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A NEW METHOD FOR CONTOUR COMPRESSION

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Abstract: - A new approach for contour data approximation and compression algorithm is presented in the paper. Cartesian co-ordinates of an input contour are processed in such a manner that finally contours is presented by selected vertices of the edge of the contour. In the paper the main idea of the proposed procedure and compression of analysed method with the Ramer and the Tangent methods of contour approximation are performed. To compare the results, the mean square error and signal-to-noise ratio criterions were used. Number of operations that is necessary to perform approximation and compression procedures is also presented. The simplicity and the small number of operations are the main advantages of the proposed algorithm.

Key-Words: - contour representation, contour compression, polygonal approximation, Ramer and Tangent methods.

1 Introduction

Contours can be treated as important image structures for both coding and recognition. Contour representation and compression are required in many applications e.g. computer vision, topographic or weather maps preparation, medical images and moreover in image compression. One of the main approaches solving the problem of contour compression is the time domain approach. Most of the time domain methods are based on the polygonal approximation scheme. One of the most appreciated samples of such scheme is the Ramer algorithm, which uses the maximum distance of the curve from the approximating polygon as a fit criterion [3]. The other algorithm known as the Tangent method uses the tangent of an angle between two straight lines, called opening and closing lines as the fit criterion [7, 8, 9]. There are also procedures proposed by Sirjani [6] and Montanari [2]. Most of contour approximation methods use the Cartesian representation. In many applications the polar or Freeman's (also generalised) chain coding representations are desirable [1,4]. In this paper a new method for contour approximation and compression, proposed by A. Dziech, is presented and developed.

2 Description of the algorithm

An input contour for the proposed algorithm is extracted from 256 x 256 grey-scale images using Single Step Parallel Contour Extraction (SSPCE) method [5]. The proposed algorithm belongs to a family of polygonal methods of approximation. The idea of this method consists in segmentation of the contour points to get triangle shape. The ratio of the height of the triangle (h) and the length of the base of the triangle (b) is then compared with the given threshold value as follows

$$h / b < th \qquad (1)$$

where:
th - given threshold value.

The first point of each segment is called starting point (SP) and the last one is called the ending point (EP). To calculate these values the simple trigonometric formula is used.

If the ratio value is smaller than the threshold according to Eq. (1) the EP of the triangle is stored and SP is shifted to the EP, then a new segment is drawn. Otherwise the second point (B) is stored and the SP is shifted to the B point of the triangle. Then a new segment is drawn. The stored points determine the vertices of an edge of the approximating polygon.

The algorithm scans contour points only once i.e. it does not require the storage of the analysed contour points. The original points of the contour are discarded as soon as they are processed. Only the co-ordinates of the starting point of the contour segment, and the last processed point are stored.

The idea of the proposed algorithm is illustrated in Fig.1.

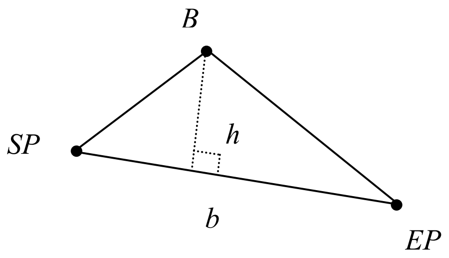


Fig 1. Illustration of the basic triangle for the proposed algorithm where h and b are height and length of the triangle respectively.

The approximation procedure starts at the time, when the first and last points of a segment are determined. The proposed criterion can be modified depending on contour representation methods. The most popular contour description methods are Freeman's chain coding, polar and Cartesian descriptions. Freeman chain coding can be used to distinguish all possible connections for both 8-connectivity and 4-connectivity schemes. A commonly used chain coding representation is the 8-Directional chain coding which uses eight possible directions to present all possible line segments connecting the nearest neighbors according to the 8-connectivity scheme. The algorithms for contour extraction are based on (3 x 3) pixels window.

Flowchart of the proposed algorithm is depicted in Fig.2.

