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Smoke and Fire Detection

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Abstract- This paper present a system which can efficiently detect fire after the image of the area has been captured by a camera. Fire has destructive properties which cannot be tolerated in any work areas. Fire is the rapid oxidation of a material in the exothermic chemical process of combustion, releasing heat and light. The light parameter and color of flame helps in detecting fire. The system first detects smoke and then fire. When smoke is present in the area it displays a message on the Security terminal. When a fire breaks in the area under consideration, the corresponding fire region in the input video frame will be segmented which covers the fire. If the area of the flame increases in the subsequent frames then an alarm is sounded.

Index Terms- Fire detection; Smoke detection; YCbCr model; Image seperation

I. INTRODUCTION

Nowadays different types of fire and smoke detectors are available in the market. Smoke detectors are used to detect smoke which indicates that fire is present. Fires with high availability of oxygen burn at high temperature and with small amount of smoke produced; the particles are mostly composed of ash, or with large temperature differences, of condensed aerosol of water. Smoke detectors works mainly on two principles: Optical and Ionization. In optical smoke detectors, LED acts as a light source and at a distance from LED we have a photo detector. In absence of smoke, light reaches the detector without any decrease in intensity. When smoke enters the room, some light is scattered by smoke particles and hence light intensity reaching the detector is less and thus the alarm is triggered. Optical smoke detector has a very high response time. Ionization smoke detector uses radioactive isotope americium-241 to detect smoke. But Ionization smoke detector is rejected as it is more prone to false alarm. All these are not a reliable tool to detect fire and smoke. Even when fire is detected, it is detected in a very late stage where any precautionary measures will prove futile. In [1] spectral and spatial features of fire is used. In [2] and [3] both YCbCr and RGB models are used.In [4] motion detection principle is used for smoke detection. In [5] image separation based method is used. In [6] L*a*b and YCbCr color spaces are used. In [7] wavelet based method is used for fire detection. In [8] and [9] YCbCr model is used. In [10] DFBIR model is used. Every method solved some or the other problem but some drawbacks existed in each of them. We will use YCbCr model in this model. The justification is given in Secion III-C The paper is organized as follows: Goal of the project is discussed in Section II. The method that we propose is explained in Section III. The working of the project is described in Section IV. The results of our project is put together in Section V and finally the conclusion in Section VI.

II. GOAL OF THE PROJECT

In this paper, the main objective is to develop an automatic system which will warn when fire breaks in the area under consideration. We propose a method which first detects smoke and then the potential fire region. Then again the area of the potential fire region is observed. If it keeps on varying then it is confirmed as a fire region and an alarm is sounded. The method is applied to each frame in the captured video and hence the response time is very less. The CCTV camera used here will capture the frame and will provide the computer for processing which will be based on MATLAB. The processing will comprise of the detection of smoke and fire. Detecting smoke and then fire reduces the false alarm rate to a great extent

The traditional approach for fire detection is based on using Smoke detector, Temperature Induction or Light Intensity. But all these methods have got limitations. They are not sensitive and the response time is high. The results of these methods depend solely on the performance of the sensors which require frequent maintenance. In Ionization smoke detector if the smoke reaches the ionization chamber then only it can be detected. These available techniques are slow and cannot detect the fire in the early stage. The application of Image processing in fire detection will make use of high brightness and color characteristic of fire flame. The recent captured frame will be compared with the reference frame to obtain a value and is compared with the threshold value and results are produced. The use of this mentioned technique will also help to detect even the small fire, whereas the conventional techniques fail at these places.

III. PROPOSED M ETHOD

A. *Fire Detection*

Fire has distinctive features such as color, motion, shape, growth, and smoke behavior. For this project we focused on feature such as color and smoke [8]. In this project the high brightness characteristic of the flame of fire, combining the image subtraction method and the saturation and brightness method to extract the flame will be used and even the area growth of the flame are taken into account, greatly reducing the false rate. In normal circumstances the frame would not contain fire. In order to improve the image processing speed of the system, the method of the current image and reference image for subtraction is used. Only those regions which have moved as compared to the reference frame will be used to detect fire, hence reducing the amount of computations. The determination

of flame or fire edges is the process of identifying a boundary between the area where there is thermochemical reaction and those without. It is a precursor to image-based flame monitoring, early fire detection, fire evaluation, and the determination of flame and fire parameters.

B. *Smoke Detection*

Smoke detection can be used for early warning of fire events. One of the distinguishing properties of smoke is transparency. When smoke is heavy enough, it is totally opaque and no visual information of the original frame is available. Even though smoke is present a slight translucent view of the background is still available [5]. Even if the difference in light intensity between the current frame and reference frame is calculated, still it would not be sufficient to detect smoke as the intensity of smoke could be different in different regions. Thus such features could not be very reliable for detection of smoke. In this paper a novel image separation-based method is proposed to detect smoke in image sequences captured by fixed video cameras.

