Research on Target Segmentation Method Based on Maximum Entropy Method

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Abstract. According to the background requirements of the target guided weapon identification, the different characteristics of the existing threshold segmentation methods are analyzed, a threshold calculation method based on maximum entropy is studied, and the aerial targets and ground target images collected by a certain type of equipment are used to adopt two-dimensional. The maximum entropy method is used to perform threshold segmentation experiments. By comparing the segmentation effects of different methods on aerial targets and ground target images, it is concluded that the maximum entropy method has better resistance to background interference and universal applicability.

1. Introduction
In the terminal guidance weapon, target recognition effect is the key link to strike the target accurately. Threshold segmentation is the key technology to realize target recognition [1-3]. Threshold segmentation is a region-based image segmentation technology, which is suitable for images with different gray levels occupied by target and background. Simply speaking, threshold segmentation is the process of separating target from background by selecting appropriate gray threshold. Obviously, the key of threshold segmentation is how to select the threshold [4-6]. So we need a method of automatic threshold acquisition to segment and extract the target. The commonly used methods of automatic threshold acquisition are: averaging method, iteration method, Otsu method. The average method is relatively simple and requires a high degree of contrast between target and background in practical application [7-9]. Iterative method can be regarded as an optimal threshold from the point of view of path planning, because the obtained threshold is inversely proportional to the center of gravity of the target and background area. However, the iterative method still requires a high degree of contrast between the target and the background. Otsu method is an automatic threshold acquisition method which maximizes the variance between classes. It is derived by Otsu on the basis of the principle of least square method. Otsu method is simple in calculation and fast in processing. It has a good segmentation effect for bimodal image of histogram, but the segmentation effect is not obvious when the proportion of target and background is large [10-12]. In this paper, a threshold calculation method based on maximum entropy is studied. Compared with the above methods, the application of maximum entropy method requires less contrast between target and background, and its application is limited less.
2. Threshold Calculation Method Based On Maximum Entropy

In digital image processing, the entropy reflects the overall picture of the image. When the image contains the target, the information at the intersection of the target and the background is the largest, that is the maximum entropy. Maximum Entropy Threshold Segmentation is based on this principle for image segmentation.

(1) One-dimensional Maximum Entropy Method

According to information theory, entropy is defined as

\[ H = - \int_{-\infty}^{\infty} p(x) \log p(x) \, dx \]  

(1)

In the formula, the probability density function \( p(x) \) of a random variable \( x \) is expressed. In digital images, random variables \( x \) can be gray values, regional gray levels, gradients and other features. The so-called maximum one-dimensional entropy of gray level is to select a threshold to maximize the information of the first-order gray level statistics of the two parts of the image segmented by this threshold.

Let the image with gray scale range \([0, L-1]\) be divided into target \( O \) and background \( B \) by threshold \( t \). The pixel distribution of \([0, t]\) and \([t+1, L-1]\) are respectively:

\[ B: p_0, p_1, p_2, \ldots, p_t \]

\[ O: p_{t+1}, (1-p_t), p_{t+2}, (1-p_t), \ldots, p_{L-1}, (1-p_t) \]

As, \( P_t = \sum_{i=0}^{t} p_i \), Let two information entropy are \( H_B(t) \) and \( H_O(t) \), so

\[ H_B(t) = -\sum_{i=0}^{t} \frac{p_i}{P_t} \ln \frac{p_i}{P_t} = \ln P_t + \frac{H_t}{P_t} \]  

(2)

\[ H_O(t) = -\sum_{i=t+1}^{L-1} \frac{p_i}{1-P_t} \ln \frac{p_i}{1-P_t} = -\frac{1}{1-P_t} \left[ \sum_{i=t+1}^{L-1} p_i \ln p_i - (1-P_t) \ln(1-P_t) \right] \]

\[ = \ln(1-P_t) + \frac{H - H_t}{1-P_t} \]  

(3)

Among them, \( H_t \) and \( H \) respectively

\[ H_t = -\sum_{i=0}^{t} p_i \ln p_i \]  

(4)

\[ H = -\sum_{i=0}^{L-1} p_i \ln p_i \]  

(5)

The entropy \( H(t) \) of the image is the sum of \( H_B(t) \) and \( H_O(t) \).

\[ H(t) = \ln P_t (1-P_t) + \frac{H_t}{P_t} + \frac{H - H_t}{1-P_t} \]  

(6)
When the maximum value of entropy $H(t)$ is taken, the corresponding gray value $T$ is the optimal threshold, that is, the gray value $T$.

$$T = \arg \max \{H(t)\} \quad (7)$$

(2) Two-Dimensional Maximum Entropy Method

One-dimensional maximum threshold segmentation only uses the gray information of points but does not make full use of the spatial information of images. In the sense of noise, the gray features of regions are obviously lower than the gray features of points. Therefore, if the two features can be used together, the information of images can be better represented. The two-dimensional maximum entropy method is to use the above ideas to achieve effective segmentation of images.

If the size of the original image is $M \times N$, the gray level is $L$, and the four pixels of each pixel and its four neighborhoods are one region, then each pixel corresponds to a pair of gray-level-area gray-level mean values, and there is possible value for such data pairs. Let the gray level $n_{i,j}$ of the representative point be $i$, pixel points of regional gray mean is $j$ and the probability of the occurrence of the gray level $p_{i,j}$ of the representative point-the mean of the regional gray level $(i, j)$, then

$$p_{i,j} = \frac{n_{i,j}}{M \times N}, (i, j = 1, 2, ..., L) \quad (8)$$

$Up$ is a two-dimensional histogram of the image with respect to the point gray-level-area gray-level mean pair.

