OPTIMIZED FLAME DETECTION USING IMAGE PROCESSING BASED TECHNIQUES

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Abstract

Present work is an in depth study to detect flames in video by processing the data captured by an ordinary camera. Previous vision based methods were based on color difference, motion detection of flame pixel and flame edge detection. This paper focuses on optimizing the flame detection by identifying gray cycle pixels nearby the flame, which is generated because of smoke and of spreading of fire pixel and the area spread of flame. These techniques can be used to reduce false alarms along with fire detection methods . The novel system simulate the existing fire detection techniques with above given new techniques of fire detection and give optimized way to detect the fire in terms of less false alarms by giving the accurate result of fire occurrence. The strength of using video in fire detection is the ability to monitor large and open spaces. The novel system also give the opportunity to adjust the system by applying different combination of fire detecting techniques which will help in implementation of system according to different sensitive area requirement.

***Keywords*:** Fire detection, Video processing, Edge detection, Color detection, Gray cycle pixel, Fire pixel spreading.

1. Introduction

Fire detection system sensors are used to detect occurrence of fire and to make decision based on it. However, most of the available sensors used such as smoke detector, flame detector, heat detector etc., take time to response [1]. It has to be carefully placed in various locations. Also, these sensors are not suitable for open spaces. Due to rapid developments in digital camera technology and video processing techniques, conventional fire detection methods are going to be replaced by computer vision based systems. Current vision based techniques mainly follow the color clues, motion in fire pixels and edge detection of flame. Fire detection scheme can be made more robust by identifying the gray cycle pixels nearby to the flame and measuring flame area dispersion.

2. Overview of fire detection

This section covers the detail of the previously proposed fire detection methods. It is assumed that the image capturing device produces its output in RGB format. During an occurrence of fire, smoke and flame can be seen. With the increasing in fire intensity, smoke and flame will be visible. An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.So, in order to detect the occurrence of fire, both flame and smoke need to be analyzed. Many researchers used unusual properties of fire such as color, motion, edge, shape. Lai et al. [7] suggested that features of fire event can be utilized for fire detection in early stages. Han et. al. [5] used color and motion features while Kandil et al. [2] and Liu et al. [6] utilized shape and color features to detect an occurrence of fire.

2.1. *Edge detection*

Edge detection method is used to detect the color variance in an image. The edge detection system compares the color difference and provides an edge based on it. From this edge detection the output provides a shape of flame. From the work [9] we get the Eq. (1), Eq. (2) and Eq. (3) which show how to find the edge in an image.

To detect vertical edges,

$$Ex_{x,y} = | P_{x,y} - P_{x+1,y} | \qquad \forall x \in 1,N-1;\ y \in 1,N \qquad (1)$$

To detect horizontal edge

$$Ey_{x,y} = | P_{x,y} - P_{x,y+1} | \qquad \forall x \in 1,N;\ y \in 1,N-1 \qquad (2)$$

Combining Eq. (1) and Eq. (2), new Eq. (3) that can detect vertical and horizontal edges together is formulated.

$$Ex_{x,y} = | 2xP_{x,y} - P_{x+1,y} - P_{x,y} +1 | \qquad \forall x,y \in 1,N-1 \qquad (3)$$

2.2. *Color detection*

A fire is an image can be described by using its color properties. This color pixel can be extracted into the individual elements as R, G and B, which can be used for color detection. Noda et al. [8] have used R and G elements and find out that there is a correlation between G/R ratio and temperature distribution, where as temperature increases, G/R ration also increases. So, due to this, color of flame can provide useful information to guess on the temperature of a fire and also fire phase. In terms of RGB values, this fact corresponds to the following inter-relation between R, G and B color channels: $R > G$ and $G > B$. The combined condition for the fire region in the captured image is $R > G > B$. Besides, R should be more stressed than the other components, because R becomes the dominating color channel in an RGB image of flames. This imposes another condition for R as to be over some pre-determined threshold, RT . However, lighting conditions in the background may adversely affect the saturation values of flames resulting in similar R, G and B values which may cause non flame pixels to be considered as flame colored. Therefore, saturation values of the pixels under consideration should also be over some threshold value. All of these conditions are summarized in the following composite condition [3]:

Condition1: $R > RT$
Condition2: $R > G > B$
Condition3: $S > (255 - R) * ST / RT$

where ST is the value of saturation when the value of R channel is RT. If both of the three conditions are satisfied for a pixel, then that Pixel is considered as a fire colored pixel. As it is known, the saturation will decrease with increasing R value. This is formulated in the term (255-R)*ST /RT . In fire color classification, both values of *RT* and *ST* are defined according to various experimental results, and typical values range from 40 to 60 and 170 to 190, for *ST* and *RT*, respectively.