C. *Color Space Selection*

There are various color spaces such as RGB, HSV, HIS, YCbCr, YIQ, YUV and so on. There are some following characteristics using the YCbCr as the color space: 1) Separates the brightness and chrominance effectively; 2) We can directly get the YCbCr through linear transformation from RGB space, hence the computational efficiency is relatively high [11]; 3) Color characteristics are confined to 2 values: Cb and Cr, hence computations are reduced.

D. *Flowchart*

The flowchart of our proposed method is shown in Fig. 1

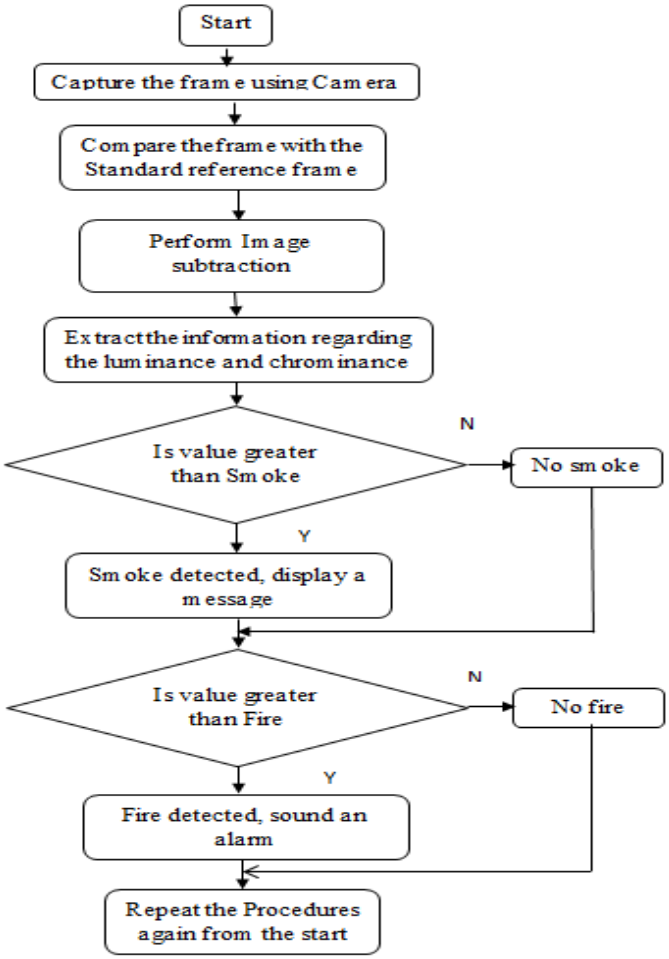


Fig. 1. Flowchart

IV. WORKING

As we selected YCbCr model, we have to calculate values of brightness and saturations. The steps involved are:-

A. *RGB Band Separation*

Each pixel is represented by three values, the amount of red, green and blue. Thus an RGB color image will use three times as much memory as a gray-scale image of the same pixel dimensions. RGB image consists of 3 matrices overlapping each other. First one determines the red value, second determines the green value and third determines the blue value.

B. *Brightness and Saturation Calculation*

In the image-based fire detection system, the interference of the background image can be regarded as an important factor that causes the ultimate false alarm. Therefore, accurately extracting the flame image from the scene image is particularly important. The color in the image can be expressed in three- color components including R (red), G (green) and B (blue). The Red saturation is Cr = R / (R + G + B), Blue Saturation is Cb = B / (R + G + B) and the average brightness is

Y = 0.22 * R + 0.587 * G + 0.114 * B

C. *Smoke detection*

Smoke detection is a very important step in fire detection. Generally, methods for detecting fires using cameras combine smoke detection methods and flame detection methods. Smoke detection method use color and motion information to detect smoke from digital images [12]. As most of the objects that catch on fire first starts giving a smoke, if we are able to detect smoke in an early period, we could prevent fire. Also smoke detection will help us curbing false alarm situation. Smoke has a peculiar color, high in blue saturation. Hence we use YCbCr color model [5]. The histogram of test images of smoke is shown in Fig. 3 and Fig. 4 Through a large number of experiments, it is been found that when the blue saturation of a point is between 126 to 138 and the red saturation is between 112 to 128, it can be regarded as a smoke region. Thus we get the image of the smoke segmented region. A message will be displayed at the terminal and will help in preventing fire.

Fig. 2. Smoke Image

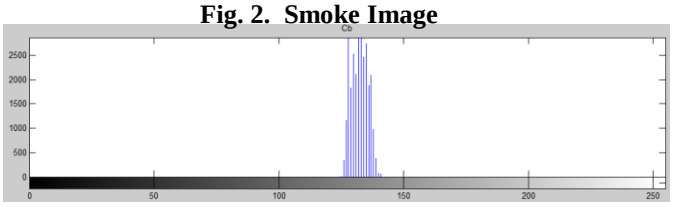


Fig. 3. Histogram of Cb

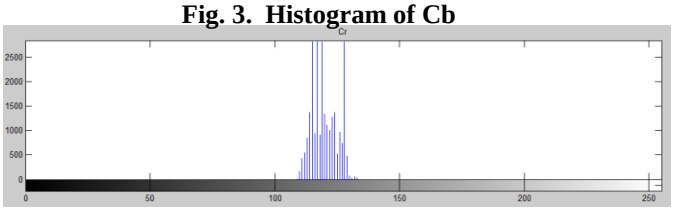


Fig. 4. Histogram of Cr

D. *Detection of Potential Fire regions*

Because there is no fire in the most time, the background image of the camera is usually consistent. In order to improve the image processing speed of the system, the paper introduces the method of the current image and reference image for subtraction [8].In order to achieve the purpose of detecting fire, a threshold is set for Cb and Cr values. Studying various test images, a range of values are selected for Cb and Cr which are possibly fire regions. All those pixels which satisfy the threshold are termed as suspicious regions. This segmented image also consists of some noise.

