The Extraction of the FAE Image Profilogram Based on the Grey Level Thresholding

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Abstract

The profilogram of FAE (fuel-air explosive) fuel explosion image is the important base to analyze the explosion process. In this article, the double peak method, the iteration method, the OTSU method, and the maximum entropy criterion method are respectively used to confirm the threshold, and extract and compare the profilograms of the FAE fuel explosion image, which could establish the base for the further experiment analysis.

Keywords: Profilogram, Explosion image, Grey level thresholding

1. Introduction

FAE first occurred in 1960s-1970s, and it is one the most important conventional weapons, with the name of "mini-nukes". Since it came out, the fuel, the warhead structure, and the ignition mode all have been developed largely (Kenneth S Brower, 1987, P.1405 & Bull C, 1982, P.7-22). To quicken the research and application of FAE weapons is very important to enhance the national defense strength of China, and strengthen the fighting capacity of the force. The throwing rule and the clouds formation of the FAE fuel explosion are the most important research content in the FAE studies, and many research institutions in China and foreign countries have developed the research about this aspect in succession.

The image profilogram is one of the most basic characteristics of image, and it often takes most information of the image, and it is the key to analyze and process the explosion image. If the extraction of profilogram is not exact, the subsequent analysis would face large error, even false result, so the profilogram extraction method according with the explosion image should be found and researched.

2. Definition of profilogram

The profilogram is to connect the marginal points in the image according to certain strategy, and it is the very important base of many aspects such as the image segmentation, the target region identification, and the regional formation extraction in the image analysis domain. Though the marginal profilogram is very important in the image processing and analysis, but up to now, there has not been the exact and extensively admitted mathematical definition of the margin.

The image margin occurs by the discrete form of local characteristics of the image, i.e. it includes the local parts of the image with the most significant variations of brightness, such as the mutation of grey level, the mutation of color, and the mutation of texture structure, and the margin of the object is the parting of different regions. The image margin has two characteristics such as the direction and the amplitude, and generally, along the trend of the margin, the grey level changes slowly, and the grey level of pixel changes drastically perpendicular to the margin. According to the characteristics of the grey level change, the grey level change includes the step type, the roof type, and the flange type (seen in Figure 1).

3. Grey level thresholding

The image grey level thresholding is a kind of image segmentation technology which has been used extensively (Shen, 2005, P.281-286 & Luo, 2006, P.17-20 & Cai, 2006, P.122-124). It uses the difference of the grey level characteristic between the target object with the background in the image, and regards the image as the combination of two sorts of area with different grey levels, and selects one proper threshold, and confirm whether each pixel point in the image should belong to the target area, or the background area, and obtains the corresponding binary image. It could not only compress data and reduce the storage content, but also largely

simplify the subsequent analysis and processing approach. This method first confirms one grey level threshold in the range of the image grey level, and then compares the grey level values of various pixels in the image with this threshold, and divide the corresponding pixels into two sorts according to the comparison result, and the grey level values of the pixels exceeding the threshold belong to one sort, and the grey level values of the pixels less than the threshold belong to the other sort. These two sorts of pixel generally belong to two areas in the image, so the thresholding could segment the area. The thresholding includes the whole thresholding and the local thresholding. For one image, the segmentation could be based on multiple thresholds, or based on single threshold, and though the multiple thresholds segmentation could further enhance the segmentation quality of the image, but its principle is same with the single threshold segmentation, and only the segmentation skills are different.

From above approaches, to confirm the threshold is the key of the image segmentation. The threshold generally could be written as the form as follows.

$$T = T[x, y, p(x, y), q(x, y)] \tag{1}$$

Where, $P(x, y)$ represents the grey level value of the pixel point (x, y), and $q(x, y)$ represents the local characteristics of this point. If $p(x, y) > T$, the point (x, y) is noted as the object point, or else, it is noted as the background point. According to different limitations of T, three different types of threshold could be obtained, i.e.

The whole threshold $T = T[p(x, y)]$, and it is only related with the characters of various pixels in the image;

The local threshold $T = T[p(x, y), q(x, y)]$, and it is related with the values of various pixels in the area, and the relationships with the neighboring pixel values;

The dynamic threshold $T = T[x, y, p(x, y), q(x, y)]$, and it is related with the spatial coordinate of pixel, and the pixel character of the point, and the local area character of the point.