2.3. *Motion detection*

Motion detection is used to detect any occurrence of movement in a video. It is done by analysing difference in images of video frames. There are three main parts in moving pixel detection: frame/background subtraction, background registration, and moving pixel detection[10].

The first step is to compute the binary frame difference map, by thresholding the difference between two consecutive input frames. At the same time, the binary background difference map is generated by comparing the current input frame with the background frame stored in the background buffer. The binary background difference map is used as primary information for moving pixel detection.

In the second step, according to the frame difference map of past several frames, pixels which are not moving for a long time are considered as reliable background in the background registration. This step maintains an updated background buffer as well as a background registration map indicating whether the background information of a pixel is available or not.

In the third step, the binary background difference map and the binary frame difference map are used together to create the binary moving pixel map. If the background registration map
indicates that the background information of a pixel is available, the background difference map is used as the
initial binary moving pixel map.It is done by analyzing a different between two consecutive images. Ko et al.
[4] assumed that,

$$DiffF \; . \; . \; _n \; . \; k,1 \; \tilde{.} \; X_n[k,1] \; . \qquad (4)$$

$$_n \; . \; k,1 \; . \; . \; . \; _n \; . \; k,1 \; \tilde{1} \; .. X_n \; . \; k,1 \; . \; \{ \; \text{If } DiffF < t$$

$$X_n \; . \; k,1 \qquad . \qquad . \; . \; \text{else}$$

Xn[k,l] is the intensity value at location *k,l* in the nth frame while *Bn* is background intensity value at the same pixel position. *DiffF* is frame difference, where it finds the difference between an image and previous image as in equation (4). . is weight value-real number between 0 to 1 and *t* is the threshold value assigned.

3. Proposed technique

The aim of this paper is to develop an identification system to detect an occurrence of fire based on the video image. In this paper, we use flame properties to conduct the fire detection as shown in Fig. (1).

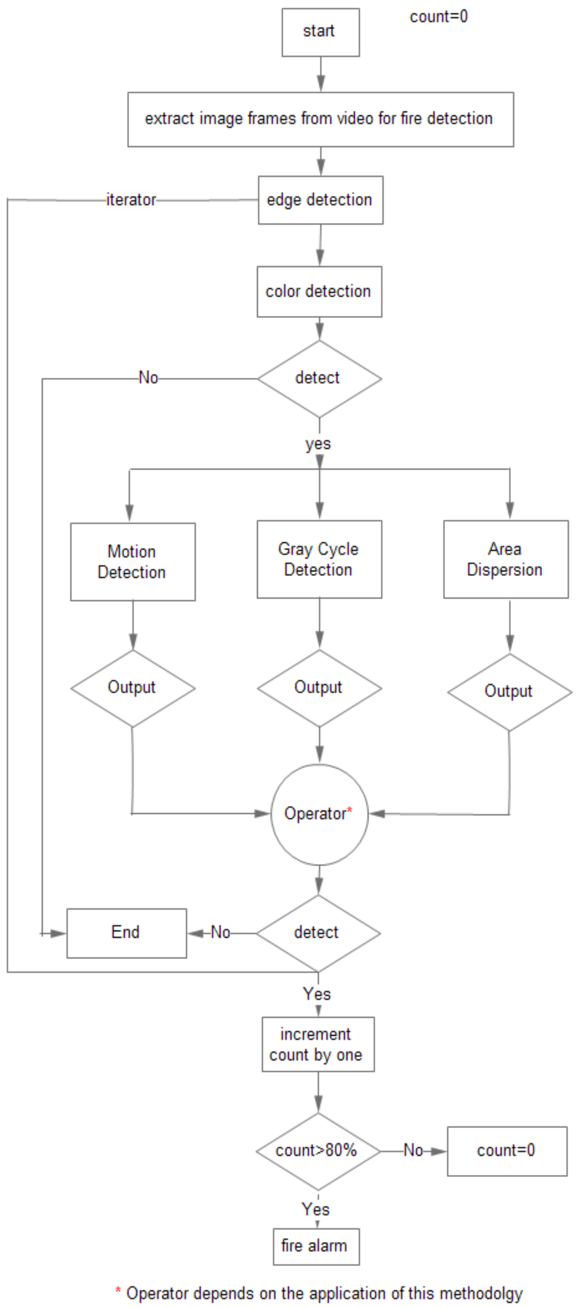

Fig. 1. Proposed fire detection system.

Specified operator gives us the flexibility to use different combinations of detection methods .so that, we can implement the system according to the specific requirements of use. For example:

(1) For highly sensitive area, we can apply the OR gate (||) operator. So that the system will prompt for fire, if any of the method will detect the occurrence.

