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Fire Detection using Image Processing

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Abstract: *To reduce loss of life and property from fire, an early warning is an imperative. A fire detection system based on light detection and analysis is proposed in the paper. This system uses HSV and YCbCr color models with given conditions to separate orange, yellow, and high brightness light from background and ambient light. Fire growth is analysed and calculated based on frame differences. The overall accuracy fromthe experiments has been greater than 90%.*

Keywords: Fire Detection; Flame Detection Fire Video; Conflagration; Color Segmentation; Image Processing

I. INTRODUCTION

Fire, especially fire in buildings, can spread quickly and cause great loss of life and property. Therefore, early fire detection and warning is imperative. Fire detectors, smokedetectors and temperature detectors have been widely used to protect property and give warning of fires. However, smoke and temperature detection is slower than light detection, which is the substantive detection method proposed in this paper. Furthermore, to cover the entire area potentially subject to fire,many smoke or temperature fire detectors are required.

In order to facilitate earlier detection of fire, and to monitorthe spread of the fire, we propose a fire detection system basedon light detection, as distinct from smoke or heat detection. The system has been designed to detect fire in class A and classC objects, as defined in the National Fire Protection Association Standard. Class A objects are defined as being wood, paper, cloth, rubber or plastic. Class C objects are electrical objects such as outlets, power boards, electric motors and so on. Class A and class C have similar fire flame characteristics. This system acquires video input from anyvideo camera, such as a web camera. The system will trigger an audible alarm and provide visual images of the fire ass red box superimposed over the image of the fire flame in the videosequences.

This paper is organized into five sections: Section I introduces the project; Section II describes related work and reviews previous works; Section III presents our proposed system in detail; Section IV describes our experimental results,and also describes our experimental process and how we testedthe system. Section V is the Conclusion.

II. RELATED WORKS

There are many fire detection systems based on video imaging described in research reports, icluding some of detection using video sequencing. The fire detection research based on video sequences can be classified into two categories:fire flame detection and fire smoke detection [1]. Since our proposed system relates to fire flame detection, this will be discussed in this section.

Flame colors used to detect fire are described in [2-4]. Wenhao and Hong [2] extracted flame objects by iterative adaptive threshold techniques, and then used fire flame color asa part of characteristic information analysis to detect fire. Juanet al. [3] proposed the analysis and extraction of flame colors inthe RGB-color space. Celik and Demirel [4] used YCbCr colors space to separate luminance from chrominance. It is possible for a false detection if only color characteristics have been used. There is research regarding flame shape characteristics [1]. Junying and Xiaoxiao [5] proposed a fire detection method by searching for sharp corners on the contourline of multi-layer closed contours of flame images. Yan et al. [6] also developed flame characteristic detection based onthreshold and the dynamic contours of flames. Since fire flames have so many shapes within a video sequence, it is likely to receive less accurate visual information. There is extensive research using comprehensive information on the characteristics of flame [1]. Rong et al. [7] proposed a fire detection technique based on color, motion, and pattern characteristics of fire, which uses a generic color model as well as the geometrical independent component analysis model, the cumulative geometrical independent component analysis model, and BP neural network based on multi-feature of fire patterns. Lei and Liu [8] used frame differences, median filtersin the reducing noise process, and Bayes classifier in the recognition process to detect fire. Celik [9] divides the proposed algorithm into two parts, which are fire color modeling and motion detection. The color modeling part uses CIE L*a*b* color space. The motion detection parts uses frame/background subtraction, background registration, andmoving pixel detection.

Our proposed method is a real time processing method anduses simple algorithms based on color conditions and fire growth checking.

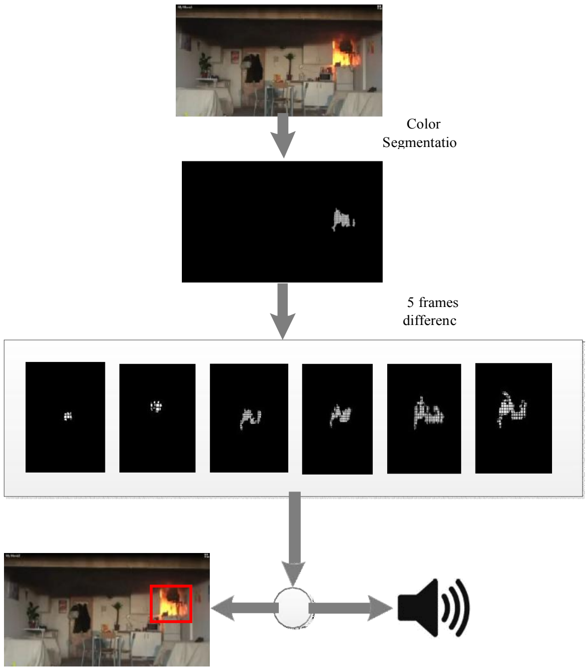

Figure 1: The system overview of the proposed system

III. THE PROPOSED SYSTEM

3.1 System Overview

The system overview of the proposed fire detection systemfor buildings is shown in Fig.1. The input image given in Fig.1 was downloaded from the website http://www.youtube.com/watch?v=PcSVaQeBl0M. The input of the system can be real-time video from any video camera such as a web camera. First, the expected fire and background are separated by the developed color segmentation and received fire location frames. Next, the two consecutive fire location frames are compared to check fire growth.

