Advances in Engineering Research (AER), volume 116
International Conference on Communication and Electronic Information Engineering (CEIE 2016)

Analysis of spectral characteristics for forest fire images based on Fourier Transform

Zhi-Jian Yin[a], Qiang Luo[b], Tian-Tian Tang[c] and Zhao-Pan Wu[d]
School of Communications and Electronics, Jiangxi science & technology normal university, Nanchang 330000, China
EmaiL: [a]86412656@qq.com,, [b]13576918019@163.com, [c]614994205@qq.com, [d]654591305@qq.com
www.jxstnu.cn

With the continuous development of the national economy, people pay more and more attention to the monitoring and early warning of forest fire. Due to the particularity of the forest area and geographical conditions, if the forest fire happens, it will be a bursty and destruction of natural disaster. As forest fires identification problem research, the research based on image to identify forest fire has become the main research direction. By using the spectrum characteristics of the Fourier transform to research the forest fire image, the paper analyzes it in the frequency domain of the image by using histogram equalization and smoke spectrum. This paper finally analyzes the energy distribution of fire image, which paves the way for the further study of forest fire recognition.

Keywords: Forest Fire; Fourier Transform; Frequency Domain; Energy Distribution.

1. Introduction

In the forest fire monitoring system nowadays, traditional forest fire monitoring scheme cannot meet the actual needs. The fire recognition scheme based on the fire image must be the main direction of future research of forest fire forecast. This paper focuses on the characteristics of Fourier fire image. Through the forest fire image Fourier transform, first it will be dealt through histogram equalization and Butterworth low-pass filter, and in the end the fire image edge information is more prominent. In this paper finally analyses the energy distribution of fire image, and the dissertation has important significance for forest fire prevention.

2. Image Fourier Transform and Transform Characteristics

In digital image processing, scientists have proposed many kinds of application in different areas of digital image transformation methods, such as wavelet transform and K-L transform, and Fourier transform is not only the most common image processing, but also the most important a digital image transformation method.

In 1982, in the heat conduction theory, Fourier proposed an arbitrary periodic function can divide into infinite different frequency sine signal , namely Fourier series, the process of solving the Fourier series is the Fourier transform, one-dimensional signal f(x), Fourier transform formula:

$$F(u)=\int_{R} f(x)*e^{-jux}dx,\ j=\sqrt{-1} \tag{1}$$

Two-dimensional Fourier transform has an important position in the field of modern digital signal processing. The mathematical meaning of the two-dimensional Fourier transform is transforming a non periodic discrete matrix into a series of discrete periodic matrix, and its physical meaning is transforming the spatial domain of the image brightness distribution into image in the frequency domain distribution of value, Fourier transform provides an alternative analysis method for digital signal and image processing.

For two-dimensional images, assuming that the image size is M*N, then the image that is the cycle of the M*N discrete signal, Fourier transform type 2-DFT, the expression of the formula is as follows:

$$F(u,v)=\sum_{x=0}^{M-1}\sum_{Y=0}^{N-1} f(x,y)e^{-j2\pi(ux/M+vy/N)} \tag{2}$$

Among them, u=0, 1, 2, M-1, v=0, 1, 2, ..., N-1, and u, V is frequency value. Y, X is the frequency values in the airspace, M and N is the digital image size. From the publicity can be seen, after the digital image transformed by Fourier transform, the frequency domain cycle signal is also the size of the M*N.

The frequency spectrum of the image information reflects the distribution of each frequency in the digital image, after image signal is transformed by Fourier transform spectrum, the spectrum distribution is: with the frequency from low to high, the energy distribution is from large to small, and the image spectrum to DC corresponding spectral components as the center of distribution. The direct current in the spectral image reflects the average brightness of the digital image. Such as a large area of desert in the digital image is like a picture of a single color and slow change region. And the corresponding frequency value is very low. And compared to those areas of severe surface attribute transformation, such as urban remote sensing images, the corresponding high frequency content is relatively large. From the physical effect, the two-dimensional Fourier transform is transforming the digital image from time domain to frequency domain, that is, analyzing the characteristics of the image in the frequency domain. From another point of view, the essence of Fourier transform is transforming intensity distribution function of the image through two-dimensional Fourier transform to the image in the frequency domain distribution function, so that we from the view of frequency domain, to analyze and extract the image characteristics in time domain.

3. Enhancement Spectrum of Fire Image

In this paper, It needs to enhance forest area in the image, so post processor can distinguish more parts of the forest fire image. Then we use histogram equalization method to achieve the enhancement of the region image.