(2) For general purpose, we can apply the combination of any two methods. So that the system will prompt for fire, if at least two methods will detect the fire.

(3) For Less sensitive area, we can apply the AND gate (&&) operator. So that the system will prompt for fire, only if all methods will detect the fire.

4. Methodology

The purpose of this paper is to develop an optimized system to detect an occurrence of fire based on video images. In this project the authors use the previously proposed methods to conduct the fire detection and propose new techniques to implement in parallel. That would give more optimized results in detection of flame. In developing the system the following stages are involved.

4.1 Edge detection

Edge detection method is used to detect the color variance in an image. Block Diagram of Edge Detection System is as in Figure 2. Using MATLAB/Simulink, an Edge Detection model is built based on this block diagram.

Fig. 2. Block diagram of edge detection system.

Fig. 3(a) Original image.

Fig. 3(b). Image after applying edge detection.

Fig. 3 (a) shows the original frame i.e frame 1 and the Fig. 3 (b) which is the result of the detected edge of this image. The edge detection system compares the intensity difference in the image and provides an image with black and white color space where high intensity area is filled with white color and low intensity area is filled with black color. The intensity difference is categorized using a global intensity threshold which is separately calculate for each image by MATLAB/Simulink, the output will provide a shape of the flame. Thus, the edge detection can be used to analyze color detection of fire.

5. Proposed Algorithm

The algorithm is based in the fact that visual color images of fire have high absolute values in the red component of the RGB coordinates. This property permits simple threshold-based criteria on the red component of the color images to segment fire images in natural scenarios. However, not only fire gives high values in the red component. Another characteristic of fire is the ratio between the red component and the blue and green components.
An image is loaded into color detection system and mapped with the extracted edge detection image. Color detection system applies the specific property of RGB pixels and give the output result as an image with a selected area of color detection. Fig. (4) shows the detected fire pixel area.

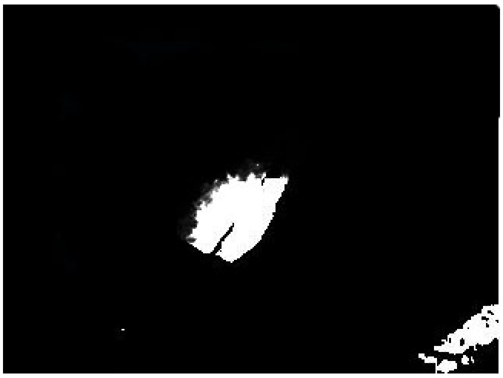

Fig. 4. Detected fire pixel area.

Color detector use the original image for color detection and give the corresponding binary image with probable fire pixel area. After getting the output from the color detection we can apply different detection techniques by mapping these detected coordinate on its corresponding original image with different combinations. We have three techniques to implements further.

- Motion Detection
- Gray-cycle pixel detection
- Area dispersion

5.1. *Motion detection*

Motion detection is used to detect any occurrences of movement in a sample video. Block diagram of motion detection system is as in Figure 5. Using MATLAB/Simulink, a motion detector model is built based on this block diagram.

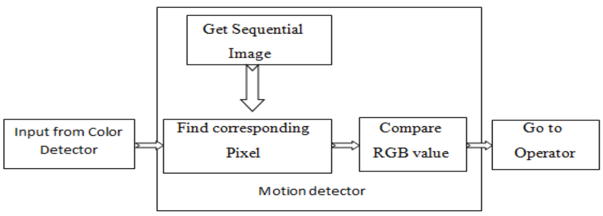

Fig. 5. Block diagram of motion detection.

We took two sequential images from video frames. After applying basic two methods edge detection and color detection we get probable area of fire pixel then we compare the RGB value to of frame1 to the frame 2 for corresponding pixel and if pixel value differs then motion detector will show motion and will give resultant output to the operator.

Fig. 6(a). First frame.

Fig. 6(b). Second frame.

In fig. 6(a) and 6(b) frame 1 and frame 2 are sequential images and after mapping the corresponding pixels in both of the frames, motion detector compares R, G, and B value of corresponding pixels and give the resultant output to the combination of operator.

5.2. *Gray scale pixel detection*

Gray-cycle detection is used to detect occurrences of smoke pixel in the selected area which is half above the area, detected by color detection method. Block diagram of gray-cycle detection system is as in Fig. 7. Using MATLAB/Simulink, a Gray-cycle detector model is built based on this block diagram.

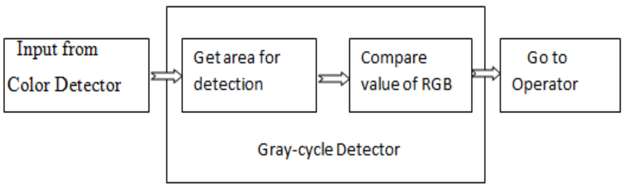

Fig 7. Block diagram of gray cycle detection.

