

# A New Boundary Tracing Algorithm of the Contour of Objects in the Binary Image

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**Abstract.** By analysis of common boundary tracing algorithm in the binary image identification, this paper proposes a universal boundary tracing algorithm based on contour, which can judge the trend of contour according to the last boundary point. In search for the next boundary point, it only needs to judge 5 points on the candidate and then the next boundary point can be found. Thus the method reduces search times and the boundary tracking is greatly reduced. The algorithm is also effective for line segment whose contour is not closed by scanning the contour to get information. Experiments show that the algorithm is not only fast, but also accurate about the contour recognition. For the object which has complex images, algorithm can embody its superiority.

**Key words:** image recognition, binary image, boundary tracing, contour of target objects, pattern recognition

## Introduction

In the field of pattern recognition, shape feature of the image is an important index for feature extraction, in many cases, only by knowing shape feature of the image can we make the further analysis of the image quantitatively. And to determine the boundary contour is a prerequisite for study of shape feature, which is also the premise of computer automatic image recognition. The recognition of the boundary contour has a significant effect on the description, identifying and understanding of the feature.

Boundary tracking is an image segmentation method based on gradient. Starting from a boundary point in the gradient map, we can determine a new boundary points, based on a previous boundary point. Traditional boundary tracking methods include the worm following method, raster scan method and T algorithm and so on. But these methods must be repeated many times to get results, and sometimes it may also repeat following the same local area, which causes the program into a loop. Target neighborhood point of boundary tracking method evolves from the worm following method, which overcomes the shortcomings of worm following method. With the method, a cycle can accurately get the contours of objects and the experimental effect is good. On this basis, the proposed algorithm in this paper can determine the trend of contour according to the former boundary point position, which can thus reduce the searching times, and improve the searching efficiency. The more complex the target image is, the more likely it is to demonstrate its superiority.

## Traditional boundary tracking methods

A common boundary tracking algorithm is the worm following method, which obeys the following rules. An ideal bug going from white background pixel area to black background pixel area and the black pixel region is represented as a closed contour. As they entered the black pixels, they turn left

and continue to the next pixel. If the next pixel is also black, then the worms turn left again. But if a pixel is white, the worms turn to the right. This process continues until the worms reach the original point. This method has the following problems:

(1) Some small convexes may be detoured, as is shown in small convex in right corner in Figure. 1. To avoid this problem, we must choose some different starting points and initial directions to repeat the process, and then take the same path as the target contour. The number of repeating times depends on the complexity of the visual images. But even if it repeats for many times, it may not be able to avoid this problem.

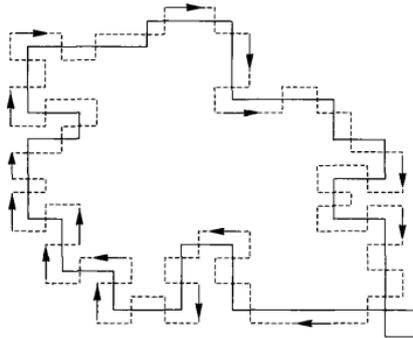


Fig. 1 identify the boundary with “worm”

(2) The worms may fall into the trap, namely they will repeatedly crawl around a local closed region, and can not go back to the starting point. To avoid this problem, the worms can be equipped with the memory function, so they can remember the former steps and return to the original road from the incorrect route. Due to the repeated courses, the total step numbers of the worms double that of a single course. Apparently, for some complex image, the calculation is too huge, or even it is impossible to realize. Also it is likely for the worms to have been stuck in the trap in the choice of the starting point, and the misjudgment is made.

Raster scan method is to track the boundary by scanning the rows and lines of the image after setting a certain threshold for many times. The disadvantage of the method is that it needs to keep adjusting the threshold, and the scanning depends heavily on the direction of the raster scanning. Also it requires the repeated combination of row scanning and line scanning. Because the blindness of threshold choice and the uncertainty of the times for row scanning and line scanning, it is very difficult to find the accurate contour of the target. T (Trace) algorithm in the contour coding can also be used to track the boundary contour line in the region. T algorithm is 4 neighborhood searching algorithm, whose searching rules are related with the entrance direction. Also its searching efficiency is not high, and can not overcome effect on the algorithm exerted by the internal hole in the boundary.

### The new boundary tracing algorithm

As the improvement of traditional algorithm, this paper proposes a new tracking algorithm, which can effectively track the outer boundary and can overcome the influence of the inner boundary on the algorithm. It can also accurately track the closed lines. The principles of algorithm are as follows: the boundary tracking start to scan image point by point from the gradient image in the upper left corner. When the target is met, it track the target in sequence until the tracking follow-up point returns to the starting point (for a closed contour) or there is no new success or follow-up point (for non closed line). If it is not closed contour, when the tracing is finished on one side, the new tracing should begin from the starting point in the opposite direction until it tracks another

point of termination. When there are multiple separated contours, in order to avoid being struck in the dead cycles, the contours should be tracked one by one. The former areas which have been treated well should be filled in by the background color.

