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Efficient Fire Detection through Video Surveillance: A Survey

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Abstract—

Fire is one of the most destructive forces that have been known to mankind. The fire has enabled a lot of technologies in a controlled format. But the uncontrolled and destructive fire has been the cause of large-scale destruction in various parts of the world. Fire needs to be contained effectively and timely, barring which can cause a significant amount of damage in a short time. There have been many researches that have been performed for the purpose of fire detection through video input from a live source. These related works have been identified and studied in detail for the formation of our approach. The traditional approaches towards fire detection have been analyzed for their merits and demerits. This is done to assist in improving our understanding of the fire detection procedures and essentially mitigating the flaws that are identified. Many of these research directions have not been up to the mark as it has not reached the desired accuracy in a stipulated amount of time. To overcome these limitations, an innovative approach for fire detection has been envisioned. The methodology for efficient fire detection through video surveillance will be elaborated further in the future publications of this study.

Keywords— *Fire detection, Image Morphology, Binarization, Fuzzy Classification*

I. INTRODUCTION

Fires are highly destructive and can cause a lot of damage as they start increasing in size and consuming material all around. Combustion through fire is complete and it creates a lot of smoke and Ash. The fire has the capability of spreading fast by being assisted through wind and combustible material. Forest Fires have been responsible for creating a lot of damage to the ecological well-being of an area by completely devastating and destroying everything in its path. Forest fires, especially dangerous, have the wreak Havoc on the inhabiting species as well as lead to large-scale removal of forest cover.

Fires can also happen in residential areas and houses. These fires are usually caused due to short circuits or mismanagement of the radiators or any other heating elements in the house. Fire can be highly difficult to predict and can also turn into a highly dangerous phenomenon that can lead to large scale loss of life and property in their wake. There are a lot of precautions that are put in place to reduce the incidence of fires in various different situations. Such as sprinklers and smoke detectors that are used to detect the signs of a fire and provide preliminary treatment of the fire so that it does not spread and gain a lot of power which can lead to very disastrous results. There are fire brigades in every major

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location in the city that respond to any fires so that it can be contained and prevented from spreading further.

Technological advances have also led to the creation of various different sensors that can be used for the purpose of detecting fire. But most of the sensors are not as accurate and should be used in a combination with each other to provide a somewhat accurate picture of a fire. The use of video surveillance can also help in the early detection of fire which can help in reducing the damage done by such fires. Image processing is a highly specialized concept that processes the image and content to provide insightful information automatically. This is done through the use of video footage that is converted into frames and fed to an image processing algorithm. The image processing algorithm processes the image to the use of machine learning and provides information about the condition of Fire if it exists or not. This technique is highly superior as there are already various cameras in place due to the security concerns that have been rising in the world.

The fire is measured as one of the vital and imperative assets. Identification of flame and fire using computerized monitoring methods such as video surveillance systems has been a significant consideration over the last decade. There are additional complexities in deciding whether the region identified as a flame is a flame or not. The main reason behind this is the continuous change in the colour of fire from red-yellow to nearly white. Multiple options like motion and shape of fire must be considered as the region of fire can't be detected solely by one feature color. Initial systems made use of only a few parameters for fire detection which detected the fire but it was not an accurate and precise way of fire detection. If all the parameters and its attributes are taken into consideration then it is possible to get the exact nature of fire i.e how much and where the fire is present. The traditional way of detecting fire makes mostly the use of sensors that sense the fire using fire parameters but the sensors require a certain amount of time to detect the presence of fire. But this technique takes more time to detect the fire and till then flames of fire may get converted to hazardous damage-causing fire which leads to a huge loss of properties.

Fires also occur in various forests and other dense vegetative areas. These fires are highly common in dense and hot regions such as California, Australia, etc. These forest wildfires are very deadly as they quickly increase in size. This is due to high combustible vegetative matter such as trees and leaves catching fire easily and the aid of the dense forest in the nearby spread of the wildfire extensively. These fires destroy a lot of wildlife and also lead to the displacement of large amounts of wildlife and other animals.

