Research Journal of Applied Sciences, Engineering and Technology 5(11): 3083-3086, 2013
ISSN: 2040-7459; e-ISSN: 2040-7467
© Maxwell Scientific Organization, 2013
Submitted: August 17, 2012 Accepted: September 17, 2012 Published: April 05, 2013

An Algorithm for Minimal Circumscribed Rectangle of Image Object Based on Searching Principle Axis Method

[1, 2]Faquan Zhang, [1, 2]Guofu Wang, [1]Qingning Zeng and [1]Jincai Ye
[1]Depertment of Information and Communication, Guilin University of Electronic Technology, Guilin 541004, China
[2]Guangxi Key Lab of Wireless Wideband Communication and Signal Processing, Guilin 541004, China

Abstract: In this study, we propose an algorithm of searching principle axis method which can save a lot of time. The initial position of the horizontal principle axis and the vertical principle axis and the rotation center are obtained using least square method. The horizontal principle axis is acted as a right-angle side and initial enclosing rectangle is obtained. Instead of rotating the image object, we only rotate two principle axes by rational rotational direction, region and interval until the minimal circumscribed rectangle is found. The results show that calculating complexities are decreased remarkably and computation speed and result precision are increased.

Keywords: Image processing, minimal circumscribed rectangle, principle axis method, searching, searching speed

INTRODUCTION

The minimal circumscribed rectangle of the image object is a significant parameter to further analyze the image and recognize the image objects. The circumscribed rectangle of a geometric graph includes all points and lines in the graph and its sides are contact with the graph. According to the definition, there are a lot of the circumscribed rectangles for a graph. The circumscribed rectangle be of minimal area is the minimal circumscribed rectangle. So the minimal circumscribed rectangle is unique and describes some geometric features including length and width of the image object (Boris, *et al*., 2009; Kun *et al*., 2009). The minimal circumscribed rectangle is widely used in many aspects. It can be employed in optimization design to improve design blueprint (Fang and Zhang, 2006). It can also be used to implement automation recognition on the targets in the automatic picking robots (Gao *et al*., 2008) (Mulan *et al*., 2011). In the intelligent monitoring system it always is utilized to find some interesting targets in time (Zhiqiang *et al*., 2010; Wu *et al*., 2004; Li *et al*., 2008; Shuai *et al*., 2010). The common algorithm is to rotate the image object or to format chain code of all vertexes to find the circumscribed rectangle (Dong *et al*., 2010) (Yao *et al*., 2009). These algorithms are of large computation and low efficiency (Liu *et al*., 2008). We present a real-time algorithm based on searching principle axis to decrease computation remarkably and improve operation efficiency significantly.

In this study, we propose an algorithm of searching principle axis method which can save a lot of time. The initial position of the horizontal principle axis and the vertical principle axis and the rotation center are obtained using least square method. The horizontal principle axis is acted as a right-angle side and initial enclosing rectangle is obtained. Instead of rotating the image object, we only rotate two principle axes by rational rotational direction, region and interval until the minimal circumscribed rectangle is found. The results show that calculating complexities are decreased remarkably and computation speed and result precision are increased.

SEARCHING PRINCIPLE AXIS METHOD TO FIND MINIMAL CIRCUMSCRIBED RECTANGLE

The fundamental principle of searching principle axis is described as follows. First, we find the initial principle axis using the least square method and determine the circumscribed rectangle based on the initial principle axis. Second, we keep the position of the image object and rotate the initial circumscribed rectangle. Because the circumscribed rectangle has only four sides and they are mutual verticality and can be expressed by linear equation, the amount of computation is very small. Finally, we obtain the minimal circumscribed rectangle by selecting the one be of minimal area in all circumscribed rectangle.

Given the ellipse object in the image, we describe the procedures of this algorithm in detail. The size of the image is 176 multiply 258, that is, 176 rows and 258 columns.

Corresponding Author: Faquan Zhang, School of Information and Communication, Guilin University of Electronic Technology, Guilin 541004, China

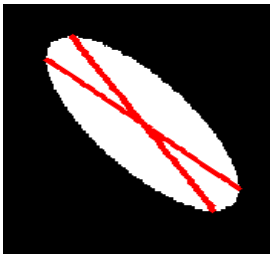


Fig. 1: Initial position of the principle axes

Step 1: To determine the initial position of the principle axis: We seek starting point coordinate and end point coordinate of the object in every column in the image and calculate middle point coordinate of the present column:

$$x_i = x_{i1} + x_{i2}/2 \text{ , } y_i = y_{i1} + y_{i2}/2 \qquad (1)$$

We fit line by the least square method used all middle point coordinates (x_i, y_i) (i = 1, 2, … ,N) and obtain the linear equation of the horizontal principle axis as $y = k_1x + b_1$.

Similarly we seek successively starting point coordinate (x_{j1}, y_{j1}) and end point coordinate (x_{j2}, x_{j2}) of the object in every row in the image and compute middle point coordinate (x_j, y_j) of the present row. By using the least square method to fit line, we get the linear equation of the vertical principle axis as $x = k_2y + b_2$.