As is shown in table 1, if the point  $(x,y)$  is a boundary point, the next boundary point must be within 8 adjacent domains of the point  $(x,y)$ . The coordinate representation of 8 pixel position in the adjacent domains and coding representation are shown in table 2. The problems are to determine what rules to follow in order to quickly and effectively search and find the next boundary point in 8 adjacent domains.

Table 1 Eight neighborhoods pixel coordinates

$(x-1,y-1)$	$(x-1,y)$	$(x-1,y+1)$
$(x,y-1)$	$(x,y)$	$(x,y+1)$
$(x+1,y-1)$	$(x+1,y)$	$(x+1,y+1)$

Table 2 Eight neighborhoods pixel coding

3	2	1
4	P	0
5	6	7

According to the relative position of the former point and the current point, we can roughly determine the boundary trend. Therefore in search of the next point, there is no need of calculate and compare the 8 adjacent domains of the current point. But according to position's difference between the previous point P and the current point C (a total of 8 possible directions), the next point can be tracked by calculating and comparing the 5 pixels in the edge direction, which will greatly reduce the amount of calculation is quite.

So the principles of searching for the next boundary point are as follows: set N as position coding of the current point P  $(x,y)$  at 8 adjacent areas of the previous boundary point C. from the position coding N, the position where the current point  $(x,y)$  in 8 adjacent areas moves clockwise 2 pixels is the position where the new searching for the next boundary point starts. If it is not boundary point, then from the starting point of the search, searching in counter clockwise direction sequentially for 5 times can find the next boundary point.

For example: see table 2, if the position coding of the current point P in the previous boundary point is 1, then we know that according to the criterion, the starting point of the search is the point whose position code is 7. If it is not the target point, from the beginning point 7, we can sequentially search the points whose position codes are 0, 1, 2, 3 respectively. When the first point appeared in the gray area is equal to the target value, the pixel is the next boundary point needed. The steps of 8 neighborhood boundary tracking algorithm to be implemented are as follows: set the value of background point in the image is 0, the target point is 1,  $P_k$  is the kth boundary points, the initial value of k is 0, and t is the number of boundary end points.

(1) Setting value of the interested target area label;

(2) Scanning image from left to right and from top to bottom until discovering the first point whose pixel is 1 and whose value is label. The point is the starting point of the boundary  $P_0$ , store the coordinate  $(x, y)$  in the sequence list of boundary points, and preset t is 0 and the position code is 0;

(3) determining the starting position of searching the next target according to the above criteria, then from the current position in the counterclockwise direction, check the 8 neighboring pixels of the current boundary point, when the pixel label value is equal to the predetermined tag value for the first time, the pixel is the new boundary point  $P_k (k=k+1)$ , and record its position coding value

in the 8 neighborhood areas;

(4) if the new boundary point  $P_k = P_0$ , then it returns to the starting point, and the contour tracking finishes, the coordinate of the point stored at the boundary point sequence is the external boundary points of the object, then turn to the step (7);

(5) if the new boundary point  $P_k \neq P_0$ , consider  $P_k$  as the current point, record its position code, and then turn (3);

(6) If the target point is not found, it indicates that the point is the end point of the contour, and the numbers for the end points is  $t$  plus 1. If  $t=1$ , set  $P_0$  as the current point, whose position code is 4, turn to step (3), if  $t=2$ , then turn to step (7);

(7) If it needs to track other target contour, turn back to step (2); otherwise, the algorithm terminates.

Because this algorithm can memorize the position of current points in the former boundary point, in the search for the next target point, there is no need to search all the points in the 8 neighborhood areas. It only needs to search for 5 times to find the target point, and the intelligent character greatly shortened the time of boundary tracking.

## Experimental results

Experiments show that by using the method of documentary, it needs to search the 8 neighborhood areas respectively for 4368 times and 9896 times, but by using this algorithm, it only needs to search the 8 neighborhood areas respectively for 3310 times and 7438 times to accomplish the boundary tracking of the object. The working efficiencies were increased by 24.2% and 24.8%. Therefore, for the target which has complex image, this algorithm can embody its superiority.

## Conclusion

The new algorithm, compared with the traditional boundary tracking algorithm, can scan the information of the target areas' contour for one time. At the same time, according to the method of searching boundary points in the 8 neighborhood areas, it only needs to search the areas for maximum 5 times to find the target point, which greatly shortened the time of boundary tracking and improve the efficiency of contour tracking. Experiments show that the proposed algorithm in this paper is effective for the boundary tracking of the object in the binary image.

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