The histogram equalization is a method of automatically adjusting the image contrast quality by using the gray level transformation. The basic transformation principle is to obtain the gray level transformation function through the probability density function of the gray level. Simply says, that is making the probability distribution of known digital image through specific change way, into a uniform probability distribution of digital image. Making it more convenient for us to deal with it later. In the case of continuous random variables, the mathematical relationship between the transformation function and the probability density of original function is:

$$s = T(r) = \int_0^r p_r(r)dr \quad (0 \le r \le 1) \tag{3}$$

And $T(r)$ must meet the conditions: $(0 \le T(r) \le 1)$

In the discrete form of digital images, the mathematical relationship between the transformation function and the probability density function of the original function is:

$$s_k = T(r_k) = \sum_{i=0}^{k} \frac{n_i}{N} = \sum_{j=0}^{k} p_r(r_j) \quad \text{Among } (0 \le r_j \le 1 \quad k = 0,1,2,\dots,L-1) \tag{4}$$

According to digital image processing, the general steps of image histogram equalization are:

1. Using software comes from the function of the histogram to process digital image.

$$p(s_k) = \frac{n_k}{n} \quad k = 0,1,2,\dots,L-1 \tag{5}$$

2. Using the cumulative distribution function of the original digital image of the statistical histogram transform, to get a new image gray.

3. The approximate processing, and using the new gray image to replace the

old grayscale. At the same time, the gray values are multiplied to get Ps(S).

In the actual image transformation process, first of all, statistics from gray distribution of the original image should be figured out, then according to the corresponding formula, to calculate distribution histogram of original image, finally the gray level histogram distribution function to transform the original image pixels from one to one, In this paper a fire image is as an example, showing the effect of digital image histogram equalization. Its comparison is as shown in figure 1 and figure 2.

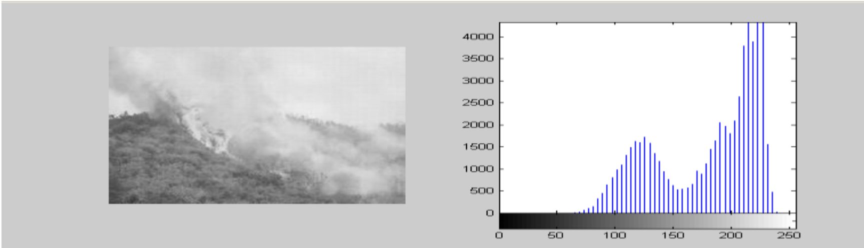

Fig. 1 The gray scale and the histogram of the original image

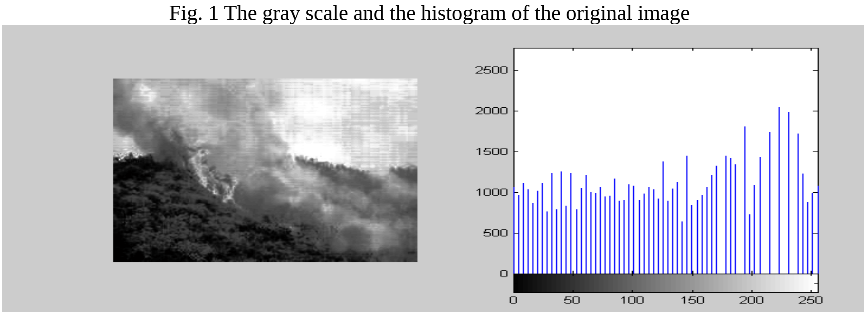

Fig. 2 The gray scale and histogram after the the equalization of histogram

From the experimental results, we can see that the digital image after histogram equalization significantly improves the contrast of the digital image. The smoke and flame area in the image is more obvious, and the edge feature of the image is highlighted. For the next image spectral analysis and digital filtering of the image, it has played a great role.

4. Energy Spectrum Analysis of Fire Image

In the natural environment, we know that the mountain edge of the image is more clear. But if there is a forest fire disaster, fire smoke will block the mountain edge. Making the collected image edge information is not a lot. This section is on the basis of the characteristics of forest fire images launches the research, and focuses on the analysis of image spectral energy distribution. So it can recognize fire in image signal better. According to the prior analysis of two-dimensional Fourier transform, we can not only get the image amplitude spectrum and phase spectrum, but also get the image of an important information, that is energy spectrum, which reflects the is digital image energy feature and the image signal in the frequency domain energy into cloth. Its mathematical definition is as follows:

$$E(u,v) = \left|F(u,v)\right|^2 = R^2(u,v) + I^2(u,v) \tag{6}$$

In the formula, F (U, V) is the amplitude spectrum of the image, R (U, V) is the image amplitude spectrum of the real part, I (U, V) is as the imaginary part of the amplitude spectrum of the image.

We use a fire image as an example, to analyze the energy distribution of fire image signal. The size is 256*256. In general, the frequency band of the image signal is limited, and we know that the energy distribution of the image decreases with the increase of frequency according to the amplitude spectrum of the front. The spectral energy is larger, the brightness of the point is stronger, similarly, the energy is small then the brightness of the point is smaller. As shown in figure 3-12-b, most of the spectral energy of the image is concentrated near the low frequency of the energy spectrum, and the spectrum is spread around the image. The energy of high frequency part is weak and distributed at the edge of the energy spectrum.