The wildfires are extremely difficult to detect as they occur in large patches of dense forests which can be highly inaccessible. The extensive connections required to set up a traditional fire detection system using sensors and other expensive equipment is not feasible. These sensors also need to be in the vicinity of the fire which requires an enormous amount of sensors as the forests spread across acres of land that are not practically viable.

Thus, a video-based fire detection system combats all such inconsistencies and provides viable improvements in the fire detection paradigm. The video method also covers a large area that can be effectively used to provide fire surveillance. This would also allow the fire departments to effectively perform mitigation procedures before the fire gets out of hand. The video-based fire technique allows much earlier detection of fire which is highly critical for combating such widespread destruction.

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Detecting fire does not only mean detection of the region for fire but it considers several sets of factors like increasing nature of fire, which are the components for fire causing, getting minute regions of fire, detecting the amount of fire, etc. With the use of a multi-expert system, the detection of fire is done in a fast as well as in an accurate manner. So the proposed system provides fire detection using a combination of three fire parameters: colour, motion, and shape in conjunction with the use of fuzzy logic.

II. RELATED WORK

D. Pritam introduces the fire detection systems that have been getting increased attention from various researchers nowadays. This is due to the fact that fires have been highly damaging and have led to large scale destruction on various events. Traditionally fire is detected using an array of different sensors such as heat temperature smoke etc. Some of these devices are highly expensive and have to be used in combination with other sensors to achieve high accuracy. Therefore, the use of video surveillance or vision-based fire detection techniques has been extensively useful and increased accuracy [1]. Therefore, the authors in this paper proposed an efficient and accurate fire detection technique that utilizes image processing in the LUV colour space to provide effective fire detection. The proposed methodology has been tested to achieve higher accuracy than the other techniques on the same platform.

S. Wu focuses on the major three problems: false detection, early fire detection, real-time, and forest fire detection. Faster R-CNN, YOLO, and SSD are some of the methods to detect the forest fire. The oldest and traditional methods are human observation which is labour-consuming and time-consuming. [2] Regression Tree (RT), Logitboost (LB), Adaboost (AB), Maximum Likelihood (ML), and Multi-Layer Perceptron (MLP) are the five segregation methods used for classification accuracy. As it is extremely important for real-time forest monitoring and safety of the forest.

S. Lei narrates that fire detection has been highly difficult and largely uncharted territory for various researchers working on image processing. Most of the conventional techniques that utilize image processing for fire detection have very little robustness and very low adaptability to interference [3]. Therefore, the authors in this Publication have proposed an improved fire detection technique that is based on utilizing consecutive frames and their centroid variety to effectively classify fire. The probable methodology utilizes the RGB-HIS color model for the purpose of identification of the flame. The proposed methodology is highly accurate and detects fire correctly.

H. Dang-Ngoc introduces the paradigm of utilizing unmanned aerial vehicles for fire detection through the use of aerial footage. Fires are highly dangerous and destructive and can be fatal to a lot of forest fire officials that get inside to have a closer look. Therefore, the utilization of UAV is useful for the purpose of wildfire surveillance. For this purpose, the researchers in this publication have designed a methodology for analyzing aerial video footage to detect fire in the forest [4]. The proposed methodology has been tested extensively and the experimental results indicate that the accuracy of the model is 93%.

S. Vijayalaxmi states that most of the fire detection systems that are utilized are not highly accurate and often result in fake fire detection. Most of this is due to the fact that the various sensors can sometimes provide garbage values that cannot be trusted [5]. The authors in this paper outline an efficient fire alarm system that utilizes video frames as input for the detection of Fire. The proposed

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methodology utilizes Spatio-temporal features and motion information to identify fire effectively. The experimental results indicate that the fire alarm is highly accurate and a much better system than the conventional sensor system.

