Multi-Feature Based Fire Detection Using Video Image Processing

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Abstract: ***As fire is one of the great threats for human security fire detection systems are one of the most important components in surveillance systems used to monitor buildings and environment as part of an early warning mechanism that reports preferably the start of fire. It is very challenging for conventional fire detection systems to provide fire protection for large industrial applications and atria, such as power plants and petrochemical processing plants, shopping malls, churches, hotels, office buildings, and airports. Present work is an in depth study to detect flames in video by processing the data captured by an ordinary camera. The proposed method analyzes the frame-to- frame changes of specific low-level features describing potential fire regions. These features are color, randomness of fire area size, fire boundary roughness and saturation. Because of flickering and random characteristics of fire, these features are powerful discriminants 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.***

Keywords: Video processing, Fire detection, Color detection, Motion detection, Edge Detection

1. Introduction

Fire is one of the most common and harmful disaster hence with the increasing fire losses, people come to realize the importance of detecting fire in its initial stage. It is the prerequisite condition for making full use of the method of fire extinguishing, decreasing fire loss, keeping life safety and keeping property undamaged. Therefore research workers all over the world all try to study new techniques to realize early detection of fire accurately and quickly. Fire is a process of combustion that brings disaster. It becomes harmful when fire loses control and spreads about.

In traditional 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 . 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. Also cameras can detect and pinpoint fire from long distances as soon as the fire starts, allowing the fire to be dealt with before it gets out of control. Furthermore, cameras can cover very large areas, potentially mitigating their high cost compared to other fire detection technologies. Video-based fire detection even has the potential to be placed on mobile platforms such as planes and robots.

As fire has distinctive features such as color, motion, shape, growth, and smoke behavior fire detection is possible by using the color clues, motion in fire pixels, saturation and edge detection of flame

2. Overview of fire detection

Since fire is a complex but unusual visual phenomenon, we decided upon a multi-feature-based approach for our algorithm. The hope and the goal of such an algorithm is to find a combination of features whose mutual occurrence leaves fire as their only combined possible cause. As fire has distinctive features such as color, motion, shape/geometry, growth, and smoke behavior. For this project we focused on features such as color, motion, shape, saturation and density.

2.1. Color Detection

The fire has very distinct color characteristics, and although empirical, it is the most powerful single feature for finding fire in video sequences. Based on tests with several images in different resolutions and scenarios, it is reasonable to assume that generally the color of flames belongs to the red-yellow range. Laboratory experiments show that this is indeed the case for hydrocarbon flames, which are the most common type of flames seen in nature. It is noticed that for a given fire pixel, the value of red channel is greater than the green channel, and the value of the green channel is greater than the value of blue channel[5].

And its relation is given as,

$f_{R\,(m,n)} > \bar{f}_R$

Where, f_R is the red channel representation of f and $\bar{f}_R$ is the average pixel value of f_R . In addition,

$f_R(m,n) > f_G(m,n) > f_B(m,n)$

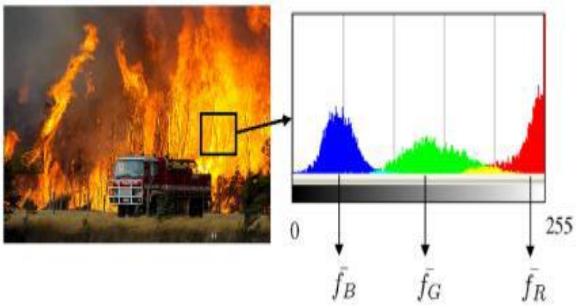

Figure 1: Histogram of a fire region.

2.1.1 Method 1

Color pixel can be extracted into the individual elements as R, G and B, which can be used for color detection and using correlation between G/R ratio and temperature distribution, i.e. 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[2][5].

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 :

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].

2.1.2 Method 1I

YCbCr color space is chosen intentionally because of its ability to separate illumination information from chrominance more effectively than the other color spaces. The rules defined for RGB color space in order to detect possible fire-pixel [1-3] or smoke-pixel candidates can be transformed into YCbCr color space and analysis can be performed [3].

