Detecting, Intimating the Fire Accidents in Video Process

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Abstract— This paper presents a fire-alarming method based on video processing. We propose a system that uses color and motion information extracted from video sequences to detect fire. Flame can be recognized according to its color which is a primary element of fire images. Thus choosing a suitable color model is the key to detect flames from fire images. An effective fire detection criterion based on color model is proposed in this paper by intensive experiments and trainings. The detection criterion is used to make a raw localization of fire regions first. However, color alone is not enough for fire detection. To identify a real burning fire, in addition to chromatic features, dynamic features are usually adopted to distinguish other fire aliases. In this paper, both the growth of fire region and the invariability of flame are utilized to further detect the fire regions as a complement of the detection criterion. The effectiveness of the proposed fire-alarming method is demonstrated by the experiments implemented on a large number of scenes.

Keywords – Fire-alarming, detect fire images, fire detection

I. INTRODUCTION

Most of the proposed methods and conventional systems used in today's areas that need fire protection, are for indoors, and their mechanical systems are designed to detect not the fire itself but its byproducts. Presence of certain particles generated by smoke and fire is detected by most of those systems. Alarm is not issued unless particles reach the sensors to activate them. Also, infrared and ultraviolet sensors that are also commonly used produce many false alarms. By the help of machine vision techniques, it is possible to get better results than conventional systems because images can provide more reliable information.

A. FIRE AND ITS PROPERTIES

Typically, fire comes from a chemical reaction between oxygen in the atmosphere and some sort of fuel. For the combustion reaction to happen, fuel must be heated to its ignition temperature. In a typical wood fire: First something heats the wood to a very high temperature. When the wood reaches about 150 degrees Celsius, the heat decomposes some of the cellulose material that makes up the wood. Some of the decomposed material is released as volatile gases. We know these gases as smoke. Smoke is compounds of hydrogen, carbon and oxygen. The rest of the material forms char, which is nearly pure carbon, and ash, which is all of the unburnable minerals in the wood (calcium, potassium, and so on). The char is also called charcoal. Charcoal is wood that has been heated to remove nearly all of the volatile gases and leave behind the carbon. That is why a charcoal fire burns with no smoke.

The actual burning of wood then happens in two separate reactions: (1) When the volatile gases are hot enough (about 260 degrees C for wood), the compound molecules break apart, and the atoms recombine with the oxygen to form water, carbon dioxide and other products. In other words, they burn. (2) The carbon in the char combines with oxygen as well, and this is a much slower reaction. A side effect of these chemical reactions is a lot of heat. The fact that the chemical reactions in a fire generate a lot of new heat is what sustains the fire.

As they heat up, the rising carbon atoms (as well as atoms of other material) emit light. This "heat produces light" effect is called incandescence. It is what causes the visible flame. Flame color varies depending on what is being burned and how hot it is. Color variation within in a flame is caused by uneven temperature. Typically, the hottest part of a flame glows blue, and the cooler parts at the top glow orange or yellow. The dangerous thing about the chemical reactions in fire is the fact that they are self perpetuating. The heat of the flame itself keeps the fuel at the ignition temperature, so it continues to burn as long as there is fuel and oxygen around it. The flame heats any surrounding fuel so it releases gases as well. When the flame ignites the gases, the fire spreads.

On Earth, gravity determines how the flame burns. All the hot gases in the flame are much hotter (and less dense) than the surrounding air, so they move upward toward lower pressure. This is why fire typically spreads upward, and it's also why flames are always "pointed" at the top.

II. FRAME SUBTRACTION METHOD FOR FLAME DETECTION

A. MOTION DETECTION

System looks for if there is motion going on in consequent frames. The method proposed for motion detection is Frame Subtraction. By subtracting consequent frames from each other, the area where motion occurs can be detected. In order to remove false detections caused by motion of the camera, the difference of pixels belonging to areas outside of the motion can also be calculated and then subtracted from all pixels. This method removes the necessity of using a stable camera.

Figure 2-1. Detection of motion with frame subtraction

B. COLOR DETECTION

Consequent pixels that belong to a flame have certain properties. According to a previous work [1], A sample fire-color cloud in RGB space (a), and the spheres centered at the means of the Gaussian distributions with radius twice the standard deviation (b) are shown in Figure 2-2.

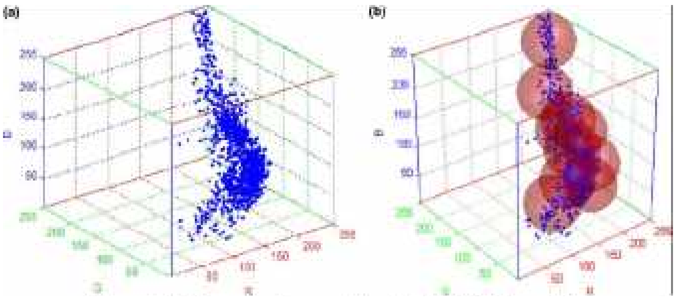

Figure 2-2. Fire-pixel properties in the RGB Space [1]