D. Zhang explains that real-time fire detection has been a challenge for various reasons such as the reaction time of various sensors and algorithms that are used to combine the data and process it. Therefore, the use of video sequence data is very useful for the detection of fire effectively [6]. Thus, in this Publication, the authors have utilized contour shaping information along with pixel value variation in fire video sequences for detection of fire in real-time. The authors employed hidden Markov models for eliminating the false positives in the fire detection system. The experimental results indicate that the proposed methodology produces promising results in the fire detection paradigm.

X. Xu explains that kitchens are the main source of family fires fuel leakage is also one of the central causes of fire and explosion incidents and also fire due to the improper utilization of different electrical equipment found in the kitchen. [7] In the proposed paper the author introduces a realized fire test bench for fire hazard testing. Temperature is the main parameter to measure the kitchen fire probability on the test bench. K-type thermocouples are utilized to calculate the temperature of various points in the kitchen. Thus the result of the proposed paper extracts a methodology for the prevention and detection of kitchen fire.

Shuchao Li narrates how the amount of buses in China is increasing every year. Arson, malfunction, traffic accidents are one of the main reasons for the fires in buses. The availability of an extinguishing system through the use of water mist depended on the type of fire in the bus. The compressed gas in the canister issues power for the agent flowing. [8] Utilization of water mist in the vehicles was quantified through a large scale test by using the fire extinguishing efficiency. Fire retardant chemicals or other ingredients are usually provided to the water to increase the capability.

Ke Chen explains there are a lot of fires reported across the world in the recent year. The fires cause a lot of problems such as there has been an increase in the damages and the loss occurred to the lives and property worldwide. [9] Therefore, to eliminate these problems and reduce the impact and the frequency of fires across China, the authors have proposed the use of a video based approach to detect fires. The proposed technique has been quantified through the use of various experimentations to achieve satisfactory results.

X. Xiang elaborates on a vision-based fire detection system as it is one of the most popular systems than the traditional fire detection system. The detection of fire using vision has been one of the recent developments in the paradigm of fire detection. This is due to the fact that vision-based techniques are useful for enabling effective fire detection in a constrained environment. The detection of fire is achieved through the effective use of color detection of the fire and motion of the smoke and flames. [10] The authors in this paper have analyzed a collection of fire detection techniques and proposed an effective approach using the LUV color space.

Z. Jiao elaborates on the problems that are faced by wild detecting fire in a forest. The forest is a rapidly changing landscape where a lot of dense shrubbery trees and animals have got a lot of movement. This movement is highly difficult to predict and model into a fire detection system. Therefore, the authors in this paper discuss effective object detection techniques that can help detect forest fire in real-time [11]. The real-time protection of forest fire would allow for effective and timely

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remedial measures to be taken to reduce the damage done by the Fire. The proposed technique has been tested extensively to yield promising results.

O. Giandi narrates the smart home technology in recent times which makes it easy for a person to work and increases convenience. One of the most essential home automation functions is fire detection and alert. [12] To reduce the occurrences of the large amounts of fire and save property and lives the symptom detection of fire in the house is important. In the proposed system researcher applies a prediction of fire and the appearance of fire through the detector by using these new systems for fire detection. The system gives an alert after gas leak concentration is detected.

III. ALGORITHMS AND TECHNIQUES USED

1. *RECURRENT NEURAL NETWORK(RNN)* -

It is a type of neural network where these deep learning algorithms save the output of processing nodes and input the result into the model. It includes loops within the network; this gives it a memory effect, but training these recurring neural networks in particular is very expensive.

2. *FUZZY DECISION TREE* -

The decision tree approach is one of the most useful and highly regarded classifiers that are used for effective classification of various attributes. But the decision tree approach is limited as it only assigns truth or false values for the classification purpose. This is a hard segregation that is highly difficult to mimic the real life consequences. Real life does not contain hard values of truth and falseness. Therefore the combination of the fuzzy crisp values which provide a range of values between the truth and false values for effective and complete segregation.

