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Fire Detection in Video

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***Abstract*— we propose a method for fire detection. We present an automatic system for fire detection in video sequences. There are many methods to detect fire however, we are using background subtraction. The method that uses general video captured from any sources. We propose fire detection and identification using background subtraction and morphology technique. We will establish a reliable background updating model based on statistical and use a dynamic optimization threshold method to obtain a more complete moving (object) fire. And then, we will introduced morphological filtering to eliminate the noise and solve the background disturbance problem. At last, then filters for colors consistent with fire. The fire is accurately and reliably detected.**

Keywords*— *fire detection; background subtraction; background model; image difference algorithm

I. Introduction

Fire has always threatened properties and people's lives. Most known fire detection technologies mainly uses smoke analysis ,particle sampling, and temperature sampling, however due to high false alarm rates fire detection systems with using these technologies have limited effectiveness. Optical approaches are increasingly appropriate alternatives to conventional methods.

Due to the rapid developments in digital camera technology and computer vision system, the fire detection technologies available which are introduced based on image processing. Motion, color, and shape or dynamic feature these features generally considered in to Image processing based systems. Currently, methods used in fire detection are mainly the frame diffraction method, the background subtraction method and the optical flow and level set method [2]. Frame subtraction method [3, 4] is based on the difference between two consecutive images. For detection of the presence of moving objects it will take the difference between two consecutive images. its calculation is comparatively simple and implementation is very easy. For a variety of dynamic environments, it has strong adaptability, but it is generally very difficult to get a whole outline of moving object, as a result the fire detection is not accurate. Optical flow method [5, 6] is uses to calculate the image optical flow field, and do clustering processing according to the optical flow distribution characteristics of image.

This method can get the complete movement information and the method is very accurate to detect the moving object from the background, but it require a large quantity of calculation, poor anti-noise performance, sensitivity to noise, due to this it is not suitable for real-time demanding occasions. To detect moving objects the background subtraction method [7] is to use the difference of the background image and current image, with simple algorithm, but very sensitive to the changes in the external environment and has poor ant interference ability. So, it will provide the most complete object information in the case of the background is known [8]. In this paper, we uses a static camera condition, based on the background subtraction we combine dynamic background modeling with dynamic threshold selection method, and update background on the basis of accurate detection of object, this method must be very effective to enhance the effect of moving object detection.

II. Background subtraction method

The background subtraction method is the common method of motion detection. It has technology that uses the difference of background image and the current image to detect the motion region [9], and it is generally able to provide data included object information. Initialization and update of the background image are the main key feature of this method. The effectiveness of both will affect the accuracy of test results. Therefore, this paper the method is used effectively to initialize the background, and in real time it will update the background.

A. *Background image initialization*

There are many ways to get the initial background image. For example, with reference the first frame it will take it as the background directly, or the average pixel brightness of the first few frames as the background or using a background image sequences without the prospect of moving objects to estimate the background model parameters and so on. Among these methods, the most commonly used method of the establishment of an initial background is the time average method [10]. But, this method cannot work with the background image which has the shadow problems (especially the region of frequent movement). This problem can resolve simply and effectively as, by taking the median from continuous multi-frame. So we select the median method in this paper to initialize the background. Expression is shown below as :

$$B_{Init}(x,y) = median\, f_k(x,y) \quad k=1,2,\ldots,n \qquad (1) \qquad k$$

Where B_{init} is the initial background, n is the total number of frames selected.

B. *Background Update*

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For the background model its better adapt to light changes, in real time the background needs to be updated, so as to accurately extract the moving object. In this paper, the background update algorithm is as shown below:

In moving object detection , the pixels judged as belonging to the moving object maintain the original background gray values, not be updated. For the pixels which are judged to be the background, we update the background model according to following rules:

$$B_{k+1}(x,y) = \beta B_k(x,y) + (1-\beta) F_k(x,y) \quad (2)$$

Where $\beta \varepsilon (0,1)$ is update coefficient, m this paper β=0.004. $F_k(x,y)$ is the pixel gray value in the current frame. $B_k(x,y)$ and $B_{k+1}(x,y)$ are respectively the background value of the current frame and the next frame.