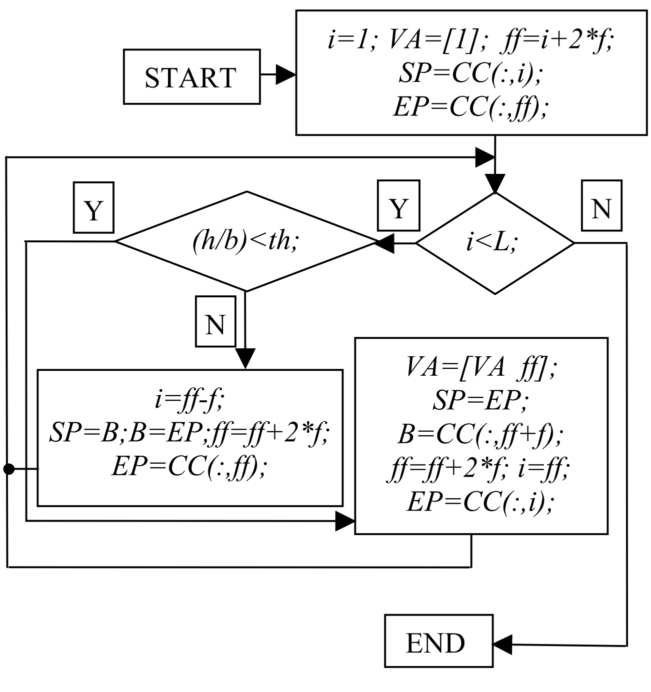


Fig 2. Flowchart of the proposed algorithm.

where:

VA - sequence of indices of the final vertices;
CC - sequence of the input for the contour;
SP - starting point;
EP - ending point;
h ,b, th - as mentioned before (see Fig.1 and Eq.1);
f - length between each two points of the triangle.

The main feature of the proposed algorithm is its short computational time. This feature is related to the fact, that there is no need in searching the maximum of the distance as in Ramer method.

3 Applied measures

The proposed approximating method is related to the data compression problem. To evaluate its compression ability, the following compression ratio was introduced

$$CR = \frac{(L_{CC} - L_{AC})}{L_{CC}} \cdot 100\% \qquad (2)$$

where:

L_{CC} - length of the input contour;
L_{AC} - length of the approximating polygon.

The mean square error (MSE) and signal-to-noise ratio (SNR) criterions were used to evaluate the distortion introduced during the approximating procedure. The MSE criterion is defined by the following equation

$$MSE = \frac{1}{L_{CC}} \sum_{i=1}^{L_{CC}} d_i^2 \qquad (3)$$

where:

d_i - distance between i vertex and the input contour line.

The SNR is defined by the following formula

$$SNR = -10 * \log_{10}\left(\frac{MSE}{VAR}\right) \qquad (4)$$

where:

VAR - variance of the input sequence.

Performed analysis and experiments show that SNR should be greater than 30 dB to obtain the expected compromise between compression ratio and quality of reconstruction. In the case of high threshold level, the contour details are eliminated and level of introduced distortion can not be accepted. The range of the threshold values depends on the length between two points of the triangle.

4 Results of the experiments

To visualise the experimental results a set of two test contours was selected. Selected contours are shown in Fig. 3.

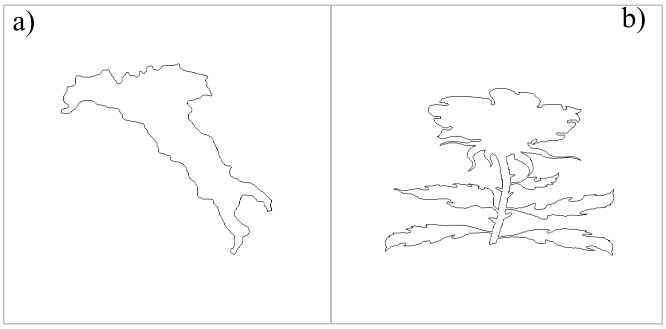


Fig. 3. Test contours: a) Italy, b) Rose.

Some exemplary reconstructions of Italy contour, are shown in Fig. 4 (related results are in Table 1).

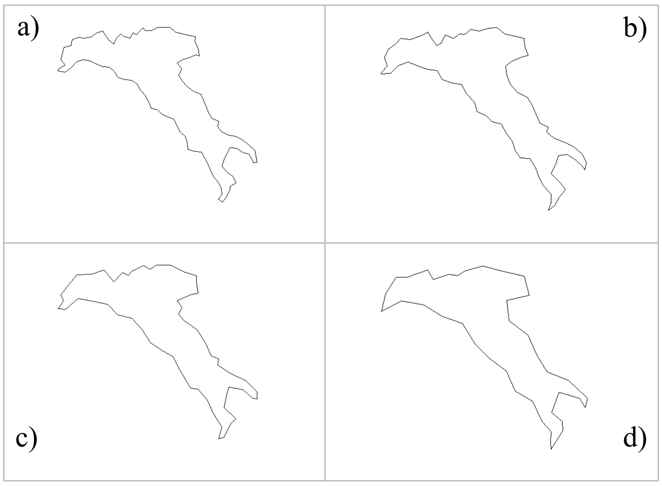


Fig. 4. Results of approximation for Italy contour.