Fire and flame color model proposed in [2] defines flame pixels. In the RGB space, there must be a relation between the R, G and B color channels that is: R > G > B. R has to have a higher value than a pre-determined threshold RT. Since lighting conditions in the background can cause non-flame pixels look like flame pixels, Saturation values of the pixels under inspection must also has a higher value than some pre-determined threshold ST. ST is the value of saturation when the value of R channel is RT. So the conditions we have for a flame pixel are:

1. R > RT
2. R > G > B
3. S > (255 – R) * ST / RT

C. ADVANTAGES AND DISADVANTAGES OF METHOD

Advantages –

- It is easy to implement the method
- Every pixel in the frame is checked
- Doesn't need a stable camera

Disadvantages-

- Needs more processing power for it's calculations for each frame of each pixel

III. FIRE DETECTION WITH CHROMATIC FEATURES

Any algorithm of fire detection may firstly require a segmentation of fire region from an image for analysis, so employing an appropriate color model is vital to fire detection. To simulate the color sensing properties of the human visual system, RGB color information is usually transformed into a mathematical space that decouples the brightness (or luminance) information from the color information. Among these models, HIS (hue/saturation/intensity) color model is very suitable for providing a more people-oriented way of describing the colors, because the hue and saturation components are intimately related to the way in which human beings perceive color. YCbCr is a model derived from YUV color model, the essential characteristic of which is to separating the brightness and the color information. I1I2I3 is a feature space produced by pattern recognition theory for classification. Unfortunately, all the color models above may ignore slight irregularities for not considering the types of burning materials. Moreover, each of them is only s uitable for fire detection in specific scenes.

Based on intensive experiments, we find the 3 rules introduced in [3] are effective in segmenting firecolored pixels from an image. In spite of the varieties of flame colors, the initial flames often display red-toyellow color. In order to reduce the computational complexity, the RGB color model is employed in the algorithm proposed in [3] for its simplicity. The first rule in detecting fire colors is defined as $R \geq G \geq B$. Furthermore, there should be a stronger R in the captured fire image due to the fact that R becomes the major component in a colorful image of fire. This is because that fire is also a light source and the video camera needs sufficient brightness during the night to capture the useful video sequences. Hence, the second rule adds a constraint that the value of R component should exceed a threshold, RT. However, the background illumination may affect the saturation of flames or generate a fire alias, which leads to false detections. To avoid being affected by the background illumination, the saturation value of the extracted flame needs to be larger than a specified threshold, ST. Accordingly, the saturation S should be in inverse proportion to the R component. To sum up, the three decision rules for extracting fire regions from an image can be described as follows:

Rule 1: $R > RT$
Rule 2: $R \geq G \geq B$
Rule 3: $S \geq (255-R) i S_T / R_T$

In the decision rules, both *RT* and *ST* are defined according to various experimental results, and typical values range from 55 to 65 and 115 to 135 for S_T and R_T, respectively

IV. THE PROPOSED FIRE-ALARMING ALGORITHM

Color alone is not enough to identify fire. There are many non-fire objects that share the same color as fire, such as a desert sun and red leaves. The key to distinguish the fire and the fire-colored objects is their motion properties. Flame moves significantly between consecutive frames (at 30 frames/s), as shown in Fig.4.1

Fig. 4.1.Flame motion in four consecutive frames.

Unfortunately, some fire-similar regions in an image may have the same color as fire, which are usually detected as the real fire from the image. Those fire aliases are generated by two cases: non-fire objects with the same color as fire and background with illumination of fire-similar light sources. In the first case, the object with reddish colors may cause a false alarm of fire. The second case is usually caused by solar reflections and artificial lights which bring negative influences to fire detection, and it makes the p rocess complex and unreliable.

Generally, the growing of a burning fire will be mainly dominated by the air-flow and fuel type[4]. The flame size keeps changing in an increasing trend due to air flowing, especially for initial burning flame. To obtain the growth feature of fire, we calculate the number of fire-pixels in each frame and then compare the numbers of every two continuous frames. Let *mi* and *mi*+1 denote the number of fire-pixels in the current frame and next one, respectively. If the occurrence of *mi*+1>*mi* is more than *g* times at intervals of *tF* during a time period *T*, it reveals that there is a growing trend of the fire which increases the reliability of the detection process, where *g*, *tF* and *T* rely on statistical data of experiments.

Let *N* denote the times of comparing *mi* with *mi*+1 at the interval of *tF* during the time period *T* and *R* denote the times of *mi*+1 >*mi*. Experiment result shows that if the fire is going to spread out, the ratio *R*/*N* should be more than at least 0.7. If the value of *R* /*N* is more than 0.9, the fire is surely spreading out. The ratio *R*/*N* between 0.7 and 0.9 is mainly determined by the material of fuel and air-flow. In this paper we choose 0.8 as the value of ratio. The flow chart of the growth criterion is shown in Figure 4.2.