As we fixed the camera position, for the long period of time the background model can remain relatively stable. Using this method we can effectively avoid the unexpected phenomenon of the background, like sudden appearance of something in the background which is not included in the original background. Moreover by updating the gray pixel value of the background, the impact brought by light, and other changes in the external environment can be effectively adapted.

III. Moving Region Detection

A. *Moving Object Extraction:*

After the background image B(x, y) is obtained, subtract the background Image B(x, y) from the current frame Fk (x, y). If the pixel difference is greater than the set threshold T, then we determines that the about pixels appear in the moving object, otherwise, as the background pixels. After threshold operation the moving object can be detected. Its expression is as follows:

$$D_k(x,y) = \begin{cases} 1, \left| F_k(x,y) - B_{k-1}(x,y) \right| > T \\ 0, Otherwise \end{cases} \quad (3)$$

Where *Dk (x, y)* is the binary image of differential results. Gray-scale threshold is T, its size determines the accuracy of object identification.

As in the algorithm *T* is a fixed value, only for an ideal situation, is not suitable for complex environment with lighting changes. Therefore, the dynamic threshold method proposes in this paper, we therefore dynamically changes the threshold value according to the lighting changes of the two images obtained. On this basis, add a dynamic threshold ΔT to the above algorithm. Its mathematical expression is shown below as:

$$\Delta T(x,y) = \lambda \bullet \frac{1}{MXN} \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} \left| F(i,j) - B(i,j) \right| \quad (4)$$

Then

$$D_k(x,y) = \begin{cases} 1, \left| F_k(x,y) - B_{k-1}(x,y) \right| > T + \Delta T \\ 0, Otherwise \end{cases} \quad (5)$$

Where A is the inhibitory coefficient. Set A to a value according to the requirements of practical applications, and 2 is the reference values. M x N is the size of each image to deal with. M x N numerical results indicate the number of pixels in detection region. ΔT reflects the overall changes in the environment. If small changes in image illumination, dynamic threshold ΔT takes a very small value. Under the premise of enough pixels in the detection region, ΔT will tend to O. If the image illumination changes significantly, then the dynamic threshold ΔT will increase significantly. The impact of light changes effectively suppress by this method.

B. *Reprocessing:*

As the complexity of the background, in addition the difference image obtained contains the motion region, also a large number of noise. So, noise needs to be removed. This paper adopts median filter with the 3 X 3 window to filters out some noise.

After the median filter, the motion region, includes not only fire parts, but also may include swaying trees, moving cars, flowing clouds and flying birds, and other non-body parts. For further processing morphological methods are used. Firstly, to effectively filter out non-fire activity areas corrosion operation is taken. Secondly, to filter out most of the non-body Meter expansion and corrosion operations are done. Some isolated spots of the image and some interference of small pieces are eliminated using the expansion operation, and we get more accurate fire region.

C. *Extraction of fire :*

After median filtering and morphological operations, some accurate edge regions will be got, but the region belongs to the fire could not be determined. By analyzing the characteristics of color feature, based on the results of the methods we will get the fire.

