Research on Segmentation Method of Target Image in Vision Measurement

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Abstract. Highly reflective material target captured by the camera will form a mixture of the original target and its reflection image, and the above method is unable to accurately segment the image. To solve this problem, we proposed a method based on two-dimensional gray histogram contour projection segmentation algorithm. This algorithm is based on the grayscale image grayscale-field to establish the two-dimensional gray histogram, and use the two-dimensional histogram oblique segmentation method to filter out noise, then the Otsu method is used to projection segmentation and look for the best threshold segmentation in a straight line, so as to get the target image to be detected. Finally, use the convex polygon method to process the edge of the target. Experimental results show that the proposed method can accurately segment the target from the blurred image.

Introduction

Vision measurement technology, which is based on the computer vision, uses the image sensor to detect the spatial coordinates of objects, and then detect the size, shape and motion of objects, etc. In recent years, vision measurement technology has been used in many engineering projects, such as monitoring vibration of bridge, monitoring settlement of railway, monitoring deformation of tunnel wall, and monitoring the structural deformation of large mechanical structure(such as gantry crane, large telescope). In the field of measurement, the detected object usually is the target designed to meet the requirements of the measurement. When the measurement of the distance is far way or the measure environment is bad, made of common materials of target already can’t meet the measurement requirements, so here we need to design a target made of special material, for example, high-reflective materials. In the visual measurement, the first step is to segment the image which contains the target, the segmentation results have a direct impact on the feature extraction and object recognition [1]. At present, in many image segmentation algorithms, Otsu method [2] is widely applied due to its simple operation and fast processing speed. It is suitable for the situation that target and background have an obvious different gray scale, but the one-dimensional histogram only considers the gray image information, and doesn’t include the spatial information, so it is sensitive to noise. Therefore, Mr.liu proposed a two-dimensional histogram method [3, 4], and the image segmentation has a remarkable improvement. Due to the introduction of approximation, segmentation results are not very accurate. Mr. Wu proposed a two-dimensional histogram oblique segmentation method based on this [5], which is using four parallel lines to divide the histogram into interior zone, border zone and noise zone to solve the inaccurate problem.

However, for the Infrared image with low SNR, it is difficult to segment the target of interest by the general image segmentation algorithm. So, some experts do lots of research in the infrared image segmentation, Zhang [6] and others presented an infrared image segmentation method based on mathematical morphology [7], etc. These methods estimate the background and then segment the
The target, which is suitable for the segmenting outer contour of the target regardless of the internal details. And it can effectively divide some small objects from the infrared image.

The target made of highly reflective material captured by the camera will form a mixture of the original target and its reflection image, and the above method is unable to accurately segment the image. To solve this problem, we propose a contour projection method based on two-dimensional histogram to segment the algorithm. This algorithm is based on the gray level-neighborhood gray level to establish the two-dimensional gray histogram, and use the two-dimensional histogram oblique segmentation method to filter out noise, then the Otsu method is used to projection segmentation and search for the best segmentation threshold in a straight line, so as to get the target image to be detected. Finally, use the convex polygon method to process the edge of the target. As shown in Fig.1.

![Figure 1. Image segmentation algorithm flowchart.](image)

**Algorithm**

**Two-dimensional Histogram Oblique Segmentation [4]**

In this paper, the target is a circle object, and we use \( f(x, y) \) to represent the image gray value at the point \((x, y)\), and \( g(x, y) \) as the average gray value of the \( k \times k \) neighborhood, the point \((x, y)\) as the center. The \( g(x, y) \) can be defined as:

\[
g(x, y) = \frac{1}{k^2} \sum_{m=-[k/2]}^{[k/2]} \sum_{n=-[k/2]}^{[k/2]} f(x+m, y+n).
\]  

(1)

In the equation, \( K \) is generally the odd, such as 3, 5, etc. And \([k/2]\) expressed \( k/2 \) rounded down.

Using \( f(x, y) \) and \( g(x, y) \) compose the tuple \((i, j)\) to define the two-dimensional histogram, and any point of the joint probability density in the histogram is defined as \( p(i, j) \), so:

\[
p(i, j) = \frac{c_{ij}}{MN}.
\]

(2)

In eq. (2), \( c_{ij} \) is \((i, j)\) appeared frequency, and \( p(i, j) \) meets the condition \( \sum_{i=0}^{L-1} \sum_{j=0}^{L-1} p(i, j) = 1 \).

As shown in fig.2, \( p_{ij} \) mainly is located along the diagonal of \((0,0)\)~\((L-1,L-1)\). First use four straight lines \( L1, L2L3, L4 \), which are parallel to the main diagonal, divide the two-dimensional histogram into an inner point area, two border regions and two points noises region. Then take a slash \( g = -f + T \) (\( T \) is the threshold, \( 0 \leq T < 2L-2 \)) vertical to the main diagonal to segment the image \( f(x, y) \), the binary image \( b(x, y) \) defined as:

\[
b(x, y) = \begin{cases} 
0 & f(x, y) + g(x, y) \leq T \\
1 & f(x, y) + g(x, y) > T
\end{cases}.
\]

(3)
Assuming that the target image gray level is less than the background, so the upper right area of the diagonal \( g = -f + T \) can be considered to be the target, and the lower-left points to be the background.

