International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:3, No:8, 2009

Enhancement of Shape Description and Representation by Slope

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Abstract—Representation and description of object shapes by the slopes of their contours or borders are proposed. The idea is to capture the essence of the features that make it easier for a shape to be stored, transmitted, compared and recognized. These features must be independent of translation, rotation and scaling of the shape. A approach is proposed to obtain high performance, efficiency and to merge the boundaries into sequence of straight line segments with the fewest possible segments. Evaluation on the performance of the proposed method is based on its comparison with established method of object shape description.

Keywords—Shape description, Shape representation and Slope.

I. Introduction

THE description and representation of the shape of an object are important elements in image analysis, image understanding, content-based image retrieval and pattern recognition. The intermediate step that can help identify objects with more accuracy from the images with partially occluded shape is a representation of the geometrical description of the shape by its boundary. The difficulty of shape description and representation comes from how to define the desired shape with low computation complexity and robust invariant to translation, scale and rotation. In this paper, the major goal is to enhance the efficiency with more accuracy by determining the slope of two points into general purpose shape description and representation, and to make shape description more robust invariant to translation, scale and rotation with minimum cost. A powerful shape description and representation methods must meet several criteria, including:

1) Efficiency: simplicity and compactness.
2) Accuracy: accurate and complete reconstruction.
3) Effectiveness: suitability for shape analysis and shape recognition.

Zhang and Lu [1] have provided the classification of shape description and representation techniques in Figure (1). Basically, the shape description and representation techniques can be divided into two types, viz. region-based techniques, which consider the whole area of the object to include all the pixels of the image for shape description and representation, and boundary-based techniques that used only the object contour or border. The next section provides a brief review of the approaches and methods of description and representation of shapes. The detail of proposed approach follows. This is followed by the results of the proposed approach and recently established methods It then discusses several experimental results produced from the methods presented, ending with a conclusion.

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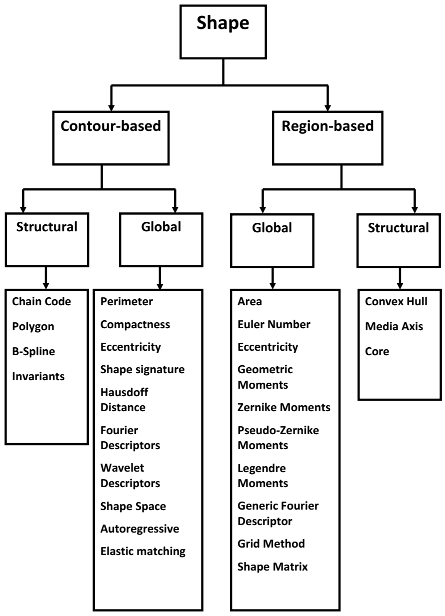

Fig. 1. Classification of shape representation and description techniques

II. RELATED WORKS

In this section, some approaches for shape description and representation techniques in the literature are reviewed.

A. Region based techniques

Jagadish has modeled a shape by using a fixed number of rectangles that overlay the object [2]. Sclaroff and Pentland [3], used the Eigen Modes of a finite element model as a shape descriptor. Kupeev and Wolfson [4], proposed the graph based approaches the spatial relationships among the parts of the object. Moment based shape representation is one of the earliest and most popular region based representations [5],[6],[7]. It provides a numerical shape preserving representation that is invariant to translation, rotation, and scale. Lu and Sajjanhar have suggested a grid based approach that is simple and intuitive [8].

B. Boundary based techniques

El Rube et al. proposed a wavelet based technique that is affine invariant and achieves good results [9]. Cortelazzo et al. [10], proposed a chain coding technique and string matching technique, but the technique is not scale invariant. Basri et al. [11] minimized to match shapes represented by outline curves involves finding a mapping from each curve, from one image, to another. Sebastian and Kimia, [12] reported the curve-based techniques that were characterized by their lack of rotation and scale invariance as well as their sensitivity to articulations and deformations of the shape's parts. Sebastian et al. used the medial axis transform and its shock graph variant is effectively for shape matching. Also they represented the shape of an object as a skeleton that is not scale invariant. It has also been found that the curves and skeletons perform comparatively well in many cases [13].

