Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 6 Issue 7, July - 2019

Design of Forest Fire Prevention System Based on Images Recognition Algorithm

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Abstract— **Fire often causes great losses, and forest fires often have the characteristics of sudden, destructive and difficult rescue. Traditional forest fire detection methods have some limitations. Now image recognition algorithms are widely used in forest fire prevention. This project starts from forest background image and image to be detected, according to the difference image and the result image processed by morphology, select areas of suspected flame and smoke, then according to the specific characteristics of flame and smoke, pick up the target of flame and smoke area. Finally, validate target area coincidence characteristics of fire's circularity and smoke's high frequency energy attenuation. Experiments show that the algorithm selected in this design can effectively identify forest fire flame and smoke.**

Keywords—forest fire；image recognition；flame characteristics；smoke characteristics

I. INTRODUCTION

As we all know, forest fires are extremely harmful, often with a wide range and wide spread. They will not only destroy forest structure to a certain extent, promote negative changes in forest environment, disturb the weather, water and soil in forest ecosystem and lose balance, but also threaten nearby villages and towns and endanger people's lives and property in forest areas. Safety. Once a large-scale forest fire occurs, it will also produce a large amount of smoke polluting the air. In addition, fighting forest fires requires a lot of manpower, material and financial resources.

Early detection and early prevention are particularly important in forest fires. Forest fire detection and early warning can detect hidden dangers in time and detect the occurrence of fires quickly, so as to effectively reduce the loss of forest and people's lives and property when fires occur.

Early forest fires are not easy to detect, often more hidden, the forest area is vast, and the background is more complex [1]. Forest fire monitoring technology needs to eliminate these interference factors. How to recognize early forest fires intelligently becomes a key issue. Nowadays, with the rapid development of digital image technology and the maturity of related image recognition algorithm technology, it is becoming feasible to apply image recognition algorithm widely to forest fire prevention, and a feasible forest fire prevention system can be established accordingly.

Traditional forest fire monitoring technologies, including the use of various sensors, artificial forest protection monitoring, aircraft aerial survey, satellite monitoring and so on, have some limitations. The detection technology based on image recognition in forest fire prevention system is based on digital image processing technology. Domestic and foreign researchers choose flame and smoke as the research object in detection. At present, scholars are committed to image processing of fire detection methods [2], flame and smoke processing and recognition.

II. FLAME IMAGE RECOGNITION

When forest fires occur, there are two obvious characteristics: fire flame and fire smoke, which can be used as the basis for judging the occurrence of fires. By extracting and analyzing these two targets according to certain rules, we can get the result image that accords with the occurrence of fire detection. Usually, the content of an image is described by image features. For images containing flame, the most obvious feature in image feature analysis is the color feature of flame. In general, color features are based on pixels, and there is no too much requirement for the size and direction of the image itself, and there is no dependence, so there are not many restrictions in the application.

When fire occurs in a forest background, the color of the flame can be easily distinguished from the green trees and forests. Therefore, in the research, the image under RGB color model is extracted and analyzed. Generally speaking, the color of flame has red, yellow, orange and other colors, and the detection of flame color is the most intuitive and fast [3]. These colors have certain regularity in the color space of visual color model [4].

A. Analysis of Color Features

Now we analyze a group of images which contain flame. These images are stored in computer with RGB color model, so we can start with RGB model. Existing batches of images containing flame and images without flame (including interference sources such as strong light) are analyzed by statistical analysis of RGB component distribution.

