A New Contour Tracing Method in a Binary Image

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***Abstract*—this paper presents a novel fast single-pass contour tracing algorithm in a binary image. The proposed algorithm is viewed as follow steps: firstly a set of contour segments of all object contours can be generated and traced in a top-down line scan fashion; then all contour segments are employed to be integrated into respective intact contours; finally all results are converted into the chain code as the final output. This algorithm can extract multiple contours of an image in one pass and never lose any outer and inner contour of object region. It is faster on implementation. Experiments results prove those advantages.**

Keywords-contour tracing; contour integrating; chain code; crack code

I. INTRODUCTION

Object contour is a prominent shape feature of an object in an image. The object contour is useful in object analysis, pattern recognition, image restoration and object features computation such as the perimeter, area, and corner. [1]. H. Freeman created a chain code representation [2]. Chain code provides a very compact region representation and is widely used as standard input format for numerous shape analysis algorithms.

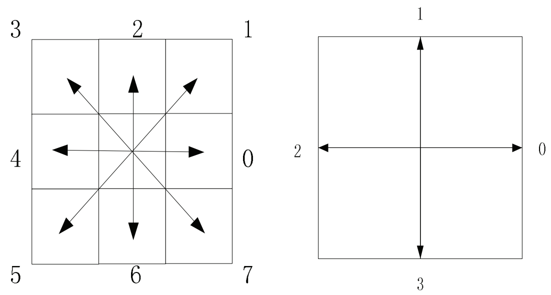

Figure 1. Chain codes & Crack codes

There have been several algorithms documented to generate the chain code. But when tracing complex region, those algorithms frequently repeat trace one contour or lose one contour. It is impossible for those algorithms to precisely tracing contours [3]. A Rosenfeld introduces the concept of crack code [4]. A crack coding method which preserves the homogony of the image is described in [5]. The chain code and crack code can be easily transformed to each other [6]; chain codes and crack codes are encoded as shown in Figure 1.

Some scholars proposed their improved algorithm on crack code. Sang Hongshi etc use the connected component labeling information for acceleration of algorithm [7]. Ref. [8] adopts a unique contour labeling method using automaton for contour tracing. Zhang Tianxu combines pixel information with crack information to improve tracing algorithm's robustness [9]. However, the generation process of the object contour chain is a non-local operation since the object contour in the image can be an arbitrary shape. The process of contour tracing is a serial fashion and requires a long processing time.

This paper presents a novel fast single-pass contour tracing algorithm for tracing contours in a binary image. The proposed algorithm adopts a top-down contour tracing fashion to generate the contour segments of all object contours and then integrate the contour segments into respective intact contours.

The rest of this paper is organized as follows. Section II introduces some definitions of proposed contour tracing algorithm. In section III, the proposed algorithm is detailed present. Section IV shows the results of experiments and analyzes the performance of the algorithm. Concluding remarks are provided in Section V.

II. RELATED DEFINITIONS

An object of a region type can be represented by a set of the closed contours in a binary image, including an outer contour surrounding the object and perhaps some inner contours contained by the object. Objects comprising pixels of white (white as object) are called 'islands', which are set in a 'lake' of pixels of black (black as background). Islands are encoded by following the edge clockwise and lakes are encoded counterclockwise [5]. By the direction of traced contour, we can affirm the contour type, whether is an outer contour or inner contour.

A contour crack can be classified into three types: contour starting crack, transition crack and contour ending crack. A starting crack exists when the current pixel is white, the left pixel is black and the current pixel has not been traced. A contour starting crack can be viewed as a splitting crack of two pieces of sub-contours. A contour ending crack is a merging crack of two sub-contours. Other cracks will be the transition crack. For example, Figure 2 illustrates a binary pattern of character 'A' and its corresponding outer and inner contours. In Figure 3, the contour starting cracks are denoted as ①, ② and ③ respectively, the ending cracks are marked as ⊕ and the rest cracks are the transition crack.