III. PROPOSAL METHOD

After locating and segmenting the object of interest, its shape is represented according to its boundary or its region. After the representation stage, the shape description is used to characterize the shape by extracting its important features. Basically, to locate the closed boundary that minimizes grouping cost, firstly, the boundary image is divided into fixed size blocks (e.g. 10 X 10 or 20 X 20) depends on the block size Figure (2). Then the algorithm replaces the pixels along a boundary within each block by a straight line from its two end pixels, which are located on the side's boundary of the block Figure (3)and (4). Instead of tracing all pixels (one by one), the proposed approach deals with end pixels only. In other word, this proposed approach marks the pixel as an end pixel if the location of the pixel within the block boundaries. The proposed approach traverses the blocks that contain the boundary segments in a specific (clockwise or anticlockwise) direction until it reaches the first block where it started.

A. Steps of the proposed approach

1) Divide the image into blocks (e.g. 10X10 or 20X20), depends on the block size Figure(2).
2) Seek to find the first pixel of the original boundary within the block by calculate its location, and then determine its coordinates.
3) Seek to find the last pixel of the original boundary within the block by calculate its location, and then determine their coordinates.
4) Calculate the slope of these two points of the first and last pixels by the equation: Where S is the slope, and x, y are the coordinates of the first pixel, and x', y' are the coordinates of the last pixel and x=0, 1, 2, 3 . N-1; y=0, 1, 2, 3. N-1; and N is the block size NXN.

$$S = \frac{x - x'}{y - y'} \tag{1}$$

5) Then the length of slope of the straight line can be calculated by the following equation:

$$L = \sqrt{(x' - x)^2 + (y' - y)^2} \tag{2}$$

Where L is the slope length.

6) The difference in the slopes between any slope of the straight lines (Sk+1) and the previous one (Sk) can be calculated by the following equation:

$$D(S_{k+1}, S_k) = \frac{S_{k+1} - S_k}{1 + (S_{k+1})(S_k)} \tag{3}$$

7) The change in angle between two slopes can be calculated by the following equation:

$$\triangle\emptyset = \tan^{-1}(D) \tag{4}$$

To illustrate the proposed approach by the following example is presented, from the Figure (2), after divided the image into blocks, then the first pixel coordinate for slope 1 is (1, 0) and the last pixel coordinate is (6, 9). Therefore, x=1, x'=6, y=0 and y'=9. From equation (1) the slope 1 for the straight line one equal = - 0.55. From equation (2) the length 1 for the straight line one equal = 10.29. For the second straight line the first pixel coordinate for slope 2 is (7, 0) and the last pixel coordinate is (0, 6). Therefore, x=7, x'=0, y=0 and y'=6. From equation (1) the slope 2 for the second straight line equal = 1.16. From equation (2) the length 2 for the second straight line equal = 9.21. From equation (3) the difference between the slope1 and slope2 is:

$$D(S_2, S_1) = \frac{S_2 - S_1}{1 + (S_2)(S_1)} \tag{5}$$

Therefore, D (S2, S1) = 4.73. From equation (4) the change in angle between the slope1 and slope2 equal = 78.06o.

B. Gap filling

The represented straight lines by slopes in each block may be disconnected from each other, therefore, an additional set of straight line (gap filling lines) is constructed to connect them, and closed boundaries is detected. In other words, the gap filling lines between every pair of detected straight lines by slopes are constructed in order to locate the closed boundary. To obtain high performance and efficiency with minimum cost, the gap filling line between all possible pairs of ending points of the straight lines by slopes results is constructed. In terms of normal case, the number of gap filling lines from n detected lines is O(n2). Therefore, the number of constructed gap filling lines is reduced by not considering the ones between two slopes that are far from each other. Specifically, the threshold dT is determined as shown in Equation (6), to calculate the distance between two endings points of the chain code results. If the distance between two ending points is larger than the threshold, the gap filling line between them is not constructed.

$$dt = \frac{min\{W, H\}}{5} \tag{6}$$

C. Feature map

To improve the detection of the desirable boundary, the region information in the form of a binary feature map is introduced. Feature map M(x, y) is an image of the same size as the input image I(x, y). By using image analysis methods and/or any method like thresholding the pixels intensity of input image, the feature map is constructed. In this paper, based on the proposal method of adaptive k means algorithm [14], the feature map is constructed.

