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Forest Fire Smoke Recognition Based on Gray Bit Plane Technology

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Abstract. Apply the separation principle of the physical contradictions in TRIZ into the simulation of forest fire smoke; propose a forest fire smoke recognition algorithm based on gray bit-plane. To get eight images of moving smoke, the separation process on smoke moving images is necessary; use high-diagram image (the 7th,the 8th image) to extract contours, and extract the contour of the remaining images in the same position. Superimpose the information extracted, get the model of smoke. The results showed that compared with the traditional method based on HSI model, the proposed algorithm can achieve the fire smoke detection quickly and obtain the contour model of the smoke inside efficiently and accurately.

Keywords: TRIZ theory; gray bit plane; contour extraction; mean filtering.

1 Introduction

At present, the occurrence of forest fire is mainly monitored by far infrared and visible light in domestic. Even though that SVM has a good recognition of smoke, but its pattern classifier selection [1] has high false rate; method based on wavelet transform [2] and sparse optical flow. The smoke recognition algorithm based on least squares support vector machine[3] use the color characteristics and rate of change of the area as the feature input vectors, it can reduce the input dimension and shorten the training time.

Usually, frame difference and HSI model are selected to recognize forest fire smoke among the above smoke recognition methods. In this paper, we apply the TRIZ theory into detection, using the method based on gray bit plane and regional adaptive method to detect smoke suspicious area in a single figure with smaller amount of computation.

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2 Application of TRIZ to analyze smoke identifying simulation problems

In contradiction matrix of TRIZ theory, there is no corresponding innovative principle for the intersection of a unified parameter; you need to physically separate the contradictions in order to find corresponding innovative principles. Time became a physical contradiction. According to physical contradiction separation principle, the relationship between the smoke and the image is the whole and the parts, there are 40 innovative principles in physical contradiction separation principle that are closely-related, and some of them can be used to solve the contradiction based on whole and parts. We can learn from the corresponding principles that we can observe the details of smoke by changing the transparency of an object or the environment. In the image processing, there is a concept called the bit plane image, which can layer the images according to different gray scale values. Now, let's analyze the images by means of bit-planes.

3 Suspicious forest fire smoke region detection method based on bit plane graph

Gray bit plane[4] can obtain gray-scale image by separating the different bit planes that has the gray-scale a binary value, different gray bit plane shows different details, the Figure1 showed eight gray bit planes.

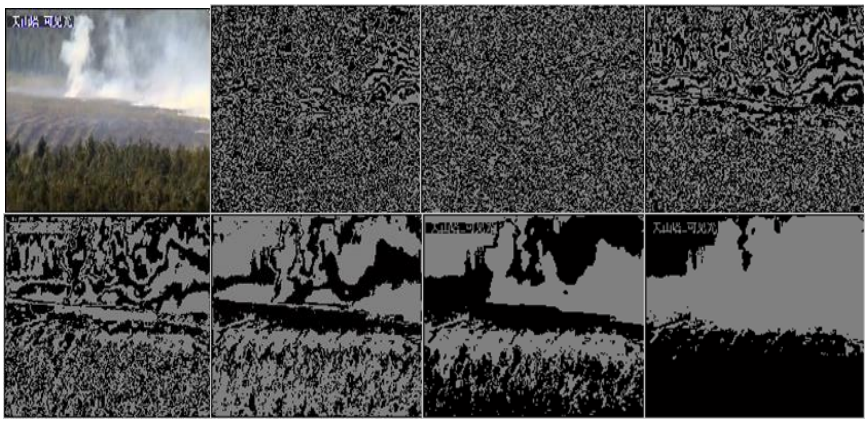


Fig. 1 Original image and gray-scale bitmap

After getting the gray bit-plane, analysis based on the characteristics it contained can be carried on, information can also be extracted. Prior to extract information, we uses mean filtering [5-6] to weaken low-bit information and smooth the high-bit information on the image. We set the image function as:

$$Z(i, j) = T(i, j) + x(i, j) \quad (1)$$

In which, $T(i, j)$ is the image information function, $x(i, j)$ is the noise function. Then, use the smooth formula to calculate which can be defined as:

$$\widetilde{Z}(i, j) = \frac{1}{N}\sum_{1}^{4} Z(i, j) = \frac{1}{N}(\sum_{1}^{4} T(i, j) + x(i, j)) \quad \textbf{(2)}$$

In which, $N = 4$, according to the analysis of probability and statistics, the noise variance is:

$$D\left(\frac{1}{N}\sum_{1}^{4} x(i, j)\right) = \frac{1}{N^2}\sum_{1}^{4} D(x(i, j)) = \frac{1}{N}\omega^2 \quad \textbf{(3)}$$

The variance of detail model of an image will reduce N times in the process of denoising by mean filtering, the smoke recognition model proposed in this paper can be defined as:

$$\delta(x, y) = g_{K-2}(x, y) \bullet g_{K-1}(x, y) \quad \textbf{(4)}$$

The main idea of the smoke models is described by the following points:

(1) Add the motion operator original picture;

(2) Get 8 bit-plane images by separating process；

(3) Get the contour of smoke by contrasting the high-bit images (the 7th and 8th);

(4) Denoise the obtained images;

(5) According the extracted contours, extract the information of the remaining images in the same position;

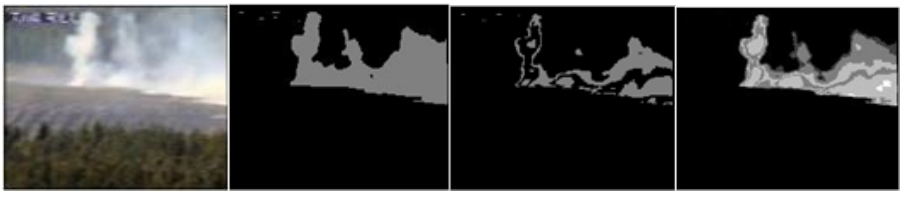
(6) Superimpose information extracted of 8 images;

(7) Get smoke models.

Through the above steps, we can obtain the recognition model of the smoke.

4 Experimental Verification

In order to verify the performance of the algorithm, the experiment is based on 23 video segments obtained from monitoring center of forest. The experiment is achieved on Matlab. In Figure 3, it showed some results of smoke recognition method based on bit-plane.



A. The original map B. Third bitmap C fifth bitmap G. Eighth bitmap

Fig. 3 Results of smoke recognition method based on bit-plane

In order to prove the validity and effectiveness of the method, we made the comparison with the method based on HIS model, Figure5 is comparison chart, and we get the average processing time as shown in Table 1. The results can be seen from the comparative experiments, the processing speed of the proposed method is much quicker than approaches based on HIS model, even though the smoke area are both basically identified.

A. Original image B. Gray-scale image C.HSI method D. Method proposed

Fig. 5 Comparison with HSI experimental diagram

Table 1. Comparison result of two methods

Image type	Fireproof period	Fire	Image number (piece)	HIS (s)	FFSGBP (s)
Visible light	spring	initial fire	280	5.312	3.827
Visible light	spring	mid fire	280	5.287	3.815
Infrared image	autumn	close range	150	2.839	2.035
Infrared image	autumn	outlook	150	2.814	2.012

5 Conclusion

The goal of forest fire smoke recognition is to identify smoke timely and accurately. In this paper, we apply the separation principle of the physical contradictions in TRIZ into the simulation of forest fire smoke and propose a forest fire smoke recognition algorithm based on gray bit-plane. Experimental results show that the method has lower amount of computation and it can satisfy the requirement of accuracy and real-time in automatic forest fire smoke recognition.

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