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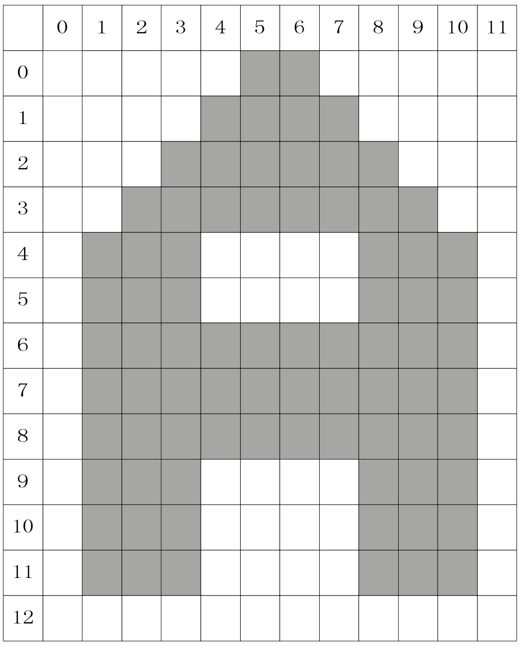

Figure 2. A binary pattern of the character 'A'

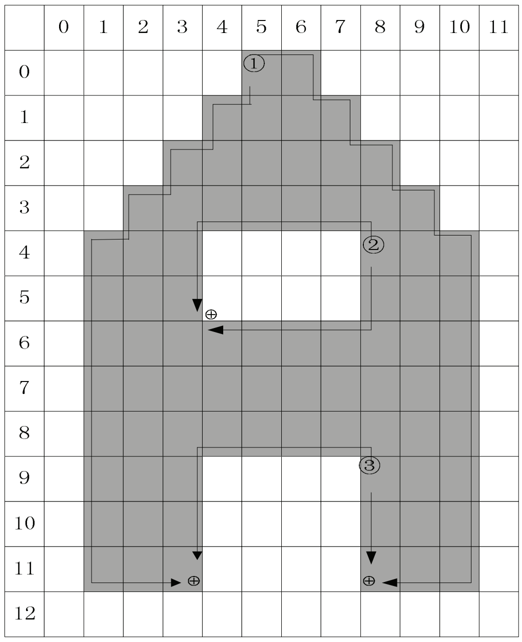

Figure 3. The contour structure

III. CONTOUR TRACING

The proposed contour tracing method is implemented in three main steps: (1) in top-down line scan fashion to generate and trace all contour segments of object contours; (2) integrate all contour segments into respective intact contours; (3) convert the step (2) result into the chain code.

These steps are detailed presented as follows:

1) Scan every row line by order, if exist contour segments with no end token, continue tracing backward crack and forward crack and labeled in the current row; if not, find new starting crack. By definition, the existence of a starting crack at coordinate (i; j) depends on the black and white information of pixels at coordinates (i; j-1) and (i; j), at the same time, it has not been labeled. A contour starting crack can be viewed as a splitting crack of two pieces of sub-contours. At the same way, each new sub-contour segment will trace backward crack and forward crack in the current row. Two contour tracing segments will end when they encounter at a common crack, and both contour segments are labeled as an end token. Figure 4 illustrate all detailed tracing step by scan line, the black arrows of every row represent traced crack in current row, the contour starting cracks are denoted as ①, ② and ③, the ending cracks are marked as ⊕. Six contour segments are generated and traced.

2) Compare the head crack and the tail crack of different contour segments, if two contour segments exist eight-connectively adjacent, merged them into a same contour segment. Repeat this operation, until all contour segments have been integrated into respective intact contour.

3) According to the eight-connectively chain code rule, convert the step (2) result into chain code.

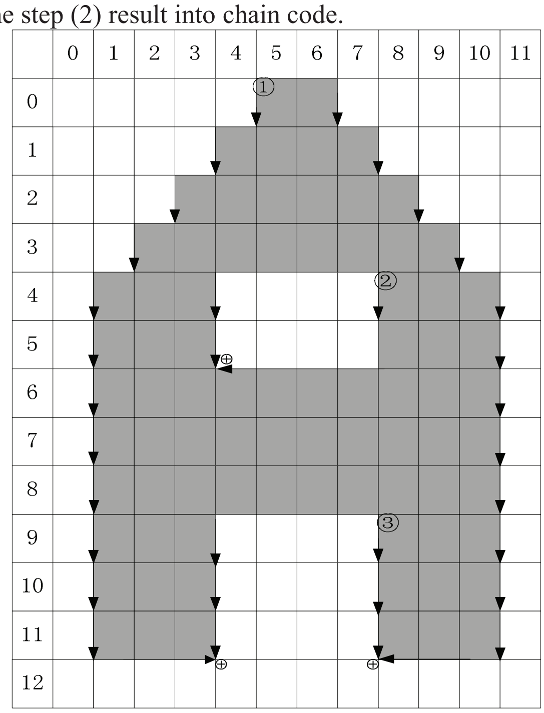

Figure 4. Detailed tracing step of scan line

IV. EXPERIENTS

Performance comparison between the conventional (or old) algorithm [5] and the proposed algorithm is implemented. Both algorithm are implemented and tested on a pc with Intel i3 M 380 2.53GHz CPU and 2G RAM. 36 images with different size and content are used in the experiment. 36 tested images are labeled as number from 1 to 36. The 36 original image and the