IV. Fire Features

AlMost fuels will burn under appropriate conditions, reacting will oxygen from the air, generating combustion products, emitting light and releasing heat. Flame is a gas phase phenomenon and, clearly, flaming combustion of liquid and solid fuels must involve their conversion to gaseous form. In the point of general fires [11], the flames usually display reddish colors; besides, the color of the flame will change with the increasing temperature. When the fire temperature is low, the color shows range from red to yellow, and it may become white when there is a higher temperature. This reveals that a low-temperature flame emits a light of high color's saturation and a high-temperature flame emits a low-saturation light. Furthermore, the color of fires during the day or with the extra light source has a stronger saturation than that of during the night or no light source. It should be pointed out that both the flame with a very high temperature and some special combustible materials may

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generate bluish flame. Another feature of fires demonstrates the changeable shapes due to the fact that airflow caused by wind will make flames oscillate or move suddenly, as shown in Figure 1. Based on video processing, this dynamic feature will reflect the corresponding effect especially on a variable flame area in an image. Besides, smokes are always generated with a burning fire and have various quantities and colors because of burning different combustible fuels. Based on the above analyses of fire, these features will be used to identify a real fire.

A. *Chromatic Analysis of Flames*

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 color models, HSI (hue/saturation/intensity) color model is very suitable for providing a more people-oriented way of observing the color, because the hue and saturation.components are intimately related to the way in which human beings perceive color [12]. Based on the discussion of fire features as described in the above, it is reasonable to assume that the color of general flames belongs to the red-yellow range. This will map the value of hue of general flames to be distributed from 0^o to 60^o. As mentioned previously, the saturation of a fire will change with various background illuminations that the saturation obtained during the day is larger than that of during the night when the visual image is captured with a color video camera. This is because that the fire will become the major and only illumination if there is no other background illumination. In this situation, the fire-flame will display as more white in the hue according to the operation of cameras. On the other hand, the fire color in an image has less white in the hue when the background illumination is comparable with the fire-light. For providing sufficient brightness in video processing, the intensity should be captured over someone threshold. To avoid leading to a fire disaster, the fire-alarm should be given as soon as detecting a burning fire early. In spite of various colors of fire flames, the initial flame frequently displays red-to-yellow color. To reduce computational complexity, the previous fire-detection algorithm [13] is based on RGB color model for extracting the fire region from an image. The corresponding RGB value will be mapped to the conditions: R ≥ G and G>B, i.e., the color range of red to yellow. Thus, the condition of fire's colors to be detected is defined as R ≥ G > B for the fire region in the captured image. Furthermore, there should be a stronger R in the captured fire image due to the fact that R becomes the major component in an RGB image of fire flames. This is because that fire is also a light source and the video camera needs sufficient brightness during the night to capture the useful image sequences. Hence, the value of R component should be over a threshold, R_T. However, the background illumination may affect the saturation of fire flames or generate a fire-similar alias, and then result in a false fire-detection. To avoid being affected by the background illumination, the saturation value of fire-flame extracted needs to be over someone threshold in order to exclude other fire-similar aliases. This will deduce three decision rules [14] for extracting fire pixels from an image, as described in the following:

rule 1: $R>R_T$
rule 2: $R \geq G>B$
rule 3: $S \geq ((255-R)*S_T/R_T)$
IF (rule1)AND(rule2)AND(rule3)=TRUE
THEN fire-pixel
ELSE not fire-pixel

In *rule* 3, S_T denotes the value of saturation when the value of R component is R_T for the same pixel. Based on the basic concept, the saturation will degrade with the increasing R component, and thus the term of ((255-R)*S_T/R_T) illustrates when R component increases toward the upmost value 255 and then saturation will decrease downward to zero. The relation between R component and saturation for the extracted fire pixels can be plotted in the Figure 2. In the decision rules, both values of R_T and S_T are defined according to various experimental results, and typical values range from 55 to 65and 115 to 135 for S_T and R_T, respectively.

