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# *A Comprehensive Study on Fire Detection*

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*Abstract* **--Accidents due to undetected fire have caused the great cost to the world. The need for efficient fire detection system is rising. Existing fire, smoke detectors are failing because of the inefficiency of the system. A vision based system with the video surveillance fire detection system is proposed to have high detection rate and low fault alert rate. Real-time fire detection is achieved by analyzing live camera footage. The fire flame features are studied and using edge detection, thresholding methods fire is detected, thus establishing a fire detection model. It uses color, motion, shape, and texture of the fire to detect hazardous fire. Color models like HSV, YCbCr are used in the system for more effective detection. It can be used for both indoor and outdoor scenes.**

***Keywords-- Video surveillance, VFD, Edge detection, denoising, thresholding, background subtraction, LBP, segmentation, RGB color model, YCbCr color model, color classification, texture classification, region merge.***

## I. INTRODUCTION

Fire is a critical environmental problem. So, Fire flame detection is one of the main issues in the security system. Conventional fire detection method uses employees to monitor the domain or implement mechanical devices. The most usually used technique is smoke detection. The chemical properties of smoke sensed by the sensors and raise the alarm. This can also cause false positive alarm. The alarm is not triggered until the smoke reaches near the sensors and activate them. These detection techniques are developed as part of the early warning mechanism. The sensor- based detection system is impractical in a large coverage area. In order to improve the detection of fire in real time and manage false positive alarm a vision based fire detection system is necessary. It acts as a standalone system. Early detection of fire is essential for the prevention of disasters. The main goal of VFD is high detection rate and lower false alarm rate. It will also apply to both day and night monitoring.

We find that it is essential to install a fire extinguisher in every building because of the government norms. When a fire breakout, which would detect the fire automatically, then directly trigger the warning alarm as well as send a warning message to the monitoring system and finally it will turn on the extinguisher based on the direction of the fire is spreading. Image processing has an important role in the detection of fire in an efficient manner based on the output.

Fire detection is essential for the safety of computer vision-based fire detection(VFD). Image processing is the main principle. Detection can be done by extracting the image features such as color, motion, shape, size, and texture. Smoke is the good identifier of fire. Nowadays, CCTV is installed in many public places for survey purpose. Now we use CCTV for fire detection. But the CCTV is not as much intelligent for detecting fire. Therefore, we need to train the system to identify the fire by advanced algorithms. Once the system has to identify the fire then it can trigger out the alarm. The system will also identify the intensity and volume of fire. This VFD technique can detect large hazardous fire at its early stage and help to prevent the disasters. There are several methods to detect fire using VFD.

The remaining of this paper is organized as: Section II briefly discussed about the methodology for fire detection, in section III presents different fire detection methods, Section IV describes comparative study of the methods & finally, Section V concludes this study.

## II. METHODOLOGY

The fire detection is a multistage process. The main stages of fire detection that are common for all the papers are (A) Pre processing, (B) fire detection, (C) Feature extraction, (D) Classification.

### *A. Pre Processing*

Pre processing is the first stage of both analog and digital

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image processing. In the preprocessing stage we prepare the input image more adaptive for processing, i.e, makes the image in standardized form. The input image may have various disturbances such as noises, illumination variation, moving background object etc. So the first step of fire detection system is to standardize the image, which involves the removal of noise, Contrast enhancement, illumination equalization and color conversion of image.

### *B. Fire Detection*

After pre processing our next intent is to detect the foreground for further processing. The background subtraction and edge detection are the most common technique used for fire detection. There are several edge detection techniques such as canny, laplacian, kirsh, prewitt and sobel. The canny is the efficient edge detection technique for fire detection.

### *C. Feature Extraction*

The features extracted from an image describe the visual properties as numerical measurement. Feature extracted in the pre-processing step, that segments the image and detects the boundary. One of the common feature in image processing is texture. The widely used feature extractions are Gabor fitters, Local Binary Patterns (LBP) & Haralick.

### *D. Classifier*

This stage classifies the feature that are taking out by the feature extraction to the respective classes. Neural Network and Nearest Neighbor are common methods for classification.