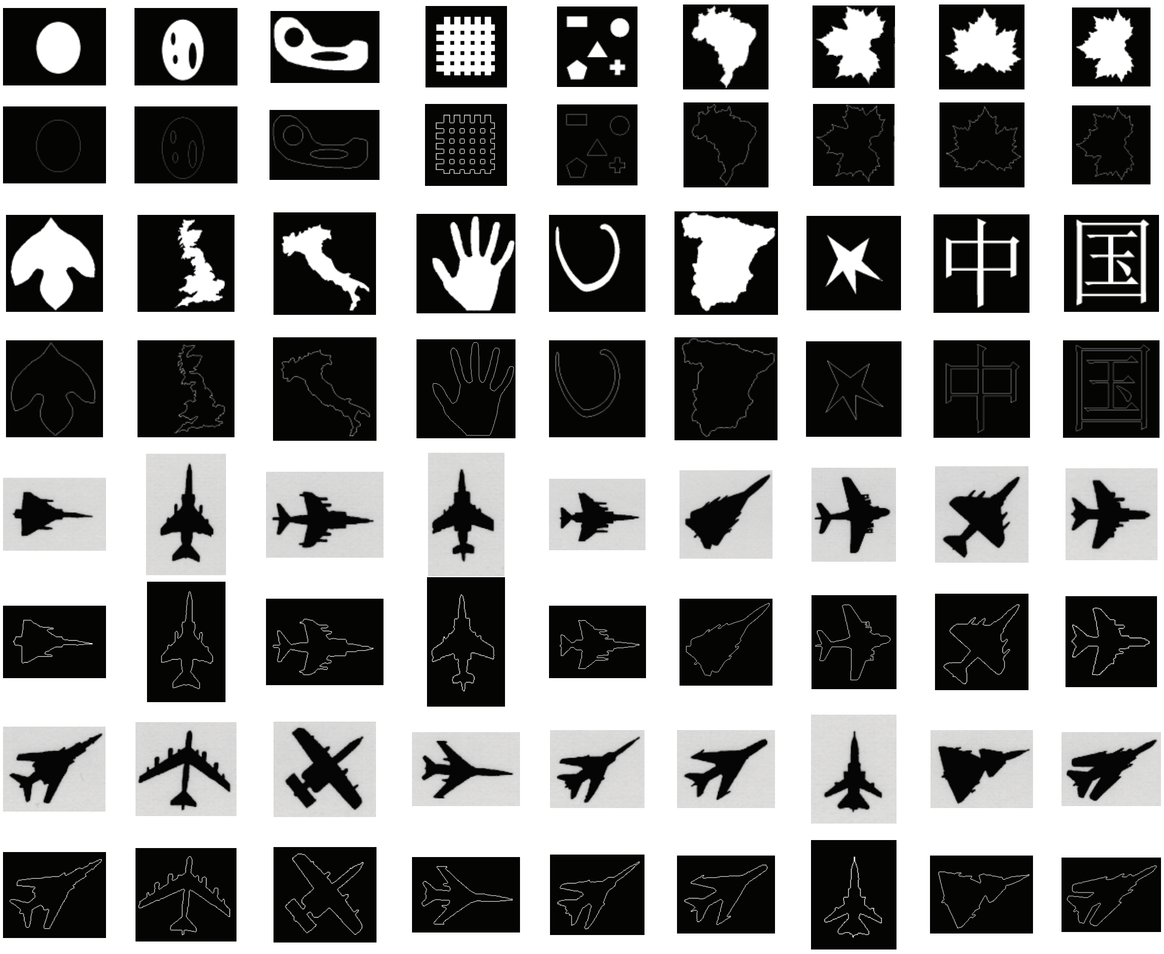

Figure 5. Tested images and traced results

traced results are showed in Figure 5. Consumed time of two algorithms on every image is presented in Figure 6 and Figure 7.

In Figure 5, the proposed algorithm has traced all outer and inner contours of tested images. At the same time, the space connectivity of contours is preserved.

In Figure 6 and Figure 7, we can see the new algorithm is faster than the old algorithm. The ratio of consuming time of two algorithms is between 1.763 and 6.579. The average ratio is 3.684.

