FIRE DETECTION USING IMAGE PROCESSING

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ABSTRACT

The main advantage of Image Processing Based Fire Detection System is the early warning benefit. This system can be installed just about anywhere in a commercial building, malls and at many more public places for fire detection. This system uses camera for detecting fires. So we do not need any other sensors to detect fire. System processes the camera input and then processor processes it to detect fires. The heat signatures and fire illumination patterns are detected in images to determine if it is a fire and take action accordingly. On detecting fire system goes into emergency mode and sounds an alarm. Also displays the status on the LCD display informing about the system.

Keyword: -*RGB Color model, YCbCr color model, motion detection background subtraction, area dispersion.*

1. INTRODUCTION

Automatic fire detection systems use physical sensors to detect and response of an fire. The physical sensor uses the chemical properties in the air are acquired by sensor and use by fire detection system to raise an alarm.This can also cause false alarms, The physical sensors are also not applicablefor outdoor environment and in large infrastructure settings such as aircraft hangers, large tunnels. Due to the rapid development of digital camera technology and advanced content based image and video processing , there is a major trend to replace conventional fire detection system with computer vision based system. There are lots of fire detection systems in which color is used in preprocessing step. Chen et al. [2], used RGB color channel information and create fire rules for the three channels separately. They used a moving detection algorithm in preprocessing step. To improve detection performance Toreyin et al. [3] proposed a real time algorithm for fire detection in video sequence. They used Combination of color and motion clues with fire flickers and then analyzed on wavelet domain to detect fire. Celik et al. [4], make use of fire detection rules after extracting foreground pixels by means of a change detection algorithm. They used method for the classification of fire/smoke pixels, separating them from the background.. Marbach et al. [5] propose a model where data are represented and analyzed in a YUV space. This model is used for representing the video data, where time derivation of luminance component Y used for first reduction of the candidate fire pixel, and chrominance component U and V used for classification whether or not the candidate pixels were in the fire section. In order to reduce false alarms, a simple motion detection algorithm is used to detect the areas containing the fire. Horng et al. [6] propose the HSI color space to roughly segment the fire-like region for brighter and darker environments.

Celik Turgay [7] proposes the CIE L*a*b color space for detection of fire pixels. In This color space the color tone are better grouped than in any other space. In vision based fire detection system, there are three major features for fire: Color pixel, moving pixels and shape. The fire pixel can be classified as both in grayscale and color video sequences. Most of the fire detection system works on color video sequences.It is assumed that the image capturing device produces its output in RGB color format, and these color information is used as a pre- processing step. During an occurrence of fire, smoke and flame can be seen. As the fire intensity is increases smoke will be visible. A good color model selection for fire pixel detection and moving pixel detection play the critical role in computer visionbased fire detection system. The combination of color and motion clues used to detect the fire.

2. SYSTEM ARCHITECTURE

In this section we will discuss the techniques proposed for fire detection.Fig.1 shows the flowchart of proposed algorithm for fire detection in video. In order to create the color model for fire we analyzed several images having fire. Since the color of fire is generally closer to red and has high illumination, and we can use this property to derive the required color model.

1.1 RGB color model

A fire image can be described by using its color properties. There are three different element of color pixel: R,G and B. The color pixel can be extracted into these three individual elements R,G and B, which is used for color detection. RGB color model is used to detect red color information in image. In terms of RGB values, the corresponding inter-relation between R, G and B color channels: R>G and G>B. The combined condition for the captured image can be written as: R>G>B. In fire color detection R should be more stressed then the other component, and hence R becomes the domination color channel in an RGB image for fire.This imposes the condition for R as to be over some predetermined threshold value RTH. All of these conditions for fire color in image are summarized as following:

Condition1: R > RTH Condition2: R > G > B.

Where RTH is the Red color threshold value for fire.

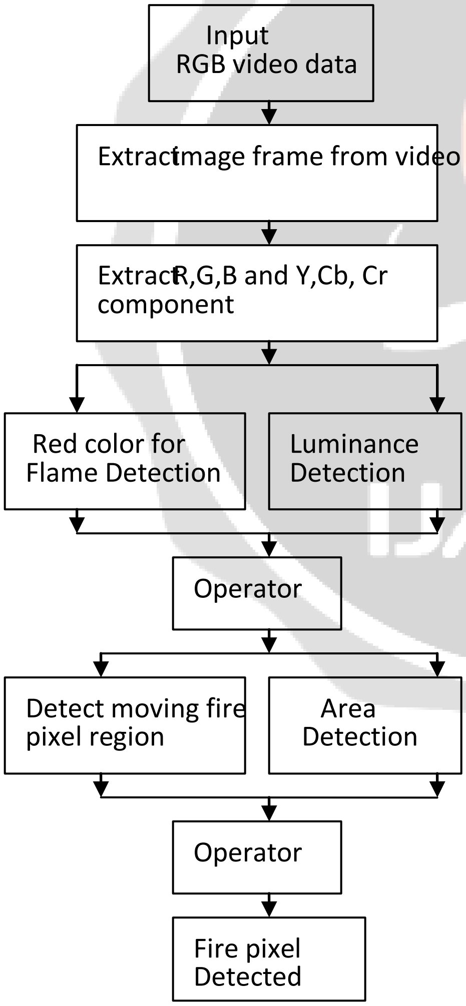
Input
RGB video data
Extract image frame from video
Extract R,G,B and Y,Cb, Cr component
Red color for Flame Detection
Luminance Detection
Operator
Detect moving fire pixel region
Area Detection
Operator
Fire pixel Detected

Fig-1 Flow chart of proposed algorithm for fire detection.