3. *IMAGE BINARIZATION* -

Image binarization approach is an effective technique for fire detection as it allows the detection of fire regions in the image effectively. This reason can be identified with high accuracy as most of the fires are highly bright due to the release of radiant energy. This is captured as a very bright portion of the image that can be effectively identified through image processing approaches. This bright spot is useful in the conversion of the image as the bright spot is coloured White and the background which is dark colour is converted into black. This technique highlights the fire and converts the image into a grayscale image forming an outline of the fire which can now be easily utilized for detection of fire.

4. *TEMPORAL DIFFERENCE* -

Temporal Difference is the difference between the images which can be utilized to achieve an effective understanding of the motion in the images. The temporal difference is useful for the detection of the motion which is useful for the detection of fire effectively.

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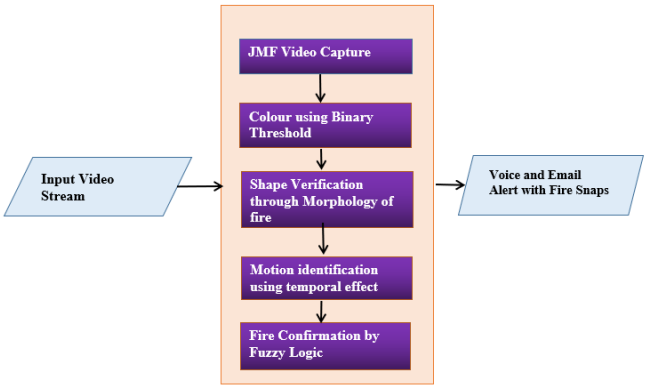

Fig. 1 Block Diagram

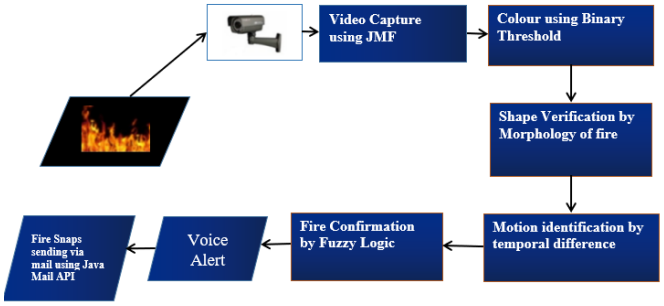

Fig. 2 Overview Diagram

IV. PROCEDURE TO BE IMPLEMENTED

First of all, the video is captured using JMF.
Then we perform image binarization.
After that motion identification is done using temporal difference between frames captured.
Shape verification by morphology of fire means the shape of fire is verified.
Then we perform fire confirmation by using fuzzy logic technique.
After confirmation of fire,there will be a fire alert as well as images of fire will be sent to the owner.

V. CONCLUSION AND FUTURE SCOPE

The presented approach for the purpose of fire has been implemented successfully through the use of a highly accurate fire detection system. A collection of related works based on the fire detection paradigm using video have been analyzed in this research article. These works have been detailed and their various advantages and limitations have been studied. This has been attempted to study the conventional approaches towards the fire detection paradigm. As it allows for a much better understanding of the current scenario for fire detection, as well as enables us to identify the various shortcomings that can be significantly improved upon in our approach. Therefore, after the thorough

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analysis of the traditional approaches, this research paper concludes that the fire detection paradigm needs an improvement. There have been various inconsistencies that have been identified such as low accuracy of detection along with a large number of false positives. Some of the methodologies with better accuracy suffer from increased computational and time complexities that need to be managed effectively.

For future research prospects, an effective approach towards fire detection has been envisioned. Our approach for fire detection will be expanded further and defined in the utmost detail in the upcoming editions of this study.

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