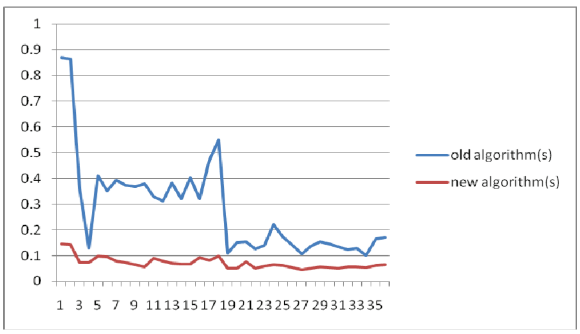

Figure 6. Consuming time of tested image

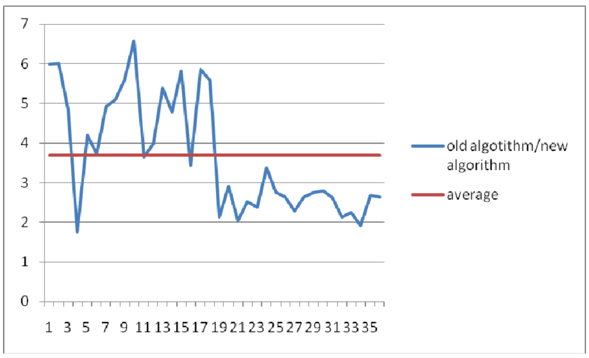

Figure 7. Ratio of consuming time of tested image

By analyzing the statistics data of all tested images, including images' size, height, width, target size, target crack number, target contour number, in Figure 8, Figure 9 and Figure 10 (the X axis has been reset according to the parameter of description of image above), we can see that the image with bigger image size, bigger object size and more target contour number will get a higher ratio. This new algorithm avoids repeatedly searching the image, greatly reduces the amount of data access and is implemented more efficient.

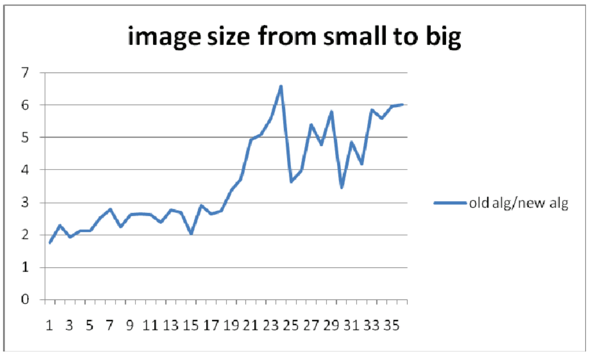

Figure 8. Image size and ratio

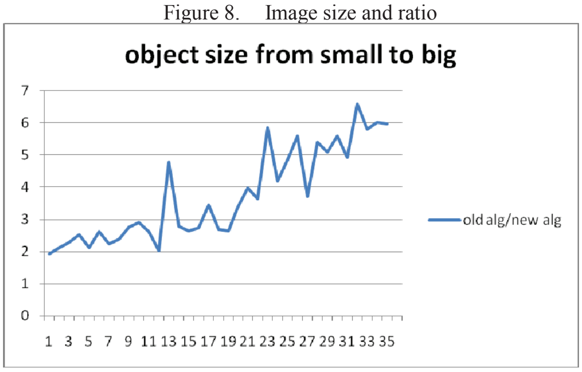

Figure 9. Object size and ratio

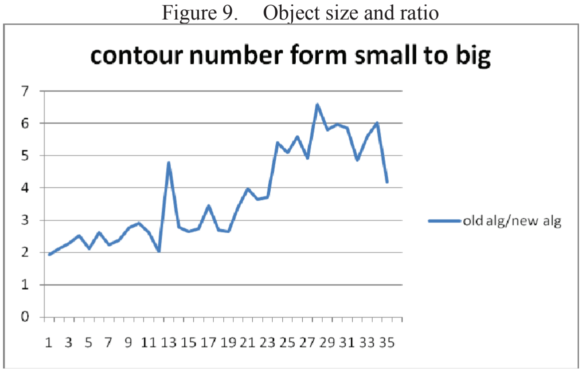

Figure 10. Contour number and ratio

V. CONCLUSIONS

A novel fast single-pass contour tracing algorithm in a binary image is presented and implemented in this paper. The proposed algorithm generates and traces contour segments in a top-down line scan fashion, then integrates contour segments into respective intact contours and finally converts all results into the chain code form. This new algorithm avoids repeatedly searching the image, greatly reduces the amount of data access and is implemented more efficient. Theoretical analysis and experimental results prove those advantages.

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