Next, we analyze and discuss the distribution and distribution of the image in the energy spectrum from the angle of mathematics. Assuming a forest fire image size is an M * N, then in the frequency domain, general m * n matrix energy of each point are added, and it constitutes the image signal of the total spectrum energy er. In other words, the spectral energy of the digital image can be obtained by the integral of the amplitude spectrum in the frequency domain. The calculation method is as follows:

$$E\mathrm{r} = \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} E(u,v) \tag{7}$$

Among them, Er is the total energy of the digital image, and E (U, V) is the energy spectrum of the digital signal.

Therefore, in the energy spectrum, we use spectrum center as the center, R made a series of concentric rings radius. The spectrum energy distribution of digital image is analyzed by analyzing the percentage of spectral energy in different radius. Its calculation method is as follows:

$$\beta = 100 \times \left[\sum_{u=0}^{R} \sum_{v=0}^{R} E(u,v) / Er \right] \tag{8}$$

In order to be able to analyze in a more quantitative the image information representation status of the forest fire image energy distribution and study digital image in smoke and image power spectrum distribution between contact, we transform the mountain and forest fire image image in spectrum transform and energy spectrum transform. The conversion results are shown in figure 3.

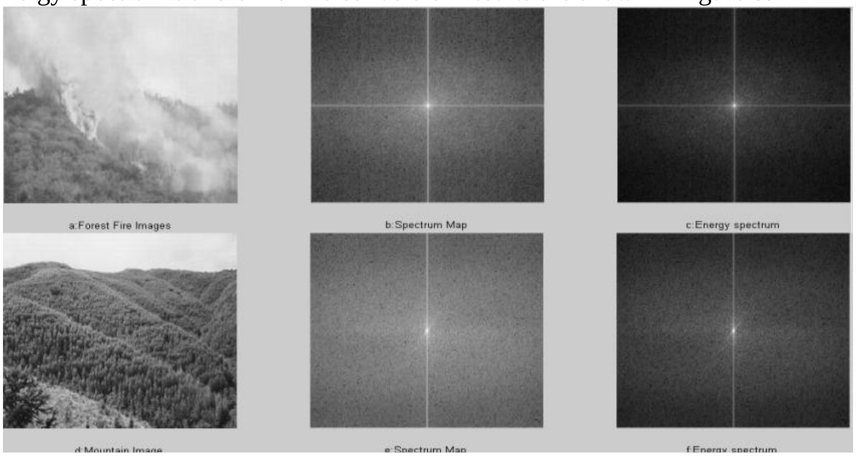

Fig. 3 The energy transform of fire image and a mountain fire

From figure 3 we can see that the energy distribution of forest fire images are mostly concentrated in the low frequency domain. And the energy contained in the high frequency part (i.e. image edge) is relatively low. And in the energy map of the mountain image although the low-frequency field concentrated most of the energy of the image, but in the high frequency part (that is, the image edge) also contains part of the energy, and significantly higher than the high frequency part of the forest fire image to high. In order to analyze qualitatively image energy distribution, image energy spectrum graph data were statistically analyzed, and the different radius of the energy distribution of image statistics, the statistical results are shown in Table 1 and 2 shows.

We can learn from the Table 1, 2 , in different radius, circle fire image energy is larger than the energy of image to the high mountains. And mountain image in the field of high frequency energy accounted for ratio (8.55%) was higher than that of the forest fire image in the field of high frequency energy accounted for higher than (2.75%). This can be used as an identifying feature of forest fire.

Tab. 1 Image energy distribution in forest fire smoke image

R(spectral radius)	Er(total energy image)	E_R (radius of energy)	B(energy ratio)
20	2534320.205	142812.1826	5.64%
40		450227.4013	17.77%
60		867979.0397	34.24%
80		1333086.103	52.60%
100		1815844.722	71.65%
120		2464726.574	97.25%

Tab. 2 Image energy distribution in mountain area

R(spectral radius)	Er(total energy image)	E_R (radius of energy)	B(energy ratio)
20	3926356.873	161899.5445	4.12%
40		555413.8361	14.15%
60		1140977.777	29.06%
80		1880889.059	47.90%
100		2702210.971	68.82%
120		3578733.231	91.45%

5. Conclusion

This paper processes and analyzes histogram equalization and smoke spectrum feature, through the forest fire image of the Fourier transform and spectrum of the image. And in the last part of the paper, it analyzes the forest fire image and the spectral energy distribution. This has an important role in recognition of these features on the fire image, and paves the way for subsequent research work.

Reference

1. Huang Rule. The study of forest fire smoke recognition method based on video image. [D]. Beijing Forestry University.2011.26-30.
2. Li Hongdi. Yuan Fei Niu. Image smoke detection using the texture and edge features of Pyramid [J]. Chinese Journal of image and graphics.2015[6].2-4.
3. Chou Guoqin. Research on flame recognition and detection technology based on image features [J]. automation and instrumentation.2012[3].6-7.
4. Liu Deying. Rice image recognition method based on image features[J]. Journal of agricultural engineering. 2012 (7). 1-2.