By analyzing the body change of initial burning flame, we find the invariability of the centroid of the flame. This paper obtains the characteristic of flame's body change by calculating the quadrature of the image. The quadrature is a digital character based on inner district. For a certain planar continuous function *f*(*x*, *y*), the *pq* rank's quadrature can be calculated as follow:

$$M_{pq} = \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} x^p y^q f(x, y)dxdy, \quad p, q = 0,1,2\cdots$$

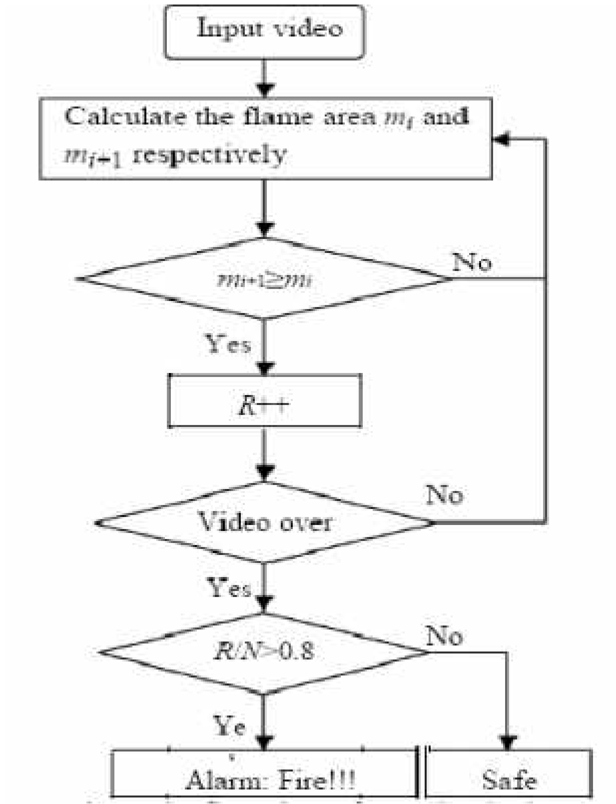

Fig. 4.2.The flow chart of growth criterion

V. SIMULATION RESULTS

Several fire detection algorithms based on chromatics features and 3 rules are simulated in this paper. Four static images that contain fires are used as test images. The original image and the localized fire regions are shown in Fig. 5.1.

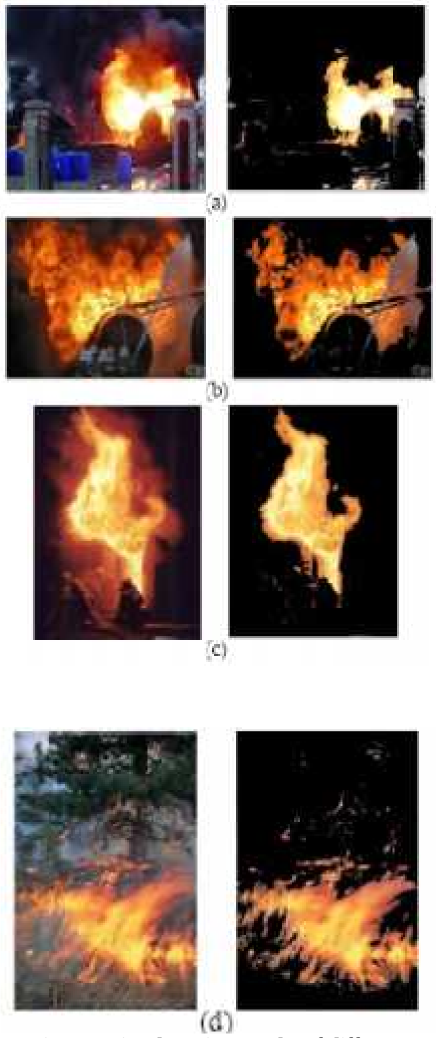

Fig. 5.1. Fire detection results of different algorithms, the left columns are original fire images, and the right ones show the localizations of fire regions. (a) RGB. (b) HSI. (c) I1I2I3. (d) 3 rules

In order to evaluate the effectiveness of the proposed algorithm, we use the algorithm to identify if the fire disaster occurs in the scenes of the video sequence. Simulation results show that the fire alarm is correctly triggered, and the frames contain fire regions are shown in Fig. 5.2.

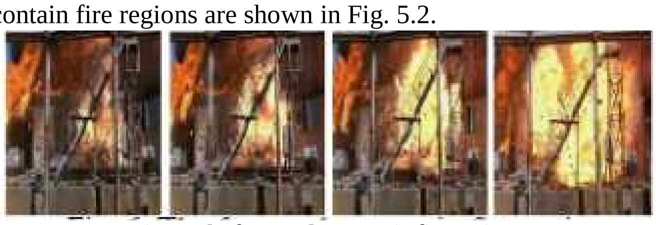

Fig. 6. The frames that contain fire regions

VI. CONCLUSION

This paper presents a fire-alarming method for detecting fire in colorful video sequences. This algorithm employs information obtained from both color and dynamic features to detect fire. Finally, a fire alarm is given as soon as the fire-alarming condition is met. Our future work is focused on applying fractal dimension to detect fire for reducing false alarms.

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