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## III. DIFFERENT METHODS FOR FIRE DETECTION

### *A. Advance algorithm for fire detection using image processing and color recognition*

An advanced algorithm for fire detection, by computing the nature of the fire was proposed by Patil A.D et al.[1]. The region of fire produce a nested ring structure of colors, changing from white to yellow, orange and red. By all these information's we have to detect the color edge. The color edge detection algorithm composed of four components. (1) Smoothening by adaptive median filter: - this filter helps to remove non-impulse noise without loss of information of the original image. Algorithm for adaptive median filter consist of two levels,

LEVEL A: -if Xmin<Xmed< Xmax

(Xmed is not impulse noise)

Go to LEVEL B

(to test if Xxy is impulse)

Else (Xmed is impulse

noise)

Increment the window size

If window size < max window size

Repeat LEVEL A

Else

Output

Xxy

LEVEL B: -if Xmin < Xxy < Xmax

(Xxy is not an impulse)

then Output is Xxy

Else (Xxy is either Xmin or Xmax)

Output is Xmed

(2)Directional color difference calculation: -The transformed values of each pixel is calculated by the weighted sum of RGB components.

Pixel(a,b)= 2*red(a,b)+3*green(a,b)+4*blue(a,b) (1)

The color difference in an image must be pointed out in four directions. So we have four 3*3 directional masks corresponds to the four directions which reduce the overhead in color difference calculation. The directional mask moved over the transformed values for each pixel for color difference calculation. (3)Threshold technique:-it is very important task in color edge detection algorithm. Here they use a single threshold value T. Observe the edge maps for a set of selected image, then take the threshold value which is acceptable. (4)Edge thinning:-It is applied to create more accurate thin edges with convolution mask.

We analyzed the static and dynamic nature of fire and proposed a detection algorithm based on the integration of spatio-temporal information in the image. This paper depend on color information and temporal variations in the pixels empirical parameters. To overcome this limitation an adaptive background subtraction model is introduces.

### *B. Experimental study of video fire detection and its applications*

Arthur K.K Wong and N.K Fong [2] has implements segmentation and recognition algorithm using video flame detection analysis. Here they use bitmap file format.

The detection is done in two steps – segmentation and recognition (1)Segmentation: -It is the process of separating objects and domain from grayscale color images. They use

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otsu's threshold segmentation method. The segmented image comprises only 0(black) and 1(white).Black indicates image foreground (flame shape) and white indicates background. The threshold value can be obtained by multi-threshold algorithm of otsu's method[2]. (2)Recognition: -After successful image segmentation, ensure that the detected image is non- flame image or flame image. For this recognition purpose, they use the nearest neighbor algorithm which requires centroid values. The NN algorithm is based on Euclidean distances.

Using the fire flame characteristics such as shape height, intensity, flame color and flicker frequency that improves the segmentation and recognition algorithm .Also introduce the tracking and predict the direction of flame spread.

### C. *Investigation of a Noval Image Segmentation Method Dedicated to forest fire applications*

S.Rudz et al.[10] proposed another method for the recognition of fire based on clustering. They compute four clusters using the component of Cb of YCbCr. The lowest value of Cb refers fire domain. Then they cancel false positive pixel by comparing reference pixel. This method can apply in both small and large domain, small domains are analyzed with the mean value of reference region and the proximity of large region are analyzed by referred histogram. This process is done in each RGB color channel.

Total six parameters are used, three constant values are set for the small region and the remaining parameters are taken as threshold value large region.

### D. *BoWFire: detection of fire in still images by integrating pixel color and texture analysis*

Daniel Y.T.Chino et al.[9] they proposed a method to detects fire in still images by using the advantage of color and text. It is done by two modules: pixel color classification and texture classification .On super pixel regions use of color is a traditional approach, use of texture is the promising which distinguish actual fire and fire like domain.

The method consists of 3 basic steps:(1)Color classification, it is done by Naïve Bayesian Classifier. It can avoids the need of a great number of parameters. An image with n pixel in RGB color space is converted to YCbCr color space. Then each pixel in YCbCr color space is served for pixel-color classification. if the pixel is detected as fire then the pixel is used to build the output image Icolor, otherwise the pixel is discarded. (2)Texture Classification, it can be done by LBP. Simultaneously, a set of superpixel of the image is generated by superpixel method. Each superpixel is passed to a local Feature Extraction process. Then the resultant vector is classified using a Feature Classification and the output is compared with the fire features. If it is detected as fire, all pixels belongs to the superpixel are used to build the output image Itex, otherwise they are discarded. (3) Region merge:
- The output from the two classifications are necessary to merge. According to their hypothesis, if a pixel is simultaneously considered as fire, then there is a chance that the pixel is actual fire. A pixel is added to merged output only if it was detected as fire in both classifications otherwise it discarded.

