acquired from the vehicle in real - time basis, a large-scale network is being established. The YOLOv3 detection method exhibits great accuracy with minimal time and cost by utilizing the highly efficient processor on the ground-station of the described system. This has a great deal of potential in real world applications for pinpointing forest fires even with minor flames. However, whether or not the fire is noticed relies in partially on the communication capability in between vehicle and the ground station.

Ke Chen [2] expresses that the timely detection of forest fire that can be highly useful in reducing the number of fire mishaps and the destruction caused by them. The researchers in this paper have proposed the use of Support vector machines for the purpose of detection of the fire. The use of computer vision allows for a much effective detection of fire which can be useful in various areas of the fire detection approach. The authors have utilized the difference between the frames as one of the useful mechanisms for the detection of motion. The effective use of the eigenvectors and eigenvalues to achieve the detection of the fire accurately.

Shi Lei [3] discusses that the paradigm of fire detection has been one of the most interesting concepts that have utilized the computer vision approach. This has been one of the most effective and a non-invasive mechanism for the purpose of detection of fire. The authors have used the paradigm of computer vision diligently to achieve the better flame recognition. Compared with the traditional flame recognition method, this method has the advantages of simplicity, fastness and strong adaptability. It can eliminate many kinds of non-fire Interference sources. This kind of fire detection method using common camera has a high practical value.

Xiaoyuan Xu [4] elaborates on the development and extinguishing process of kitchen fire in different scenarios. In oil pan fire scenario, the fire cannot be controlled by using dry powder fire extinguisher, so the fire situation is still expanding after a minute of fire extinguishing, while in kitchen flue fire, the fire situation is controlled after a minute of fire extinguishing by using water-based fire extinguisher especially for edible oil. It can be ascertained that the smoke of oil pan fire and kitchen flue fire containing edible oil is stronger than that of cabinet fire. The cabinet fire can be easily controlled by dry powder fire extinguishing, while the oil pan fire and kitchen flue fire need the combination of water-based fire extinguisher and dry powder fire extinguisher for edible oil to effectively extinguish fire.

Suleyman Aslan [5] introduces wildfire smoke detection method using motion based geometrical image transformation and DCGANs. By treating smoke as an unusual event, we develop a two-stage DCGAN training approach. Spatiotemporal dynamics of smoke event are acquired using motion-based geometric image transformation and represented within a single image accounting for ten consecutive frames. The proposed method achieves low false alarm rates while keeping the detection rate high. The proposed approach may be utilized to detect other anomalous events in forests, such as, flames or people in restricted zones.

Oxsy Giandi [6] states a model for detect fire using gas leak case prediction. The MQ-2 data sensor is sent to microcontroller and divided to be two utilize. The collected data is taken to make explosion or fire prediction based on gas concentration. The smoke and carbon monoxide data is fused with temperature and humidity sensor using fuzzy system to calculate the fire appearances. The data monitoring is not shown in real time because the parse of the serial data in

microcontroller cannot read the data quickly. The major limitation is that the fire symptom detection will be built in real hardware system and it can be monitored from mobile and a computer. The new system will be added with alarm system.

Xuan Zhao [7] explains that the primary element to make fire-alarm accuracy rate robust is the contextual objects detection based on relationship with detected smoke regions. The system effectively connects particular scenes with space-domain statistical methods to classify target objects. The models of contextual targets are not only based on the shape of them but also depend on the relative locations with smoke regions and so that scene can be described effectively. It is almost impossible for a single detected smoke region to determine the alarm of fire disaster behavior. In this paper, contextual objects detection is proposed to filter out non-disaster situation. However, undefined scene is a challenge because of the variety of situations containing smoke. This problem at present is solved with human interference and introduce new categories into system manually, which can be improved with iteration.

Shuchao Li [8] explains a water mist system Based on the characteristics of bus fire, the applicability of water mist extinguishing bus fire was analyzed. The structures of self-contained water mist fire extinguishing system and pump supplied system were summarized. Using only a bus as an example, the use of a pressure sprinkler systems fire suppression device used in the vehicle compartment was explained in great detail. A multiple fire evaluation was done to validate the retardant efficacy of water mist used in buses. All of them offering technical direction for the designing and implementation of a sprinkler systems solution for use in a vehicle.

Shixiao Wu [9] state that the task for fire detection is quite complex when performed purely through image processing approaches. Therefore, to bolster this approach and achieve accurate detection of the file, the researchers have utilized object detection techniques. Especially for false detection, the authors think area changes detection helps a lot. When the fire is bigger and bigger, the area of the fire is growing. The SSD can detect the area of the fire by four values. These four values present the coordinates of the top left corner and the coordinates of the lower right corner, then we calculate the area very easily. The system catch the two interval frame of the fire usually, when the area grows bigger, this must be the fire.

S. R. Vijayalakshmi [10] expresses that the proposed technique can be incorporated with a fully automatic surveillance system monitoring open spaces of interest for early fire warning system. The detection rate is increased by combine image processing technique along with sensing technique using sensors. Difficulties encountered in this research is the difficulty to determine the accuracy of the success of fire detection / fire danger. Future work development can be focused to generate a better formula to measure system performance and flicker into current system to achieve more robust fire detection.