If fire growth continues over five frames, the alarm be triggered and the computer screen will display the video with the red box superimposed the detected fire.

3.2 Color Segmentation

This section discusses the technique developed to segment fire from its background. It can be seen with the naked eye thatfire colors consist of orange, yellow and have a high level of brightness. Therefore, the properties of the HSV and YCbCr color models can be used to separate the flame colors from thebackground.

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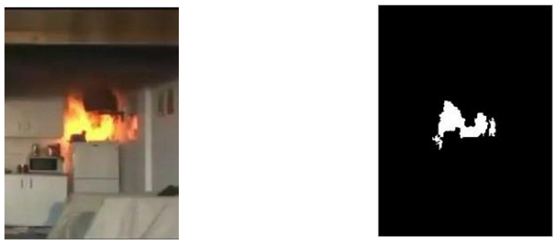
The HSV color model is used to detect information related to color and brightness. The YCbCr color model is used to detect information related to brightness because it can distinguish bright images more efficiently than other color models.



(a) (b)

Fig. 2. Color segmentation samples: (a) video input frame, and (b) corresponding fire location image

To detect fire flame, the conditions are formed as follows:

Y_mean, Cb_mean, and Cr_mean are the mean values ofluminance, blue and red components, respectively.

Each frame of the video input is processed to follow the above mentioned conditions and generate output fire location images. Each pixel of the fire location images contains either 1or 0. The pixel value 1 means the flame pixel. The pixel value 0 means the non-flame pixel.

Fig. 2 shows examples of input and output images from thedeveloped segmentation technique. Fig. 2(a) is the example of video input frame. Fig. 2(b) is the corresponding fire location image output. There are two colors, white and black, in Fig. 2(b). White color represents the pixel value 1 and black color represents the pixel value 0. Moreover, it can be seen from Fig.2(b) that the white area represents the fire location corresponding to Fig. 2(a).

3.3 Frame Differences

The developed segmentation technique can effectively detect fire flame in real-time fire video sequences as well as filed video sequences. The accuracy of the above technique is more than 80%. However, it is possible for a fault detection if there are lighted candles, lighted matches, orange clothes, or other objects with bright orange color in the video sequences. Therefore, the proposed technique has been further improved by checking fire growth. First, a noise reduction algorithm is applied to reduce the possible noise that can cause false detection. An opening algorithm is selected and applied to fire location images as shown in Fig. 3. Then, fire growth is checked by the developed algorithm as shown in Fig. 4.

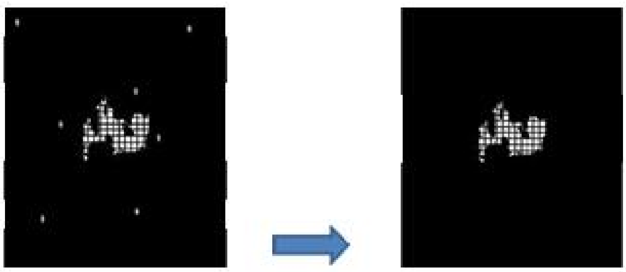


Figure 3: Results of opening algorithm

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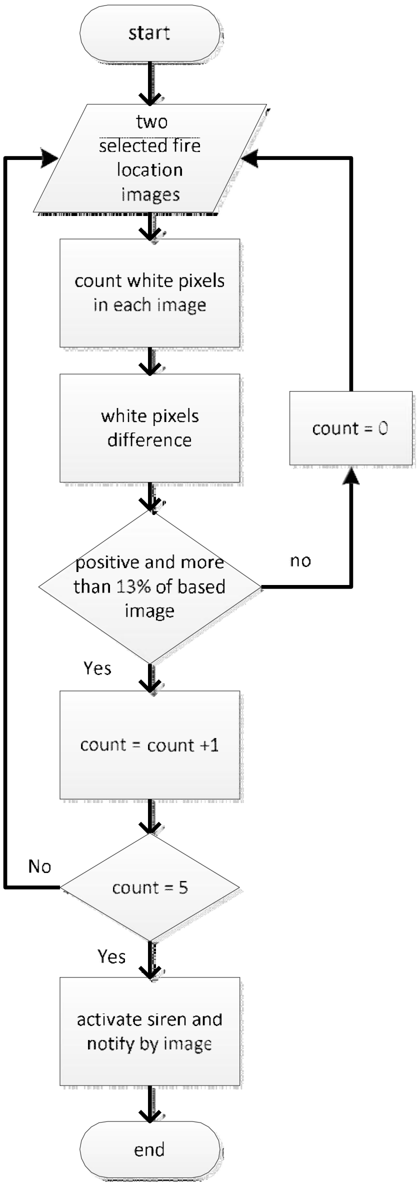
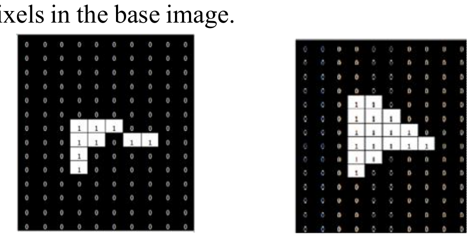