If the image contains the flame as a detection target, then obviously, the color of the flame will conform to the following formula:

$$R(x,y) > G(x,y) > B(x,y) \quad (1)$$

R (x, y), G (x, y) and B (x, y) represent the values of the three primary colors in the RGB color model, and the red component should be larger than the mean of the red basic component of all the pixels in the image. As can be seen from fig.1 and fig.2, the three primary color components containing the flame image should satisfy the following relationship:

$$R(x，y) > 200，G(x,y) < 200, B(x,y) < 100 \quad (2)$$

All the pixels of the image are selected. If the pixels satisfy both formula (1) and formula (2), then it is considered that the pixels satisfy the color characteristics of fire flame. Because the flame does not appear as a star, in most cases, there is a part of the connected area of the flame. In the algorithm, we improve it. In an image, if 60% of the points satisfy both formula (1) and formula (2), that is:

$$\begin{aligned} &R(x,y) > G(x,y) > B(x,y) \\ &R(x，y) > 200，G(x,y) < 200, \\ &B(x,y) < 100 \end{aligned} \quad (3)$$

It is considered that the connected area is a flame and can be judged as a fire flame. In the actual image, it is possible to photograph the forest environment with large space. If there is a fire and the area of the flame area appears to be smaller, then the percentage of the pixels can be adjusted according to the experience and actual conditions in the application test, that is to say, the percentage of the pixels can be adjusted by either 60% or 60%. In order to achieve better test results, the numerical range of three components of RGB should be changed appropriately.

B. *Roundness Verification*

After the recognition of flame color features, it can not be immediately determined as a fire flame. On this basis, the extracted connected area needs to be verified. The flame shape is more irregular than the light source (such as flashlight, sun, etc.). Roundness is to describe the degree of similarity between the object of study and the circle. Circumference 0-1, the closer to 1, the more similar the object of study and circle, on the contrary, the closer to 0, the more different the shape and circle are. The definition of roundness is shown in formula (4):

$$C = \frac{4\pi \cdot S}{l^2} \quad (4)$$

C denotes roundness, S denotes area, l denotes area circumference, and complexity is related to the distance of image shooting. In case of forest fire, if a picture is taken from the air or far away, the flame tends to be large, the area is large and the complexity is small; if it is very close to the flame point, then Maybe all of the images are flame areas with less complexity. Only when shooting at a suitable distance can the flame be fully presented. Based on the [5] and [3], the condition that the circularity C is less than 0.8 is considered to be in accordance with the characteristics of the flame, and the values need to be changed in different scenarios.

III. SMOKE IMAGE RECOGNITION

The results show that smoke partially occludes other objects in the early stage of fire gestation. Affected by smoke, smoke blurs background and edge information in images, and attenuates high frequency signals in frequency domain. Non-smoke images usually completely occlude background. According to the characteristics of smoke, we can use wavelet transform to extract background texture of smoke image and distinguish the characteristics of texture blurring, so as to detect or further verify the existence of smoke. By comparing the attenuation of high frequency energy between the front and back images (background image and detection image), we can further verify whether it is smoke after threshold segmentation.

A. *Wavelet Transform*

Wavelet transform can localize the time and frequency domains [6]. It has a flexible time-frequency window. Its main feature is that it can fully highlight the characteristics of one aspect of the object of study through transformation, and refine the signal at multiple scales through scaling and translation operations, so as to achieve time subdivision at high frequency and frequency subdivision at low frequency. The result of rate subdivision. Wavelet transform has the following definitions:

If $\varphi(t)$ is a real value function, its spectrum $\varphi(\omega)$ satisfies:

$$C_\varphi = \int_{-\infty}^{\infty} \frac{|\varphi(\omega)|}{|\omega|} d\omega < \infty \quad (5)$$

Among them, $\varphi(t)$ generates analytical wavelets by translation and scaling:

$$\phi_{ab}(t) = |a|^{-\frac{1}{2}} \phi\left(\frac{t-b}{a}\right) \qquad a \in R，b \in R，a \neq 0 \quad (6)$$

Among them, A is the scale of expansion and B is the scale of translation. Further discretization of scaling and translation is the research field of discrete wavelet transform. In image processing, it is often necessary to discretize the wavelet. This discrete wavelet and its wavelet transform are called DWT. In this paper, we are interested in the high-frequency components of background image and detection image, and wavelet decomposition can decompose signal and image information. After wavelet transform, the image is divided into four parts: horizontal, vertical, diagonal and low frequency. The first three parts are also high frequency information.