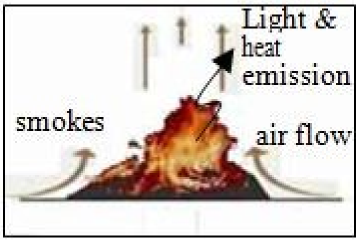

Fig. 1 Burning flame,[14]

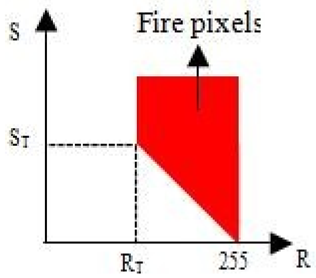

Fig. 2 Relation between R,[14]

B. *Dynamics Analysis of Flames*

Unfortunately Unfortunately, some fire-like regions in an image may Have the same colors as fire, and these fire-similar are usually extracted as the real fire from an image. These fire aliases are generated by two cases: non-fire objects with the same colors as fire and background with illumination of fire-like light sources. In the first case, the object with reddish colors may cause a false extraction of fire-flames. The second reason of wrong fire-extraction is that the background with illumination of burning fires, solar reflections, and artificial lights has an important influence on extraction, making the process complex and unreliable.

To validate area burning fire, in addition to using chromatics, dynamic features are usually adopted to distinguish other fire aliases. These fire dynamics include

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sudden movements of flames, changeable shapes, growing rate, and oscillation (or vibrations) in the infrared response. In[15], fire boxes with the growth rate are used to check areal burning fire and then release a specified action. Another approach[16] defines the degree of fire disorder as the difference between two consecutive final contour images after color masking.

For improving the reliability of detection, we utilize both The disorder characteristic of flames and the growth of fire Pixels to check if it is a real fire. Since the shape of flame is changeable anytime owing to air flowing, the size of a fire's area in an image can't maintain to be constant. And, in point of the fire accident, the flame always has a growth feature. The disorder of fire scan be measured with the pixel quantity of flame difference between two consecutive images. The decision rule on disorder measurement is deduced as:

IF$((|FD_{t+1} - FD_t|) / FD_t) \geq FTD$
THEN real flame
ELSE flame alias

Where $FD_t = F_t(x,y) - F_{t-1}(x,y)$, $F_t(x,y)$ and $F_{t+1}(x,y)$ denotes the current and previous flame image, respectively .FD_t and FD_{t+1} denote the disorder values of current flame image and next flame image, respectively. *FTD* means a disorder threshold, which will distinguish from other fire-like objects. If the above condition is satisfied, it implies that the flame may be likely a real fire, not fire-alias. For increasing the reliability, the disorder checking process should be performed for the times.

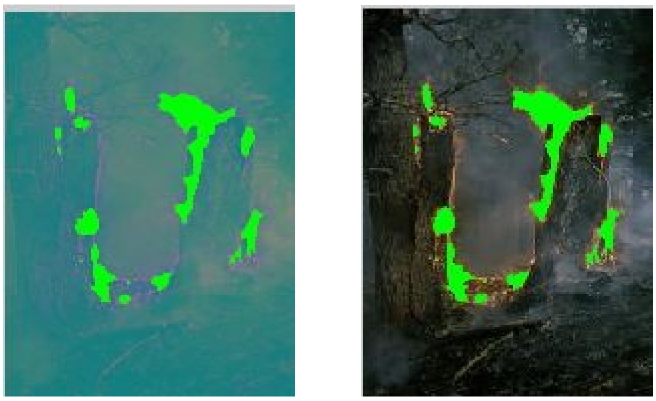
V. Fire-detection algorithm

Based on the above discussions, the proposed early fire-detection algorithm can be concluded in Figure 3. Firstly, moving regions are segmented from the captured image sequences. We establish a reliable background updating model based on statistical and use a dynamic optimization threshold method to obtain a more complete moving object. And then, morphological filtering is introduced to eliminate the noise and solve the background disturbance problem. To distinguish from fire-aliases dynamic features including growth and disorder are utilized for validating these fire-pixels extracted. It should be pointed out that if these fire-pixels satisfy the dynamic features, there is a real fire surely. As soon as anyone raising condition is satisfied, the fire-alarm is given.

VI. Experiment and result

The method proposed above in this paper by using this, ordinary PC, For indoor environment, to capture video images and implement all the procedures we use the static camera. In matlab we can easily implemented image difference algorithm .whenever fire is present it will detect and track. This algorithm detects very effectively controlled and uncontrolled types of fire.