Ethan Liu [11] in this paper mainly studies the smoke detection and identification method in early smoke detection based on video, and designs and implements the smoke detection system. The analysis summarizes the many characteristics of smoke, and identifies the smoke by its color and static characteristics as well as its dynamic characteristics. These include the characteristics of smoke in terms of color characteristics; the movement characteristics of smoke; the characteristics of the area, size and area of smoke that constantly change between frames; in addition, there are some static characteristics of smoke, and so on.

Cang Naimeng [12] narrates that the source video image of the early forest fire smoke is obtained by a more stable multi-rotor aircraft, and the background model of the early forest fire smoke video is established by the multi-modal Gaussian mixture algorithm to extract the background image; then the smoke is processed by the background blur feature The experimental results show that the detection effect is good and the accuracy is very high. The detection video used in this article adopts the method of hovering and still shooting. If it is used in actual detection, the early forest fire smoke detection of moving aerial lens is more valuable for research, but it is also more complicated.

III CONCLUSION AND FUTURE SCOPE

The video-based fire identification methodology has been thoroughly examined. This study has detailed the relevant techniques for the goal of creating our methodology. The fire is regarded as one of the most important and necessary assets. Detection of flames and smoke using computerized surveillance technologies such as intrusion detection systems has received a lot of attention in the previous few years. Conventional system is capable of detecting fire primarily employ sensors that detect the existence of fire by measuring fire characteristics; however, the detectors take a considerable amount of time to identify the existence of fire. However, this approach takes longer to identify the fire, and before then, the flames of fire may be transformed to the catastrophic destruction producing fire, resulting in massive property loss. As a result, employing Convolutional Neural Networks and Decision making, an excellent approach for identifying the fire using computer vision is being developed. This technique will be described further in future studies on the subject.

ACKNOWLEDGEMENT

It is our Great Pleasure to express our special thanks of gratitude to all our Authors and Professors for their contribution in our project for analysis and reporting of our work, also we would like to thank them who supported for important intellectual content also for article drafting and revising it.

REFERENCES

[1] Z. Jiao et al., "A YOLOv3-based Learning Strategy for Real-time UAV-based Forest Fire Detection," 2020 Chinese Control and Decision Conference (CCDC), 2020, pp. 4963-4967, doi: 10.1109/CCDC49329.2020.9163816.

[2] Chen, Ke et al. "Research on Image Fire Detection Based on Support Vector Machine." 2019 9th International Conference on Fire Science and Fire Protection Engineering (ICFSFPE) (2019).

[3] Lei, Shi & Fangfei, Shi & Teng, Wang & Leping, Bu & Xinguo, Hou. (2017). A new fire detection method based on the centroid variety of consecutive frames. 437-442. 10.1109/ICIVC.2017.7984594, 2017.

[4] X. Xu, P. Wang, N. Yu and H. Zhu, "Experimental Study on Kitchen Fire Accidents in Different Scenarios," 2019 9th International Conference on Fire Science and Fire Protection Engineering (ICFSFPE), 2019, pp. 1-6, doi: 10.1109/ICFSFPE48751.2019.9055764.

[5] Suleyman Aslan, Ugur Gudukbay, Behçet Uğur Töreyin, Ahmet Enis Çetin, "Early Wildfire Smoke Detection Based On Motion-Based Geometric Image Transformation And Deep Convolutional Generative Adversarial Networks", IEEE Signal Processing Society SigPort, 2019.

[6] O. Giandi and R. Sarno, "Prototype of fire symptom detection system," 2018 International Conference on Information and Communications Technology (ICOIACT), 2018, pp. 489-494, doi: 10.1109/ICOIACT.2018.8350730.

[7] X. Zhaa, H. Ji, D. Zhang and H. Bao, "Fire Smoke Detection Based on Contextual Object Detection," 2018 IEEE 3rd International Conference on Image, Vision and Computing (ICIVC), 2018, pp. 473-476, doi: 10.1109/ICIVC.2018.8492823.

[8] S. Li, D. Yu, Z. Ling and W. Ding, "The Application of Water Mist Fire Extinguishing System in Bus," 2019 9th International Conference on Fire Science and Fire Protection Engineering (ICFSFPE), 2019, pp. 1-5, doi: 10.1109/ICFSFPE48751.2019.9055783.

[9] S. Wu and L. Zhang, "Using Popular Object Detection Methods for Real Time Forest Fire Detection," 2018 11th International Symposium on Computational Intelligence and Design (ISCID), 2018, pp. 280-284, doi: 10.1109/ISCID.2018.00070.

[10] S. R. Vijayalakshmi and S. Muruganand, "Fire alarm based on spatial temporal analysis of fire in video," 2018 2nd International Conference on Inventive Systems and Control (ICISC), 2018, pp. 104-109, doi: 10.1109/ICISC.2018.8399002.

[11] E. liu, "Research on Video Smoke Recognition Based on Dynamic Image Segmentation Detection Technology," 2019 12th International Conference on Intelligent Computation Technology and Automation (ICICTA), 2019, pp. 240-243, doi: 10.1109/ICICTA49267.2019.00058.

[12] C. Naimeng, Y. Wanjun and W. Xiaoyu, "Smoke detection for early forest fire in aerial photography based on GMM background and wavelet energy," 2021 IEEE International Conference on Power Electronics, Computer Applications (ICPECA), 2021, pp. 763-765, doi: 10.1109/ICPECA51329.2021.9362647.

*****