D. Desirable boundary selection

To select the desirable boundary from possible closed boundaries, the grouping cost for a closed boundary is determined as shown in Equation (2), [16].

$$\emptyset(B) = \frac{|B_G|}{\int\int_{R(B)} M(x,y)dxdy} \quad (7)$$

Where BG is the total length of all the gap filling lines along the boundary B, this account for the Gestalt law of proximity, where a smaller total gap length BG represents better proximity. R(B) is the region enclosed by the boundary B and dobell integrated of M(x, y)dxdy is the sum of the feature values of the pixels, taken from a binary feature map M, inside the region enclosed by B [15].

IV. EXPERIMENTAL RESULTS

This section presents the results of the experiments conducted to assess the proposed approach by description and representation of the shape by slopes and region information for selection desirable boundary as proposed in this paper.

A. Dividing the image into blocks

After segmented the image, to detect and represent the straight lines of the boundary, the image is divided into blocks. This dividing depends on the block size for example 10X10 or 20X20. The results are presented as shown in Figure (2).

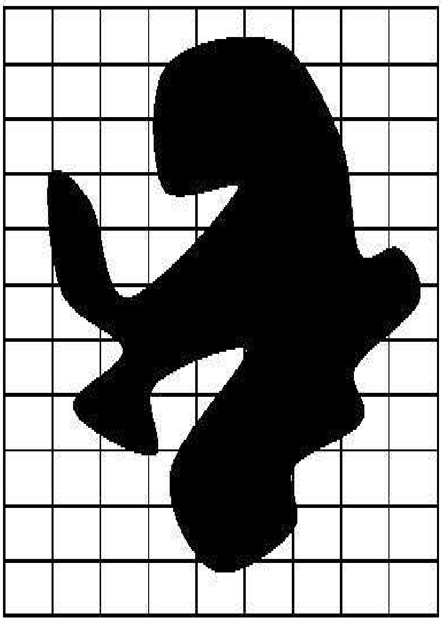

Fig. 2. Dividing the image into blocks

B. Select the first and last pixel of block

The first and last pixels of the object within the block are selected. From their coordinates (first and last pixels) should be located first, to determine the slope from these two point instead to trace all pixels of the border. The results are reported as shown in Figure (3) and (4).

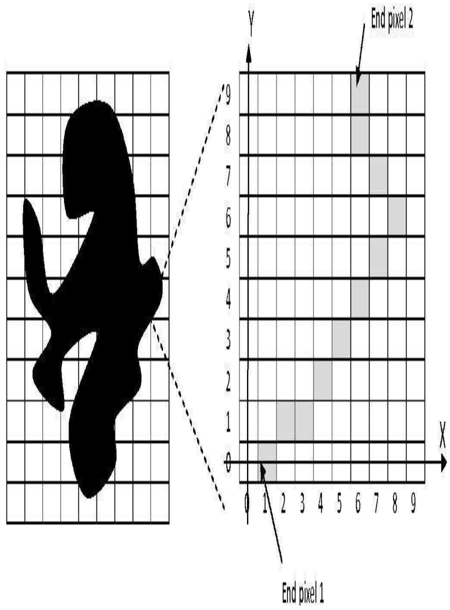

Fig. 3. Select the first and last pixel of block

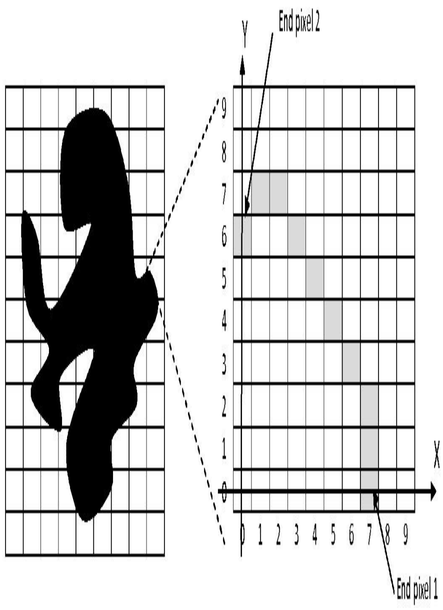

Fig. 4. Select the first and last pixel of block

C. Determine the slope

The results of the determination of the slope from the start and end two point of the first and last pixels of the object within the same block are as in Figure (5) and (6). The length of this slope can be calculated, as shown in the example above.