Figure 4: Frame-difference diagram

First, the two consecutive fire location images are selected.White pixels in each image are counted. Then, the difference between the numbers of white pixels in each image are calculated by the numbers of white pixels in the next image subtracted by the numbers of white pixels in the base image.



(a) (b)

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Figure 5: Visualization of pixels in the fire location images in the same video file: (a) frame 0, and (b) frame 5

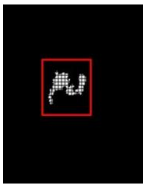

Figure 6: The superimposed red box at fire flame in the video sequences

The visualization of pixels in the fire location images in the same video file are shown in the Fig. 5. In order to check fire growth, the data difference between the two frames should be positive and large enough to be able to detect fire growth. Therefore, we selected 13% of data difference and based images, which came from our experiments. Moreover, to make sure that it is the actual fire, five-time fire growth between consecutive frames has been checked. If these conditions are correct, the system activates the alarm sound and provides image notification by superimposed red box at fire flame in the video sequences as shown in Fig. 6.

IV. EXPERIMENTAL RESULTS

A web camera with resolution of 1280x720 pixels and 30 FPS frame rate has been used in the experiment. This web camera get video input from real fire scenes. Another source of video inputs for our experiment is internet. The real fire scene videos and the downloaded videos from internet are described in table I. and table II.

First, we tested the developed color segmentation technique. One hundred fire images and one hundred non-fire images were captured from video sequences.

Table I: Burning Objects In Fire Images

Burning Objects	Number of images
Sofa in day time (from internet)	10
Sofa in night time (from internet)	10
Wood (real scene)	10
Wood (from internet)	10
Paper (real scene)	30
Plastic (from internet)	10
Cloth (real scene)	10
Electric appliance (from internet)	10

Table II: Fire Suspected Objects In Non-Fire Images

Fire suspected Objects	Number ofimages
Candle far away from camera (real scene)	10
Candle near camera (real scene)	10
Orange/yellow/ red/ green shirt (real scene)	30
Orange/yellow/ red/ green shirt (from internet)	16
Yellow bag (from internet)	8
Orange pant (real scene)	10
Orange wall or yellow wall (from internet)	10
Fire extinguisher (from internet)	3

Wood table (from internet)	3

The detail of burning objects in the fire images is shown in table I. The detail of fire suspected objects in the non-fire images is shown in table II.

Fire pixels from our technique were compared with fire pixels verified by a human. The accuracy of our technique for one hundred fire images was 90.73%. The accuracy of our technique for one hundred non-fire images was 98.13%.

Next, we used thirty fire video files and thirty non-fire video files to test our system notification.

The experimental result for thirty fire video files was 100% accuracy and gave notifications within two minutes, which means that our system can detect all fire video sequences and alert before severe disaster happens. The details of the fire videos and non-fire videos is shown in table III.

Table III: Properties of Tested Videos

Description	**Number ofvideos**
Burning sofa (from internet)	2
Burning eletric appliance (from internet)	1
Burning wood objects (from internet)	1
Burning wood objects (real scene)	9
Burning plastic objects (from internet)	1
Burning cloth (real scene)	2
Burning paper (real scene)	13
Burning box (from internet)	1
Candle (real scene)	2
Orange siren (real scene)	1
Orange pant (real scene)	1
Shirt with orange/ yellow/ red/ green ormixture of the mentioned color (real scene)	26

V. CONCLUSION

We have proposed a fire-detection system for buildings. The system uses HSV and YCbCr color models with given conditions to separate orange, yellow, and high brightness from the background. Fire growth is checked based on frame differences. Our system works very well when fire occurs, by providing significantly faster detection based on light detection and analysis. The obvious outcome is significant reduction in loss of life and property. Overall accuracy from the experiments is more than 90%, demonstrating its effectiveness and usefulness. In future work, objects and shapes, such as shirts, bags, or other objects with orange color, which are approaching the camera will be analysed. The change is size and intensity caused by relative proximity to the camera may cause false alarms.

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