Generally, the selection of threshold is based on the grey histogram (seen in Figure 1). The threshold segmentation method of the histogram is the most intuitional and general one in the application. For the histogram, this method has obvious double-peak image, with good segmentation effect. When the content of image is not complex, and the grey distribution is centralized, the simplest whole threshold is often adopted, without considering the positions of the points in the image and its neighboring area character. But in the practice, the grey histograms of most natural images change abundantly, without obvious double-peak. For these images, one method is to divide the image into many sub-images, and set up local threshold to each sub-image, and the other method is to adopt the dynamic threshold according to the space information and the grey information.

The usual threshold selection methods include the double-peak method, the iteration method, the OTSU, and the maximum entropy criterion.

(1) Double-peak method. Supposed that one image is composed by the foreground and the background, and on the grey histogram, two grounds would form the peak. The position of the lowest valley between two peaks is the location of the threshold of the image. This method is fit for the images with the obviously different of the foreground grey level and the background grey level.

(2) Iteration method. First, solve the maximum grey value and the minimum grey value of the image, and respectively note them as T_{max} and T_{min}, and the initial threshold is $T_0 = (T_{max} + T_{min})/2$. Second, according to the present threshold T_k, segment the image into two images, and respectively compute the average grey level values of two images, and note them as T_b and T_f, and the new threshold is $T_{k+1} = (T_b + T_f)/2$. Third, if $T_{k+1} = T_k$, $T = T_k$, or else, turn to the second approach.

(3) OTSU. Supposed that the grey level range of the appointed image is $[L_1, L_2]$, and the amount of the i'th grey level pixel is $h(i)$ ($L_1 \le i \le L_2$). The total amount of the pixel in the image is $N = \sum_{i=L_1}^{L_2} h(i)$, and the existence probability of each grey level is $p_i = h(i)/N$, and the grey level t is the threshold of the image, and it divides the pixels in the image into two sorts, C_0, C_1, and C_0 is the amount of the pixel which grey level is in $[L, t-1]$, and C_1 is the amount of the pixel which grey level is in $[t, L_2]$. So, solve t and maximize

$$f(t) = w_0 w_1 (u_0 - u_1)^2 \tag{2}$$

, where, $w_0 = \sum_{i=L_1}^{t-1} p_i$, $u_0 = \sum_{i=l_1}^{t-1} p_i / w_0$, $w_1 = \sum_{i=t}^{L_2} p_i$ and $u_1 = \sum_{i=t}^{L_2} p_i / w_i$.

(4) Maximum entropy criterion. Solve solve t and maximize

$$f(t) = H_0 + H_1 \tag{3}$$

, where, $H_0 = \sum_{i=L_1}^{t-1} \frac{p_i}{w_0} \ln \frac{p_i}{w_0}$, $H_1 = \sum_{i=t}^{L_2} \frac{p_i}{w_1} \ln \frac{p_i}{w_1}$.

4. Experiment results

The double peak method, the iteration method, the OTSU method, and the maximum entropy criterion method are respectively used to extract the profilograms of the FAE explosion image in Figure 2, and the result is seen in Figure 3.

Through the comparison and analysis of above methods, for same one image, the grey thresholds from different methods are different, and the profilograms are different, and the thresholds and the marginal points from different threshold selection methods are seen in Table 1. From the analysis, when using the threshold method to extract the profilogram of the explosion fireball, if the threshold is too big, the surplus part of the image will be extracted, and if the threshold is too small, the useful information will be lost, so the selection of the threshold would influence the analysis result.

5. Conclusions

By the grey threshold segmentation method, the profilogram of the FAE fuel explosion image is segmented, which could establish the base for the further experiment analysis. But because of complex experiment environment and many interference factors, when using the threshold method to extract the profilogram of the explosion fireball, some pixels of non-margin profilogram would be extracted, and one complete and successive profilogram of the fireball margin could not be obtained, which needs further image processing.