The first two steps occur parallel in which fire classified pixels are marked to produce images. BoWfire thus helps to dismiss false-positives for the image. This method is based on classification methods, rather than mathematical modeling. Here only three parameters to solve the problem.

### E. *Fast And Efficient Method For Fire Detection Using Image Processing*

Turgey Celik et al.[3], discussed a new image based real-time fire detection. he proposed algorithm which consist of three main stages (1)Fire pixel detection using color information, detecting the moving objects, and analyzing dynamics of moving fire pixels in consecutive frames. This et al.[3] algorithm models the fire pixels using CIE L*a*b* color space. It is perceptually uniform color space. So it make possible to represent the fire color information better than other color space. The moving objects are detected by background subtraction algorithm [5] together with a frame differencing algorithm to separate the moving pixels from non-moving pixels. If the moving pixels is detected as fire pixel then they further analyzed inconsecutive frames to raise a fire alarm. The proposed fire color model gave a recognition rate of 99.88%. The proposed system can be further improved by considering smoke for early stages of fire, but the system might not be able to recognize a fire by a sudden explosion.

## IV. COMPARITIVE STUDY

In this paper, fire detection by using various methods is discussed. The Table I list out the results obtained by different methods. It also includes the future scope of each method.

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Table I.LITERATURE SURVEY OF DIFFERENT METHODS OF FIRE DETECTION

| SL NO | AUTHORS | TECHNIQUES/METHODS | ADVANTAGES | FUTURE SCOPE |
|---|---|---|---|---|
| 1 | Patil A.D, Kuwar K .R, More M.S, Pagar P.A and Somawanshi S. D | • Advance algorithm for fire detection using image processing and color recognition | • The detection algorithm can identify the position of flame accurately.<br>• This can be applications for complex environment. | • This method depends on the temporal variations in the pixel using empirical parameters.so, to improve the proposed system by using an adaptive background subtraction model. |
| 2 | Arthur K.K. Wong, N.K.Fong | • Experimental study of video fire detection and its applications | • The proposed algorithm capable to overcome the segmentation problem. | • Improve the segmentation recognition algorithm by flame characteristics such as brightness, flame, shape, and height and flickers frequency. It helps to assignment the accuracy of recognition.<br>• This method also can be improved by tracking & production of flame spread. |
| 3 | S.Rudz, K.Chetehouna, A.Hafiane, H.Laurent, and O.Sero-Guillaume | • Investigation of a Noval Image Segmentation Method Dedicated to forest fire applications | • It is applicable for both indoor and outdoor applications | |
| 4 | Daniel Y.T.Chino, Letricia P.S Avalhais, Jose F.Rodrigues Jr,Agma J.M.Traina | • BoWFire: detection of fire in still images by integrating pixel color and texture analysis | • It works on still image processing and reduce false-positive result.<br>• The proposed method also reduces the number of parameters. | • The proposed system can be improved by detecting smoke |
| 5 | Turgay Celik | • Fast And Efficient Method For Fire Detection Using Image Processing | • The proposed fire color model reached detection rate of 99.88%. | • The performance of the system can be improved by considering smoke for early detection of fire |

## CONCLUSION

In this survey paper, a variety of fire detection methodologies are discussed and analyzed. The MATLAB software is used to resolve the different techniques. The performance of the existing Fire detection system seems to be low. So, a combination of fire detection algorithm is proposed for high efficiency and low false alarm rate. Hence, such models recognize fire in any environment and the intensity, direction of the fire is also calculated for the accurate and fast

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response. The system requires less hardware for fire detection which makes it cost- effective and reliable. From the comparative study we can conclude that ,the fire pixel using CIE L*a*b* color space model is fast and efficient method for fire detection using image processing. This color model reached the recognition rate of 99.88%. It can be improved by considering smoke for early detection of fire.

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