Table 1

	MSE	*SNR*	*CR* [%]	NO
a)	0.7276	40.0127	89.3855	3413
b)	2.1005	35.4084	92.4581	2424
c)	3.4743	33.2229	94.4134	1738
d)	6.5787	30.4501	96.1825	1180

NO – number of operations.

Some selected results of Rose contour are shown in Fig. 5 (related results are in Table 2).

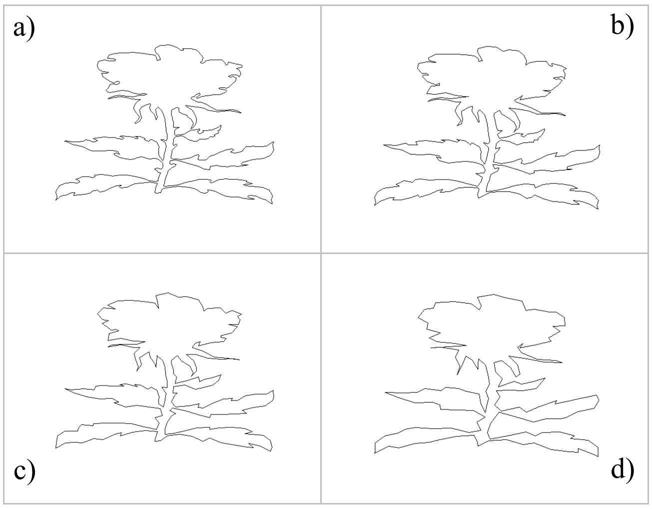


Fig. 5. Results of approximation for rose contour.

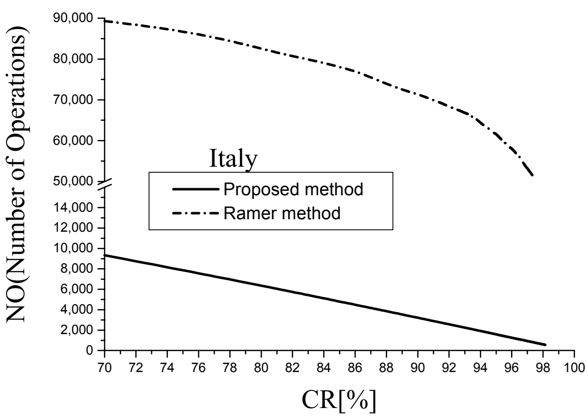
Table 2

	MSE	*SNR*	*CR* [%]	NO
a)	0.3178	46.4502	87.2280	17220
b)	1.6195	39.3783	92.8851	9743
c)	3.5979	35.9116	94.8869	7033
d)	11.9346	30.7041	96.4970	4816

NO – number of operations.

The results presented in Figs. 4 and 5 show that proposed method has good compression abilities. We can state, that compression ratio for analysed contours can be greater than 96.5%.

Comparison of the compression abilities of the proposed method with the Ramer method is presented in Fig. 6 for the analysed contours of Italy and Rose.



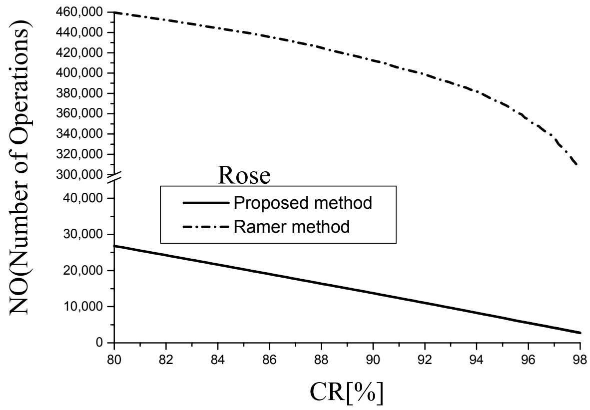


Fig. 6. Comparison of the proposed method with the Ramer method for the contours of Italy and Rose.

It is shown that the proposed algorithm is much faster than that of Ramer.