2.1 YCbCr color model

YCbCr color space is used in our model rather than other color spaces because of its ability to distinguish luminance information from chrominance information more effectively then other color model. In order to create Y, Cb, Cr components from obtained RGB Image. We will use color space transformation equation to transform each RGB pixel in corresponding Y Channel, Cb Channel, Cr Channel pixel to form a corresponding Y, Cb, Cr image.

When the image is converted from RGB to YCbCr color space, intensity and chrominance is easily discriminated.

YCbCr color space can be easily model as following for the fire:

$$Y = 16 + R * 65.481 + G * 128.553 + B * 24.996;$$

$$Cb = 128 + R * -37.797 - G * 74.203 + B * 112.0;$$

$$Cr = 128 + R * 112.00 + G * -93.7864 + B * -18.214;$$

In YCbCr color space, Y′ is the luma component (the "black and white" or achromatic portion of the image) and Cb and Cr are the blue-difference and red-difference chrominance components, will be chosen intentionally because of its ability to separate illumination information from chrominance more effectively than the other color spaces. In YCbCr color space and analysis can be performed. For a fire pixel Y(x, y) >= Cr(x, y) >= Cb(x, y), where a non-fire pixels don't satisfy this condition, where (x,y) is spatial location of a fire pixel. Such system can be useful for detecting forest fires where we can't put sensors at each location.

So we can summarize overall relation between Y(x, y), Cb(x, y) and Cr(x, y) as follows:

$$Y(x, y) >= Cr(x, y) >= Cb(x, y)$$

Now, we can have some rules for fire detection:

Rule1: R1(x,y) = 1 , if ((R(x,y) > G(x,y)) &&(G(x,y) > B(x,y)))

0 , otherwise

Rule2: R2(x,y) = 1 , if (R(x,y) > 190) && (G(x,y) >100) && (B(x,y) < 140)

0 , otherwise

Rule3: R3(x,y) = 1 ,if Y(x,y) >= Cb(x,y)

0, otherwise

Rule4: R4(x,y) = 1 ,if (Cr(x,y) >= Cb(x,y)

0, otherwise

2.2 Motion detection in video

Identifying moving objects from a video sequence is a fundamental and critical task in many computer-vision applications. A common approach is to perform background subtraction, which is used to identify any moving objects from the portion of a video frame that differs significantly from a background model. There are basically three approaches used in background subtraction for motion detection in a continuous video stream. One of the most common approaches is to compare the current frame with the previous one or with something we call background. In this paper we use Frame differencing method to detect the moving pixels in image. Frame differencing uses the video frame at time t-1 as the background for the frame at time t. The binary background difference is generated by comparing the current frame with the background frame. The flowchart for motion detection is shown in Fig.2.

This method does have two major advantages. One obvious advantage is the modest computational load. Another is that the background model is highly adaptive. Since the background is based solely on the previous frame, it can adapt to changes in the background faster than any other method (at 1/fps to be precise). As we'll see later on, the frame difference method subtracts out extraneous background noise (such as waving trees), much better than the more complex approximate median and mixture of Gaussians methods.

For noise removal a Gaussian filter can be used but we needs to be cautious about blurring.

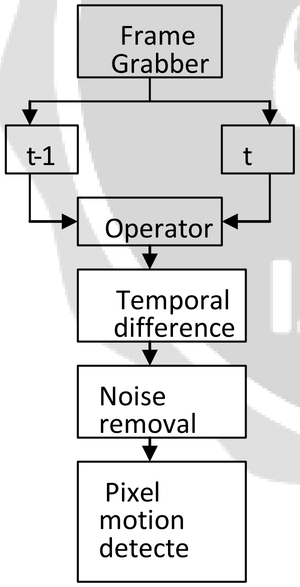

Fig -2 Flow chart for motion detection

2.3 Area detection

This method is used to detect dispersion of fire pixel area in the sequential frames. Area counts the number of pixels in an object [8]. In area detection method we take two sequential frames which comes out from color detector then we check dispersion in minimum and maximum coordinate of X and Y axis.

3. METHODOLOGY

3.1 Raspberry Pi

Raspberry Pi project development started on 2006. It is an inexpensive computer that uses Linux-based operating system, equipped with a 700 MHz ARM-architecture CPU, having a

512 MB RAM and featured with two USB ports and an Ethernet controller. It is able to handle full HD 1080 video playback and by using the onboard Videocore IV graphics processing unit (GPU), it was able to demonstrate the ported version of the Quake 3 game. It allows flexibility in the choice of programming languages and installation of software that could be used . It has the ability to serve webpage by installing Apache HTTP Webserver on it . Arduino Uno with GSM Shield.