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Table 1. Thresholds from different threshold selection methods

Method	Threshold	Number of marginal point
Double peak	235	1784
Iteration method	238	1898
OTSU	210	2048
Maximum entropy criterion method	215	1961

Step type   Proof type   Flange type
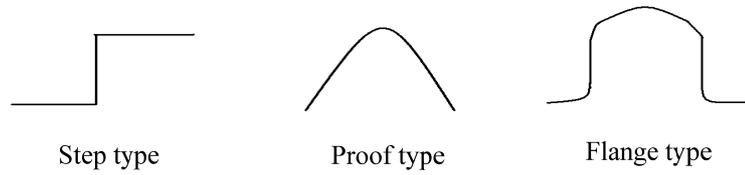
Figure 1. Grey Changes of the Image Border

Original image   Grey image   Histogram
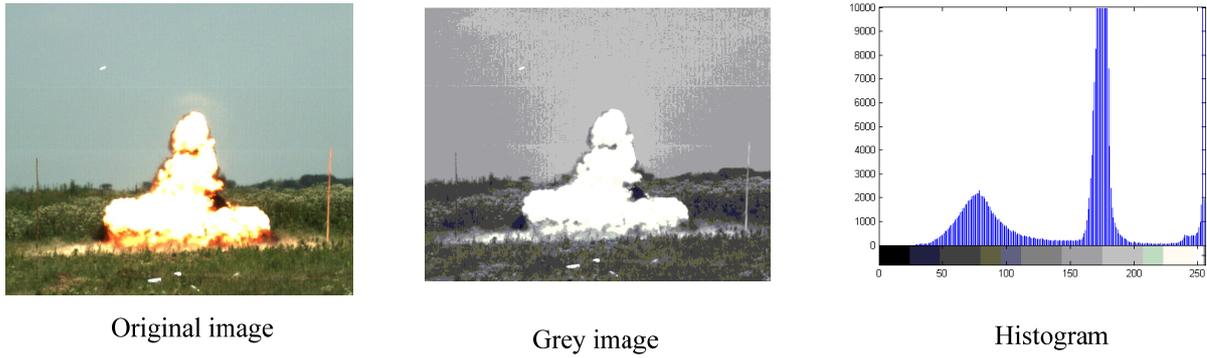
Figure 2. Principle of Threshold Squared Partition

Double peak   Iteration Method

OTSU   Maximum entropy criterion
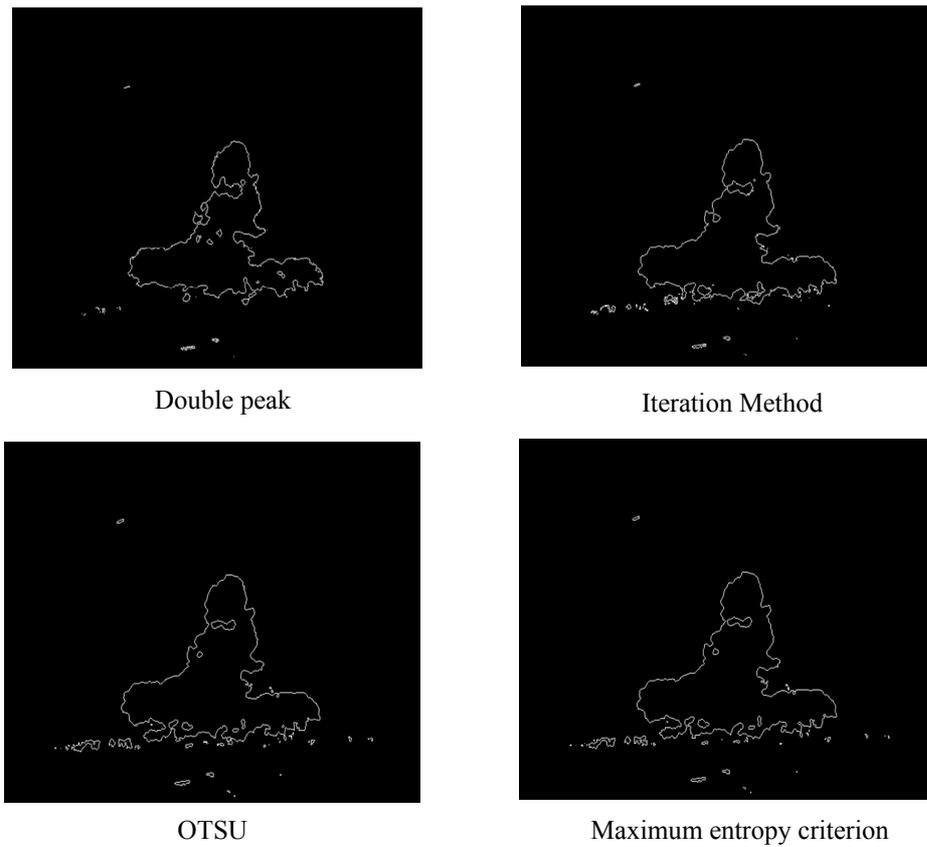
Figure 3. Effects of Four Methods Extracting Profilograms