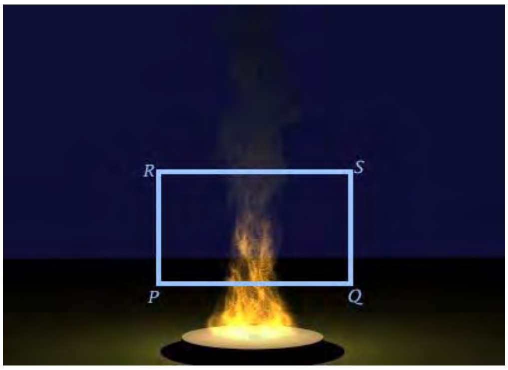

Fig. 8. Area for gray cycle detection.

The method we are going to apply on the area (PQRS) and the area of fire pixel which we get from edge and color detection method. Gray-cycle pixel have some properties in terms of RGB. This method will check these properties inside this area(PQRS) and then provide result to the operator.

5.3. *Area dispersion*

Area detection method is used to detect dispersion of fire pixel area in the sequential frames. Block diagram of area detection System is as in Figure 9. Using MATLAB/Simulink, a Area detector model is built based on this block diagram.

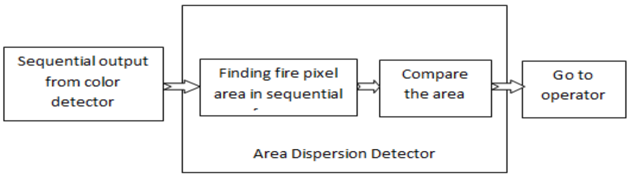

Fig. 9. Block Diagram for Area Dispersion

In this method, We took two sequential images which comes out from color detector then we check dispersion in minimum and maximum coordinate of X and Y axis, acquired from color detector.

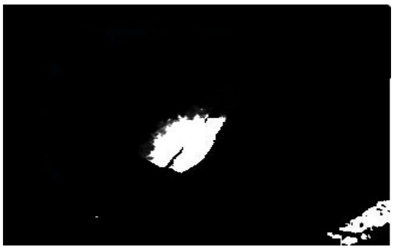

Fig. 10(a). Area detected in frame 1.

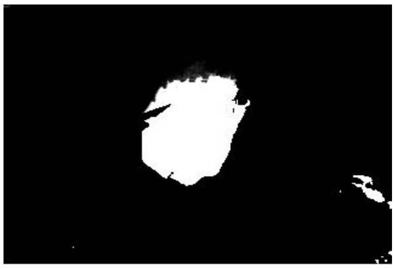

Fig. 10(b). Area detected in frame.

In this method we are comparing fire pixel area of two sequential frames as shown in Fig. 10(a) and Fig. 10(b) on the basis of minimum value of x & y and maximum value of x & y. In case of fire, if any extreme value of x and y axis will increase for next frame i.e frame 2, then there is area dispersion takes place and system will provide output to the operator. After that operator will perform operation on the basis of logic combination selected by the system.

6. Conclusion

We collected a number of sequential image frames from two original created videos which consist both fire and non-fire images. All the fire images are detected by our fire detection system and also by existing fire detection system. We have observed the difference in false alarm detection where the non fire images have been detected as fire images.

Table 1 shows that number of false alarm detection over non fire image. i.e. (19/104 means out of 104 non fire images system prompt fire for 19 images).

Methods	No. of Faulty detection	System Performance
Color Detection(by RGB color Pattern)	(19/104) = 18.26%	81.74%
Motion Detection(by comparing pixel coordinate)	(17/104) = 16.34%	83.66%
Gray cycle detection(by differencing between RGB value)	(13/104) = 12.50%	87.50%
Area Dispersion Detection(by checking deviation in area)	(10/104) = 9.61%	90.39%
Proposed Fire Detection System(by using above techniques)	(08/104) = 7.69%	92.31%

Table 1.Result that were achieved on implementing the methods on video frame.

Result shows that the system performance for fire detection comprising of only off color detection is 81.74%, comprising both of color and motion detection is 83.66%. When these methods are combined with gray cycle detection the system performance is 87.50% and when comprising of area dispersion the system performance is 93.39%. Finally when we apply the proposed fire detection system methodology by using all above techniques in combinational manner, the system performance is 92.31%. Thus application of proposed fire detection system gives us a better system performance in term of less false alarm and thus a higher system performance is achieved. Accuracy can also be further increased by applying different efficient algorithm in each phase of detection. More ever the system is more reliable in reefing the result comes out from existing detection methods.

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