Arduino Uno is an ATmega328-based microcontroller operated using 5.5 Volts input voltage supply and has a maximum operating frequency of 20 MHz . The power supply for the Arduino Uno can be either from a USB connection, DC power supply, or both. It is a high performance device which has low power AVR 8-bit Microcontroller with 32K bytes in-system and advanced reduced instruction set computing.

3.2 Software

As for the ports configurations of the Raspberry Pi, Port 24 was defined as the input port to receive any alert from Arduino Uno, Port 25 was defined as the output port and it is used to

The Raspberry Pi used a Linux-based operating system to operate. In this project, Raspbian Wheezy operating system (OS) was chosen because it is recommended by the manufacturer. The Raspbian Wheezy is the modified version of the Debian Cheezy OS. The OS image was extracted to an SD card by using the Win32 Disk Manager. The configurations of the OS such as login details and IP address settings were done. The login at startup was disabled to make sure that if the power supply to the Raspberry Pi was cut down, the Raspberry Pi will never ask for login details. The Apache HTTP webserver was installed to make the Raspberry Pi as a webserver. Theinform the Arduino Uno if the user has already confirmed the alert, while Port 23 was defined as the output port and is used to inform the Arduino Uno if the user cancelled the alert. While for the pins configurations of the Arduino Uno, Pin 13 was defined as the output pin for sending the alert to Raspberry Pi, Pin 12 and Pin 11 were defined as the input pin for receiving the information from the Raspberry Pi whether the user confirmed or cancelled the alert.

The Raspberry Pi waits for any input from the Arduino Uno on its Port 24. Upon detecting the event, the Arduino Uno will send a HIGH output which is 5V from its Pin 13 to the Ports 24

of the Raspberry Pi and the voltage will be reduced as the current flows through the voltage divider circuit. An image will be captured using the webcam. The image will be displayed on the webpage and the Raspberry Pi will wait for the user confirmation on the validity of the alert. The user can do the confirmation by clicking a submit button on the webpage. At the moment the user click, the PHP programming of the webpage will automatically open a text file named Logger file and log a command data. The Python programming will open the text file, and write a word “send” in the Logger_file. Then the Raspberry Pi will send a HIGH output which is 3.3V through Port 25 to Pin 12 of the Arduino Uno. The Arduino Uno will then generate an SMS alert and send it using the GSM shield.

4. RESULTS

We have taken two RGB image frames then algorithm is applied on it, and result is shown as in Fig.4(a) and Fig.4(b). Sample RGB image frames having fire, it contains sub images of different steps in algorithm: 1st image frame, 2nd image frame having flame, red component of fire pixel according to condition as mentioned above, motion is detected between these two frames, and last sub image shows the fire pixel detected in image.

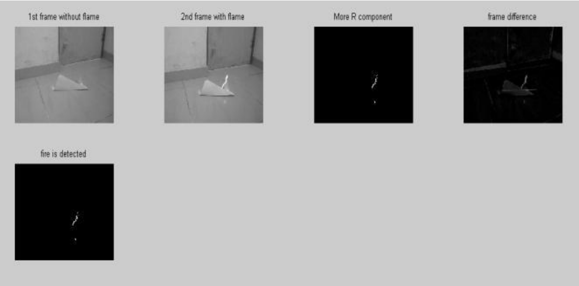

Fig- 4(a): First row shows the intermediate result of processing, and second row shows the final fire pixels

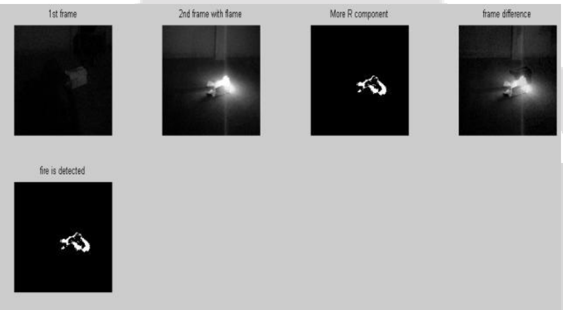

Fig- 4 (b): First row shows the intermediate result of processing, and second row shows the final firepixels

Applications**:** Used to detect fire in forest, tunnel or any other unexpected fire.

5. CONCLUSIONS

In this paper an image based fire detection system was proposed, which is based on computer vision based techniques. We have collected a number of sequential frames from original video, which consists of fire and non fire images. The proposed method consists three main stages: **-** fire pixel detection using RED and YCbCr color model, moving pixel detection and analyzing shape of fire colored pixels in frames to detect fire pixel in image. The proposed method is applied on video sequences and then fire is detected.

Texture or shape information other then area can be used to improve system's fire detection performance. The performance of fire pixel can be further improved by applying smoke detection in the early stage of fire, along with the fire detection technique

6. REFERENCES

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