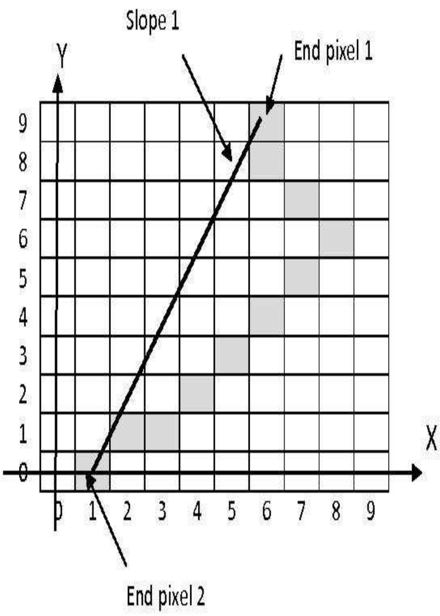

Fig. 5. Determine the slope

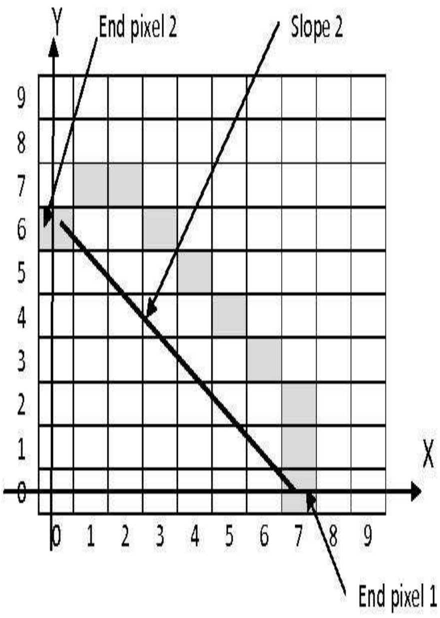

Fig. 6. Determine the slope

D. Difference between slopes

The difference in the slopes between any slope of the straight lines and the previous one can be calculated, to locate the direction of these slopes by calculating the angle between them by using the equation (4). Therefore, knowing the direction of the next straight line is very important to reduce the number of straight lines, therefore, if the straight lines with same direction then should be merge them as one straight line.

E. Gap filling results

Gap filling is used to connect between the lines from the slopes results in order to locate the closed boundary.

F. Feature map results

The feature map is constructed based on the proposal method of adaptive k means algorithm [14], to improve the connecting lines robustness boundary. Furthermore, feature map used to check the slope line refer to the object boundary or not by using the line equation below:

$$(x - x') = S * (y - y') \quad (8)$$

G. Desirable boundary selection results

The result of selection in the desirable boundary which depends on the equation (2) is reported by calculate the minimum cost of connecting lines. Therefore, the desirable boundary with minimum cost is represented.

V. Discussion

The results are obtained from different images by using the Java program to present high performance and efficiency with minimum cost for shape description and representation by using the proposed approach. The processing time that indicates the best way to accelerate the process has also been obtained by using first and last pixels detected within the blocks. To construct the desirable gap filling between slopes within the blocks, it is necessary to select the desirable gap filling by not considering the ones between two end points that are far apart from each other. It constructed the feature maps from color images as described in above section and is used to improve the lines grouping robustness and to select the desirable boundary. The results of the comparison between the proposed approach with recently previous shape description and representation methods in two different ways, viz. computation complexity and robust invariant to translation, scale and rotation are reported.

VI. Conclusion

The proposed scheme presents the relationship between the boundary representations with region information to improve shape description. Boundary detected from straight lines by slopes is affected by its computational cost performance for reaching a desirable boundary. Therefore, the low computation complexity and robust invariant to translation, scale and rotation for shape description is proposed to select the desirable boundary with minimum cost by using gap filling and feature map. Furthermore, a comparison between the proposed approach and the recent method is presented. In summary, it can be concluded that the proposed scheme was successful in selecting the desired boundary and increasing the speed of the execution process.

ACKNOWLEDGMENT

The author is indebted and in great gratitude to those who provided support and encouragement.

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