2.2. Motion Detection

Motion detection is used to detect any occurrence of movement in a video. It is done by analyzing difference in images of video frames. There are three main parts in moving pixel detection: frame/background subtraction, background registration, and moving pixel detection [2].

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 or frames.

Figure 2(a): First frame

Figure 2(b): Second frame

In fig. 2(a) and 2(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.

2.3. Edge Detection

Along with color and motion in early stage of fire the edge variation of flame is different with other hot objects, and the flame edge is prone to dither. The edge information can be extracted by detection and search. According to the shape and curvature, the edge is observed and then characteristic quantity is extracted based on the observation. The characteristic quantity behaves fluctuation, i.e., in short time, it has evident periodicity. Hence the edge detection method is used to detect the color variance in an images[1][2].

Figure 3: (a) Original image Fig 3(b) Image after applying edge detection.

Here 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 field with white color and low intensity area is field with black color. The intensity difference is categorized using a global threshold which is separately calculated for each image. Thereafter the output will provide a shape of the flame. Thus edge detection can be used to analyze color detection of fire.

2.4. Gray scale pixels detection

Fire detection scheme can be made more robust by identifying the gray pixels nearby to the flame and measuring flame area dispersion. Gray scale pixels detection is basically used to detect occurrence of smoke pixel in the selected area which is half above the area, detected by color detection method [2].

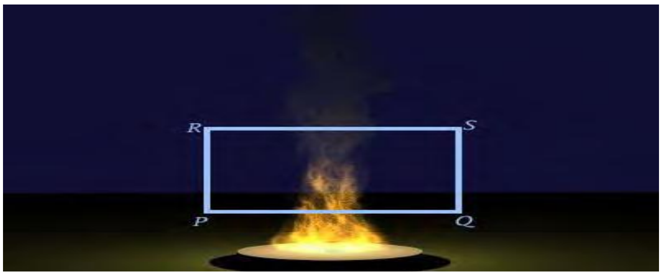

Figure 4: Area for gray cycle detection.

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.

2.5. Area dispersion

Area dispersion is used to detect dispersion of the fire pixel area in the sequential frames. In this method we took two sequential images which comes from color detector then we check dispersion in minimum and maximum coordinate of X and Y axis, acquired from color detector. In this method we are comparing fire pixel area of two sequential frames 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, then there is area dispersion takes place and system will provide output as follows[2][1].

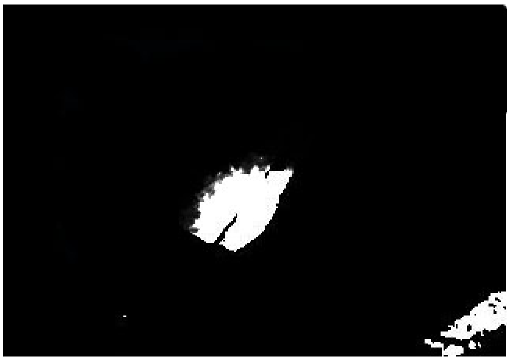

Figure 5(a): Area detected in frame 1.

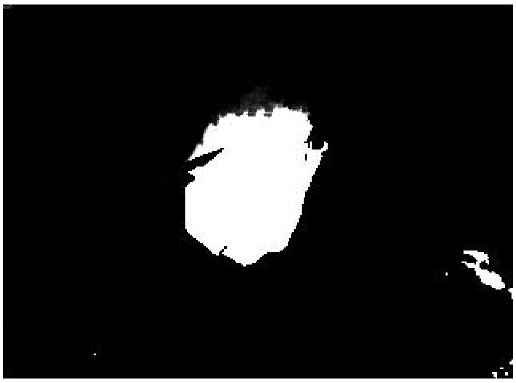

Figure 5(b): Area detected in frame.

3. Result

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 The purpose of this paper is to develop an optimized system to detect an occurrence of fire based on video images that would give more optimized results in detection of flame. Also 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.

4. Conclusion

In conclusion, this paper demonstrates a multi-feature classification approach to detecting fire in video data. Accuracy can also be further increased by applying different efficient algorithm in each phase of detection. More over the system is more reliable in reefing the result comes out from existing detection methods. In our future work we will endeavor to incorporate smoke detection algorithm into our current algorithm.

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