Specifically, an image can be decomposed into four parts after discrete wavelet transform: a low-frequency component sub-image and three high-frequency component sub-images, as shown in Figure1 below. Among them, three high-frequency component sub-images contain texture information in horizontal direction (HL), vertical direction (LH) and diagonal direction (HH). When there is smoke in the image, the energy value of these three high-frequency component sub-images is usually reduced.

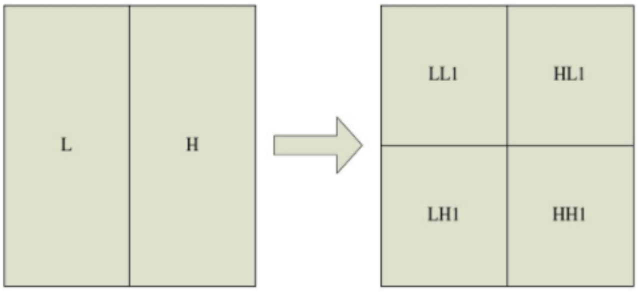

Fig.1 Wavelet transform decomposition graph

B. *High Frequency Energy Attenuation of Smoke Image*

We found two pictures, the same size, the first picture is called background image, the second picture appears smoke, called detection image, respectively, using wavelet transform to get figure 2. It can be seen that after smoke appears, the image becomes blurred, and the high-frequency component part changes from some original image information to less information. The texture information of horizontal direction (HL), vertical direction (LH) and diagonal direction (HH) is less.

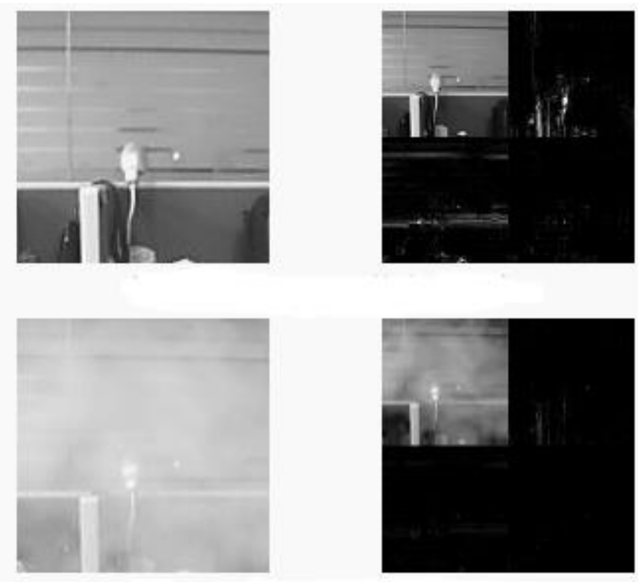

Fig.2 Background Map, Detection Map and Wavelet Transform

We can tell that there is smoke in the latter image. Comparing the high frequency energy value of the current detection image after wavelet transform with that of the corresponding background image after wavelet transform, if the corresponding energy is reduced, it means that the texture or edge of the current image is no longer the same. The background image is so sharp that smoke appears in the corresponding image block. After the maximum variance threshold is used to extract the area containing smoke in forest fires, it can't be immediately confirmed that the area is smoke. After the verification of high frequency energy attenuation, we consider it as smoke, which ensures the accuracy of the algorithm to a certain extent.

IV. CONCLUSION

Based on image recognition algorithm, this paper detects and recognizes forest fire image, identifies whether there is flame in the image, and finally gives a prompt and alarm. The design of fire prevention system is based on the platform of MATLAB, which reads the background image and the detection image in turn, carries on the image difference calculation to them, uses the closed operation of morphological processing to find the connected area, and the frame is selected and displayed, which can be used as the early warning of image frame selection; and then carries on the feature recognition and extraction to the flame and smoke, RGB three components. The part which accords with a certain range of extraction is initially considered to be flame, and is segmented and extracted by maximum variance threshold method, which is considered to be smoke. Then validate the area: flame roundness validation, smoke high-frequency energy attenuation validation, and finally output text prompts as text early warning.

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