The approximated Rose contour using Ramer and proposed method for CR = 93.3203% is shown in Figure 7 (related results are in Table 3).

Fig. 7. Approximated Rose contour
a) Ramer method, b) Proposed method.

Table 3

	MSE	*SNR*	*CR* [%]	NO
Ramer	0.62698	43.4996	93.3203	388031
Proposed	1.6978	39.1733	93.3203	9067

NO – number of operations

The comparison of the proposed method with the Tangent and the Ramer methods has also been performed [3, 7, 8, and 9].
The plots of MSE and SNR versus C*R* are shown in Figure 8 and Figure 9 respectively.

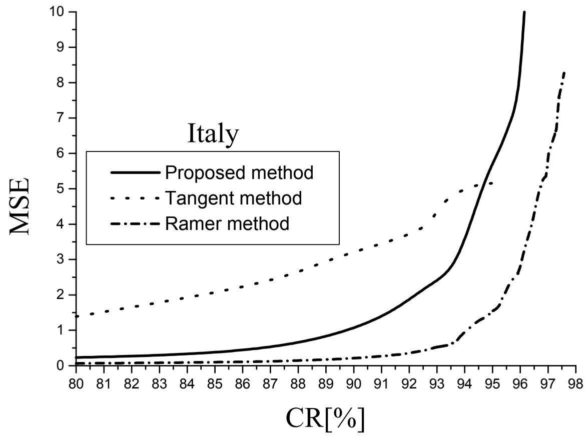


Fig. 8. Comparison of the proposed method with the Ramer and the Tangent methods for MSE versus CR for the Italy contour.

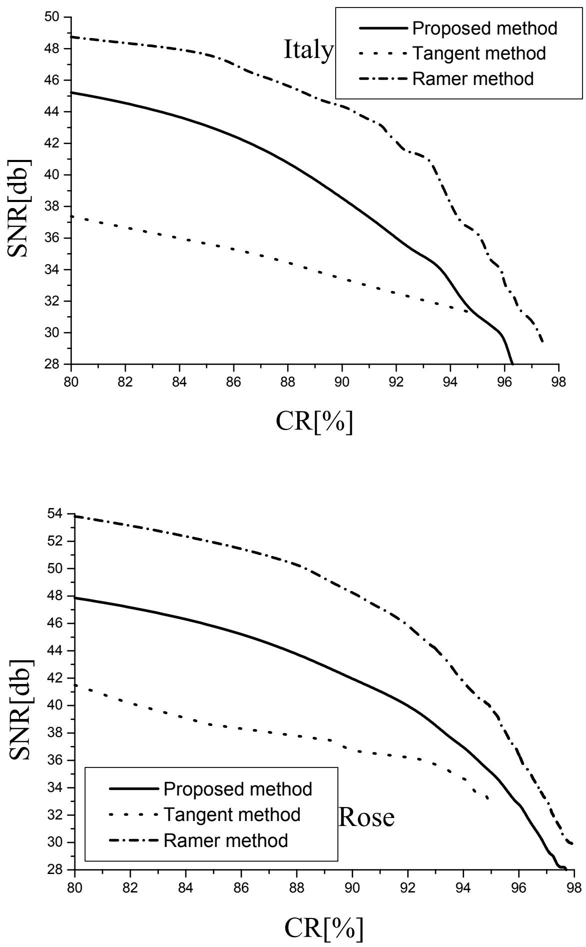


Fig. 9. Comparison of the proposed method with the Ramer and the Tangent methods for SNR versus CR for the contours of Italy and Rose.

The plots show that SNR using the Ramer algorithm is better than the Tangent method and close to the proposed method. The quality of the proposed algorithm is better and also faster than the Tangent method.

The presented results show that the proposed method is faster than that of Ramer in all analysed cases.

The reason of the large number of operations in Ramer method is related to the searching of the maximum distance from the curve segment and straight line between starting and ending points of contour segment.

5 Conclusions

The very small number of operations and good quality of approximation are the main advantages of the proposed algorithm. The proposed algorithm for contour approximation is many times faster than that of Ramer. The high compression can be obtained without significant loses of approximation quality. The approximation quality using the proposed algorithm is better and also faster than the Tangent method. The compression ratio obtained by this method is greater than 96.5% without significant visible distortion as shown in Figure (5d). Important advantage of the proposed method is the simplicity of implementation both in terms of memory requirement and fit criterion complication.

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