E. *Extracting FireFlames*

The flame color and color distribution is the basis for the identification of fire. Through the analysis of a large number of test images, it is found that humans observe an image and determine whether there is a fire, mainly based on the color of the image. Any flame can be divided into part 3 including the outer flame, the inner flame and the flame core. According to the temperature, the one of outer flame is the highest, followed by the inner flame, and the flame core is the lowest, this result in the gray of the flame image shows a certain distribution law. From the inside to outside, the color of the flame the trend which it change from white to red; from the edge to the outside, the red of the flame fades continuously [8]. Therefore, the flame color features can be used to determine and extract whether there are suspicious areas in the surveillance system, it is the most original features of the fire. 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. In terms of RGB values, this fact corresponds to the following inter-relation between R, G and B color channels: R greater than G and G greater than B. The combined condition for the fire region in the captured image is R greater than G greater than 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 has to be over some pre-determined threshold. 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 coloured. Therefore, saturation values of the pixels under consideration should also be over some threshold value. Fire flame has the feature of the high brightness and reddish color, these two points is reflected in the average brightness and the red saturation. The histogram of test images of fire is shown in Fig. 6 and Fig. 7

Through a large number of experiments, it is been found that when the blue saturation of a point is between 87 to 130 and the red saturation is between 127 to 140, it can be regarded as a suspicious sub-flame point.

Fig. 5. Fire Image

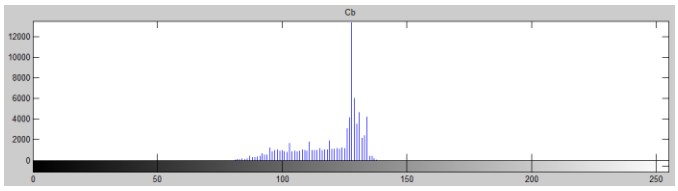


Fig. 6. Histogram of Cb

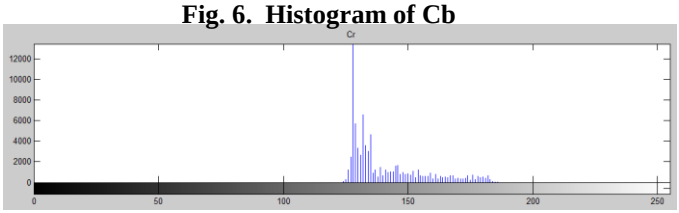


Fig. 7. Histogram of Cr

F. *Fire region confirmation*

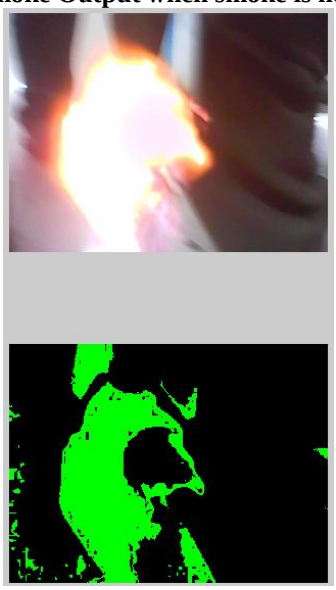
The fire suspicious regions found in Section IV-D may or may not be a fire region. So we need to confirm whether it is a fire region or not. Fire has a peculiar property of continuously changing shape and area. Hence we detect motion of the suspicious fire region and also calculate its area. If the region is displaced in the subsequent frames and the area of the region has changed, we confirm that the region is a fire region and sound an alarm.

V. RESULTS

The results of Smoke detection is shown in Fig. 8. If smoke is present a message is displayed ”Smoke is detected” and if there is no smoke the process of detection continues as shown in Fig. 9. The results of Fire detection is shown in Fig. 10. The fire area is coloured in green. If the area of this region changes at a fast rate then an alarm is sounded.

Fig. 8. Smoke Output when smoke is present

Fig. 9. Smoke Output when smoke is not present



VI. CONCLUSION

In this paper we used YCbCr color space to detect fire and smoke. We also used spatial feature of fire to decrease false alarm rate. Fire and Smoke were detected however there is a room for environment to this method. If other parameters such as spectral feature and time intensity parameter are also added, the false alarm will be reduced to a great extent. This paper presents a specific process of fire and smoke detection which can be used in work areas like banks, server rooms, data centers etc. to prevent or at least stop fire at an early stage.

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