In Fig 1, the ellipse region is the image object to search the minimal circumscribed rectangle. Two lines are the result of linear fitting using the least square method to all middle points' coordinates.

Step 2: To determine the center of rotation: We get the intersection point coordinate as the center of rotation by solving the equation group composed of the horizontal principle axis and the vertical principle axis.

Step 3: To determine the initial circumscribed rectangle: We keep the direction of the horizontal principle axis and shift down in parallel to seek tangential point between the horizontal principle axis and the image object.

The procedures of seeking the position of the lower horizontal principle are shown in Fig 2. We only need judge whether the principle axis line is intersection with the image object or not, so computation speed is very quickly.

The method to seek the position of principle axis in the upper border is the same as the above.

Using the same algorithm, we find the position of the vertical principle axis in the left border and in the right border. The results are shown in Fig 3. We solve

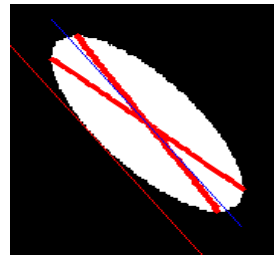


Fig. 2: Position of the horizontal axis in lower border

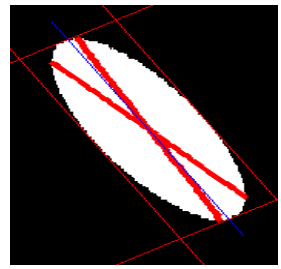


Fig. 3: Initial circumscribed rectangle

out the distances between two parallel lines in the horizontal direction and vertical direction respectively. Then we obtain width and height of the circumscribed rectangle and compute its area. Therefore, we get the initial circumscribed rectangle.

Step 4: To rotate the horizontal principle axis: In the beginning, we should determine the following three parameters including rotating region, rotating direction and rotating interval.

The horizontal principle axis is a fitting line by the least square method using middle points' coordinates of all columns. The vertical principle axis is also a fitting line using middle points' coordinates of all rows. Therefore, slope of the horizontal principle axis must be small than it of the vertical principle axis at the initial position. Rotating region should start from slope of the horizontal principle axis at the initial position and end at slope of the vertical principle axis.

For the initial position in Fig 1, slope of the horizontal principle axis and the vertical principle axis are both negative. Rotating direction is anticlockwise when the horizontal principle axis turns to the vertical principle axis.

Because rotating region has been restricted to a small range, rotating interval can be smaller and accuracy can be higher.

Step 5: To calculate the area of every circumscribed rectangle rotated: The horizontal principle axis rotates 3 times at rotating interval anticlockwise from initial position. The procedures are shown in Fig 4. Every circumscribed rectangle.

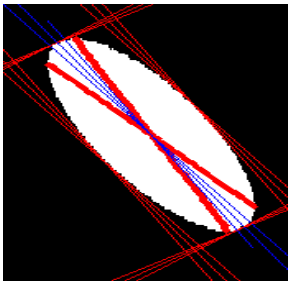


Fig. 4: Circumscribed rectangle of different position

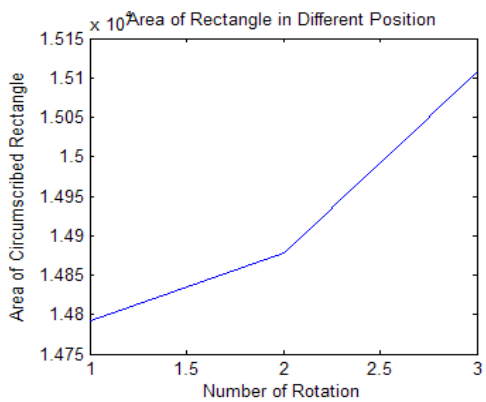


Fig. 5: Change results of circumscribed rectangle in different rotating position

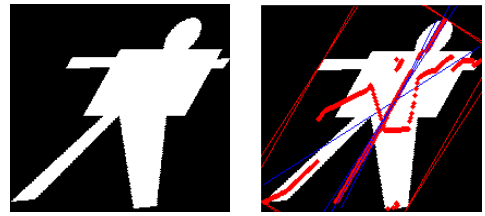
is obtained according to step 3 after every rotation. In the meantime, the area of every circumscribed rectangle is computed. Results of the area of all circumscribed rectangles in different rotating position are shown in Fig 5. It is obvious that area of circumscribed rectangle in the first is minimal, its value is 32056. We can compute the real area of the minimal circumscribed rectangle is 32158. Their relative error is:

$$\eta = \frac{|A_{MER} - A_{real}|}{A_{real}} = 0.32\% \qquad (2)$$

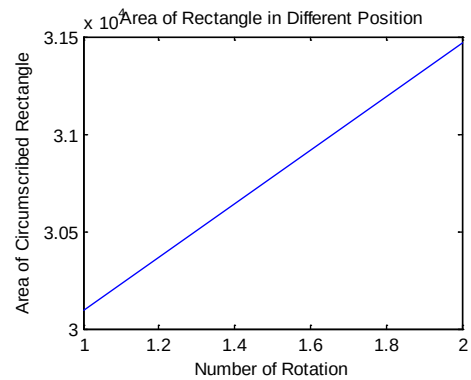
Step 6: To repeat Step 4 and Step 5 until one of the two conditions is satisfied:

- The area of the present circumscribed rectangle is larger than 1.05 times of minimal area in all circumscribed rectangles
- Slop of the horizontal principle axis is equal or larger than one of the vertical principle axis

The area of the circumscribed rectangle is not decreased or increased monotonously, so we consider that we find the minimal circumscribed rectangle and stop further loop when the area of the present circumscribed rectangle is larger than 1.05 times of minimal area. It is as shown in Fig 5 that area of circumscribed rectangle at the third loop is larger than



(a) Experimental object (b) Steps of searching the minimal circumscribed rectangle



(c) Areas of different circumscribed rectangle

Fig. 6: Searching procedure to a person shape object

1.05 times of the area of it at the first loop and loop is stop. Whole computation is remarkable decreased and operating speed is improved.

Step 7: To determine the minimal circumscribed rectangle: The minimal circumscribed rectangle is just the one which area is minimal in all circumscribed rectangles and its width and height are also can be determined

ALGORITHM VERIFICATION

The algorithm proposed is carried out on a computer with Intel (R) Core ™ i3CPU, M350, 2.26GHz, 2GB memory and Windows XP system. The program language is MATLAB.

The experimental object is the image of a person shape. We determine its minimal circumscribed rectangle using searching principle axis method. The steps are shown on Fig 6.

CONCLUSION

The new algorithm to find the minimal circumscribed rectangle for the image object, searching principle axis method, makes the amount of rotation and computation greatly reduced. Moreover, it improves arithmetic speed and decreases operation time, so it ensures that image analysis is real-time. In

Table 1: Comparison of operation time for different algorithms

Image object	Ellipse	Person shape
Rotating object	0.852	1.026
Vertex chain code	0.387	0.485
Our algorithm	0.106	0.151

order to improve performances of the algorithm we can adopt some optimization measures, such as selecting an initial principle axis, determining more optimal rotating interval. If we adopt these methods, we can increase operational precision furthermore. Table 1 shows the comparison of operation time for different algorithms.

ACKNOWLEDGMENT

The authors wish to thank the helpful comments and suggestions from my teachers and colleagues in Guangxi Key Lab of Wireless Wideband Communication and Signal Processing at Guilin. This study was supported in part by NSFC under Grant No. 61102115 and Guangxi Key Lab of Wireless Wideband Communication and Signal Processing under Grant No. 11109.

REFERENCES

Boris, D.L. and L.G. Ronald, 2009. Minimum perimeter rectangles that enclose congruent non-overlapping circles. Discrete Mathematics, 309(8): 1947-1962.

Dong, Y.N., 2001. A new mehod for efficiently implementing parallel image rotations. Acta Electronica Sinica, 9(12): 1671-1675.

Fang, J. and H. Zhang, 2006. Real-time Optimal Detection Algorithm for Chestnut's Size. Transactions of the Chinese Society of Agricultural Machinery, 37(5): 87-89.

Gao, G., J. He and G. Kuang, 2008. A survey of target's orientation estimation in SAR image. Signal Processing, 24(3):123-127.

Kun, L., F. Shumin, W. Mulan, X. Canhua and W. Zhuqing, 2009. Cotton recognition based on randomized Hough transform. Transactions of the Chinese Society of Agricultural Machinery, 41(8):160-165.

Li, B., D. Yin, X. Yuan and G.Q. Li, 2008. Oilcan recognition method based on improved hough transform. Opto-Electronic Eng., 35(3): 30-34.

Liu, T. and R. Liu, 2008. An algorithm for minimal circumscribed rectangle of a simple polygon. J. Harbin Univ. Sci. Tech, 13(2): 5-7.

Mulan, W., L. Xiaoxia, L. Kun and J. Rong, 2011. Image recognition technology in intelligent cotton harvesting machine. Proceedings - 2011 International Conference of Information Technology, Computer Engineering and Management Sciences, ICM 2011, Nanjing, Jiangsu, China, 2: 320-323.

Shuai, C., M. Yue and S. Haibo, 2010. Sausage appearance defect inspection system based on machine vision. Chinese Control and Decision Conference, Xuzhou, China, pp: 2485-2489.

Wu, X.G., D.Q. Wang and H. Sheng, 2004. An algorithm and implementation for obtaining minimum exterior rectangle of image region. Comput. Eng., 30(12): 124-126.

Yao, Q., J. Chen, Z. Guan, C. Sun and Z. Zhu, 2009. Inspection of rice appearance quality using machine vision. Proceedings of the 2009 WRI Global Congress on Intelligent Systems, GCIS, Xiamen China, 4: 274-279.

Zhiqiang, Z., N. Zhiyou, Y. Jiajia and G. Chuanzhen, 2010. Research of real-time algorithm for chestnut's size based on computer vision. International Conference on Computational Intelligence and Software Engineering, CiSE 2010, Wuhan, China, pp: 456-459.