According to the fact that the probability peaks of point gray-area gray value are mainly distributed near the diagonal line of two-dimensional histogram plane, we divide the two-dimensional histogram plane into four regions, as shown in Fig. 1. Area A and area B along the diagonal line represent background and target respectively, and area C and area D far from the diagonal line represent boundary and noise respectively. Therefore, we can determine the optimal threshold by using point gray-area gray-level mean to two-dimensional maximum entropy method in area A and B to maximize the amount of information truly representing target and background.

If the threshold is $(s, t)$ the probability of each region is normalized by the posterior probabilities of regions A and B, then the probability $p_{i,j}$ of each region is normalized by the posterior probabilities of regions A and B.

$$\begin{cases} P_A = \sum_{i=1}^{s} \sum_{j=1}^{l} p_{i,j} \\ P_B = \sum_{i=s+1}^{l} \sum_{j=t+1}^{L} p_{i,j} \end{cases} \quad (9)$$

We define discrete two-dimensional entropy as

$$H = -\sum_{i} \sum_{j} p_{i,j} \log p_{i,j} \quad (10)$$

Then the two-dimensional entropies in A and B regions are respectively
\[ H(A) = -\sum_i \sum_j (p_{i,j} / P_A) \log(p_{i,j} / P_A) \]
\[ = (1 / P_A) \sum_i \sum_j p_{i,j} - (1 / P_A) \sum_i \sum_j p_{i,j} \log p_{i,j} \]  
\[ = \log P_A + H_A / P_A \]  
\[ H(B) = -\sum_i \sum_j (p_{i,j} / P_B) \log(p_{i,j} / P_B) \]
\[ = (1 / P_B) \sum_i \sum_j p_{i,j} - (1 / P_B) \sum_i \sum_j p_{i,j} \log p_{i,j} \]  
\[ = \log P_B + H_B / P_B \]  

Where

\[ H_A = -\sum_i \sum_j p_{i,j} \log p_{i,j} \]  
\[ H_B = -\sum_i \sum_j p_{i,j} \log p_{i,j} \]  

Figure 1. Two-dimensional histogram plan.

A and B regions contain most of the pixels in the image. Compared with them, the number of pixels in C and D regions is negligible compared with the number of pixels in the whole image, so we set it up in regions C and D \( p_{i,j} \approx 0 \). Therefore:

\[ \begin{align*}
  P_B &= 1 - P_A \\
  H_B &= H_L - H_A
\end{align*} \]  

So

\[ H(B) = \log(1 - P_A) + (H_L - H_A) / (1 - P_A) \]  

\[ \text{(15)} \]
The two-dimensional entropy of an image can be expressed as sum of $H(A)$ and $H(B)$, i.e.

\[
H(L) = H(A) + H(B)
\]

\[
= \frac{H_A}{P_A} + \log P_A + (H_L - H_A)/(1 - P_A) + \log(1 - P_A)
\]

\[
= \log[P_A(1 - P_A)] + \frac{H_A}{P_A} + (H_L - H_A)/(1 - P_A)
\]

When the maximum value of entropy is taken, the corresponding vector is the optimal threshold.

\[
(s^*, t^*) = \arg \max \{H(L)\}
\]

In the following experiments, the two-dimensional maximum entropy method is used to process the image.

3. Experimental Analysis

Taking the aerial target captured by a certain type of equipment as the object of study, as shown in Fig. 2, several methods are used to segment the image, and different methods are used to calculate the threshold in Matlab environment as shown in Table 1 below.

The processed images are compared in Fig. 3, Fig. 4, Fig. 5, Fig. 6.

| Threshold | Average | Iterative method | Otsu | Maximum |
|-----------|---------|------------------|------|---------|
| Value     | 117     | 163              | 162  | 126     |

Figure 2. The aerial target image captured.

Table 1. Calculation results of different thresholding methods

Figure 3. Iterative processing results.

Figure 4. Otsu processing results.
By analyzing the processing results, we find that the average method is more ambiguous than the other three methods, and does not clearly identify the obvious target; however, the results of Otsu method and iteration method are clear, but not complete; when observing the maximum entropy method, we can clearly see the complete target, although there are still some clutter residues, but it does not affect the final recognition. No. Therefore, the maximum entropy method is considered to be the best method for threshold segmentation, that is, 126 is the best threshold for segmentation.

Taking the ground maneuvering target acquired by a certain type of equipment as the research object, as shown in Fig. 7. Several thresholding methods are used to segment the image, and the image is shown in Fig. 8, Fig. 9 and Fig. 10.

The experimental results show that the background of aerial target is relatively simple, and the effect is better after the iterative method and Otsu method are processed, and the target is clearer. However, the ground background is complex, the image after threshold segmentation is still messy and the recognition effect is not clear, so it is difficult to identify the target accurately. Only the maximum entropy method can identify the target more clearly, although there are still some clutters, but the target can be identified by a simple elimination method. By comparing the segmentation effects of different
methods for aerial and ground target images, it can be seen that the maximum entropy method has better anti-background interference ability and universal applicability.

4. Conclusion
Target recognition is the key factor affecting the accuracy of terminal guidance weapons. Threshold segmentation is the key technology to achieve target recognition. According to the requirement of target recognition of terminal guidance weapon, the main existing threshold segmentation methods are analyzed, and the threshold segmentation method based on maximum entropy method is studied in detail. Taking the aerial target and ground target images collected by a certain type of equipment as the research object, the thresholds are calculated by means of average method, iteration method, Otsu method and maximum entropy method under the environment of Matlab, and the thresholds are calculated to compare the effect of image thresholding segmentation. The results show that the maximum entropy method has the best segmentation effect for air target and ground target, and has lower requirements for the contrast between target and background in the application process, less restrictions on application, and better general applicability and anti-background interference ability. The research results can provide theoretical and experimental basis for the selection of target recognition methods for terminal guidance weapons.

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