(a) Input image (b)RGB2YCbCr



(c) Fire region image in YCbCr (d)Detected fire

Fig. 3 Detection of fire from video

Experiment results of detection of fire, uses the method we propose are shown in Fig.3. .We see that the method have a very good adaptability in the high and low illumination environment and will able to extract the complete and accurate boundary of the fire.

VII. Conclusions

The research proposes an early fire detection method based on video processing. Both chromatic and dynamic features are used to extract a real flame that is adopted for helping the validation of that fire. This method can easily distinguish the disturbances which having the same color distribution as fire. This method can distinguish fire videos from none fire videos and have a remarkable accuracy. Experiment results show that this method can distinguish flame videos from disturbances which having the same color distribution as flame, such as car lights, and have a remarkable accuracy. To compare with the conventional method, it has better characteristics of real time, accuracy rate.

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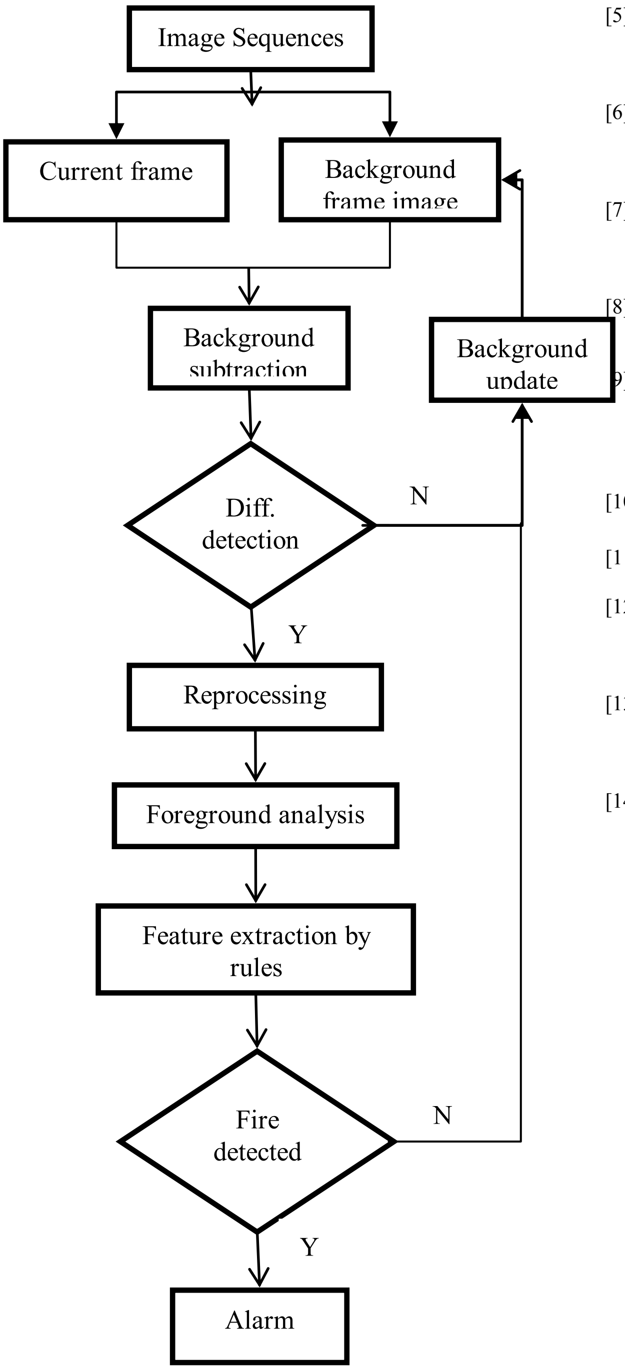

Fig. 3The proposed fire-detection algorithm

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