**Contour Projection Method to Determine Threshold**

Contour [8] is a closed curve which is connected to the adjacent points on the topographic map. The contour projection is a closed curve connected with the same elevation height points, and then projects these points vertically onto a horizontal plane, and the drawing is scaled in proportion to the drawing. Two-dimensional histogram is a three dimensional graphics and it can be as a regional landforms. In this paper, the image is only one target, so there are only two peaks in the landscape, one is the background and the other is the target. And after projection to the one-dimensional plane, there will be two contour intensive areas, as shown in fig.3.

\[
T_{fg} + T = \sum_{i=0}^{T} \sum_{j=0}^{T} h(i,j) = 255 . \tag{4}
\]

\[
N = \sum_{i=L}^{f} \sum_{j=L}^{f} h(x,y) = 255 = N - n_0 . \tag{5}
\]
Use a discriminant criterion to evaluate this line whether to meet the requirements:

\[ \eta(T) = \frac{n_t}{N} . \]  

(6)

At the time of \( \eta(T) \geq K \), this line is set up, \( 0 \leq K \leq 1 \). Then \( T \) can be iterated from 0, when \( T = t \) and \( t+1 \):

\[ \eta(t) = \frac{n_t}{N} . \]  

(7)

\[ \eta(t+1) = \frac{n_{t+1}}{N} . \]  

(8)

When the termination condition \( \Delta = \eta(t+1) - \eta(t) \) is reached and the range of \( \eta(T) \) is valid. Then the best line is reached.

**Convex Polygon Processing With Morphological Filtering**

The edge of the target binary image is inevitable of burr. In order to help the target feature extraction and recognition, in this paper, we use morphological filter [9] and convex polygon processing method [10] to optimize the edge of the target. The principle of the convex polygon is shown in fig.4, and the algorithm includes for main steps:

![Figure 4. The principle of the convex polygon.](image)

1) In the given point set select y coordinates of the minimum point H as the base point. When the y coordinates of several points are equal, and select the smallest x coordinate of a point. Then sort the points with the angle between the x axis and the vector\(<H, p>\), which is composed of the other points P and the basic point. In fig.5, for example, the points accord to the angle sorted in ascending order is H,K,C,D,L,F,G,E,I,B,A,J.

2) The point set is scanned by counter clockwise, and the establish segment\(<H, K>\) must be on the convex polygon. Then add the point C. Assuming the segment\(<K, C>\) is also on the convex polygon. So on the H, K, C three points, the convex polygons are formed by them. Then add the point D, and the segment \(<K, D>\) will be on the convex polygon, so the line \(<K, C>\) is excluded.

3) From the starting point, the rotation direction of each line segment on the convex polygon should be the same, and in contrast with the direction of the scan. If it is found that the new point makes the rotation direction of the new line segment change, and then it means the point is not on the convex polygon, it is necessary to remove the point, and then add the new point.

4) Repeat the above steps to scan the point set, and then get the convex polygon.

**Experiment Results**

To verify the proposed method in the previous section, a specific system has been built. The experiment involves five major steps:

1) Use infrared camera to capture the target, and by adjusting the size of the aperture to get a series of image with different brightness.
2) Use the image in the first step, the two-dimensional histogram is used to determine the noise points, boundary points and interior points, and the noise points and boundary points are filtered.

3) Make the projection image, and find the best threshold of the projection map.

4) Use the principle of two-dimensional gray histogram region diagonal to segment the image which is filtered.

5) Morphological filtering and convex polygon on the segmented image.


From the target one, two, and three segmentation results and data shown in Table 1 can be seen, for a better light image, the segmentation results of algorithms are similar. But for a stronger light image, other algorithms fail to segment the target image, and the algorithm proposed in this paper, can be a very good segmentation results, and the effect is obviously better than other algorithms. And then processed by morphological filtering and convex polygon, the edge of the target benefits the feature extraction and target recognition. Therefore, the proposed method has good segmentation results for this kind of target image and good robustness.

![Figure 5. The target of one segmentation result comparison.](image)

![Figure 6. The target of two segmentation result comparison.](image)
Figure 7. The target of three segmentation result comparison.

<table>
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<th>Target</th>
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<th>Algorithm2</th>
<th>Algorithm3</th>
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Conclusion

In this paper, we propose a method based on two-dimensional histogram contour projection to segment the image, introduce the principle of the two-dimensional histogram and the contour projection method, and describe the process of convex polygons. The experimental results show that, the algorithm proposed in this paper has the advantages of strong applicability and good effect detection, and it has a certain application value in the target detection which is affected by the variation in light intensity. At the same time, the algorithm of this paper has a large research space, such as the effectiveness of more targets, using more methods combined with the algorithm to improve the accuracy of the segmentation and so on.

References


