An Innovative Homotopic Algorithm for Image Border Detection

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Summary
Several algorithms have long been investigated for border detection. The border is a compact abstract object representation that preserves the shape and the size of the original object encoding an image as a set of object borders allows this image to be partially reconstructed and progressively refined back to the original image. In the present paper an innovative algorithm that simplifies the border detection using homotopic property is presented. The present algorithm introduces a new notion for order independent and dependent border detection. The present algorithm is implemented on human faces and characters, and good results are obtained.

Key words:
border detection, homotopic property, order independent, order dependent, thinning, mathematical morphology.

1. Introduction

The pattern recognition and shape analysis, methods for extracting object borders are very much studied by many researchers. A classical approach consists in working on a contour representation of the object. Another possibility is to detect the border of the object to a set of lines condensing the information of the original object while preserving its homotopy. The result can be considered as border of the input pattern. The corresponding transformations are called image border transformation. The detection of endpoints, multiple points, and closed loops of border is important for many shape recognition techniques such as those used for optical character recognition. Several formal definitions for the border, of a Euclidean set are available depending on whether wave front propagations, distance transformations, maximal disks, minimal paths, or morphological openings are considered. Fortunately, all these approaches, when applied to Euclidean sets, output similar thinned patterns.

2. Methodology

The present method effectively uses the fundamental frame work of 4-connectivity and 8-connectivity neighbor hood concept on Homotopic property and thus derives an innovative algorithm. Proper pixel deletion is the one of the important property of any border detection algorithm. A pixel is called deleted or simple if and only if the image obtained by removing the pixel is homotopic to the original image. The meaning of deleted pixel is changing pixel value from 1 to 0 where the selection criteria for homotopic property is met. An order independent homotopic border detection algorithm can be obtained by setting 0 to those of pixels of the original image what ever be considered scanning order. We represent these pixels the order independent simple pixels and they are said to be independent. Then the present study has defined a simple pixel P is independent of a simple pixel Q1 if it has one of the following configuration.

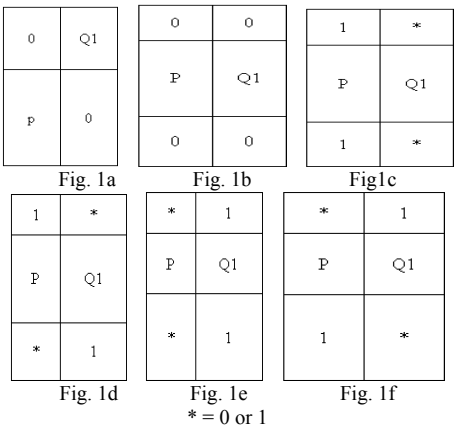

Fig. 1a Fig. 1b Fig1c
Fig. 1d Fig. 1e Fig. 1f
* = 0 or 1

Fig. 1 Representation of simple pixel configuration

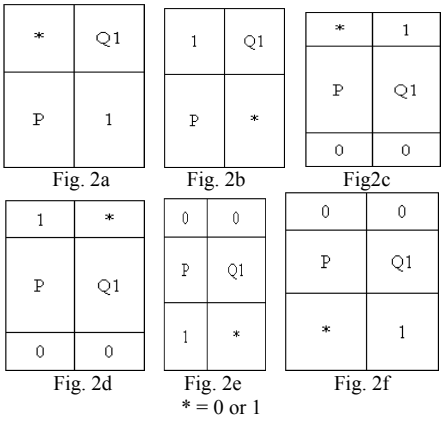

Fig. 2a Fig. 2b Fig2c
Fig. 2d Fig. 2e Fig. 2f
* = 0 or 1

Fig. 2 Representation of simple pixel p which is independent of simple pixel Q1.

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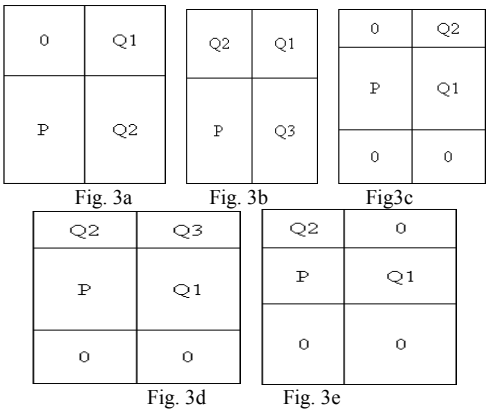

Fig. 3 Representation of non-strict independence of pixel configuration

In Fig.1 A simple pixel P is dependent on simple pixel Q1, if it has one of the above configuration. For first two configurations (Fig.1.a and Fig.1.b) P is simple. This implies that is 8-connected. The other four configurations (Fig.1.c to Fig.1.f) we denote by P1 and P2 the two pixels with value 1. P is simple, this implies at least one of its 4 neighbor has value 0.

In Fig.2 A simple pixel P is independent of a simple pixel Q1, if and only if it has one of the above configuration. We denote the pixel with * by P1 and the one with value 1 by P2. For all other configurations the simple ness become false as soon as Q1 is set to 0.

In Fig.3 in all these configurations P, Q1, Q2 and Q3 are simple pixels. First configuration as in Fig3.a P must be simple for sequences(Q2,P). Second configuration as in Fig.3.b P is simple, it has a 4 connected neighbor with value 0. Third configuration as in Fig3.c P is simple implies its un displayed 8 neighbors of P have value 0. Fourth configuration as in Fig3.d sequences(Q2,P) implies un displayed 8 neighbors of P have value 0. Fifth configuration as in Fig.3.e sequences(Q2,P) implies un displayed 8 neighbor of P have 0 value, the fact that Q1 and Q2 are simple implies that their un displayed 8 neighbors have also 0 value.

3. Proposed Algorithm

STEP1**:** Convert the given grey level image into binary image by using global average algorithm.

STEP2: If pixel P is dependent of one of its simple neighbors. Then pixel P retain its value.

STEP3: If P is strictly independent of all its neighbors. Then pixel P will be removed or assigned to zero.Else if P and Q1 are not in one of four final configurations of Fig.3. Then pixel P retains its value. Else P will be removed.

STEP4: Apply STEP 2 to 3 on the entire image, by convolution.

4. Experimental Result

The above algorithm is applied Lincon and Monalisa Images collected from text book of digital image processing by Rafael C.Gonzalez. The Fig. 4, 5 and 6 shows the original images of Monalisa, Lincon and the characters T and I. The Fig. 4a, 5a and 6a show the borders of the original images respectively.

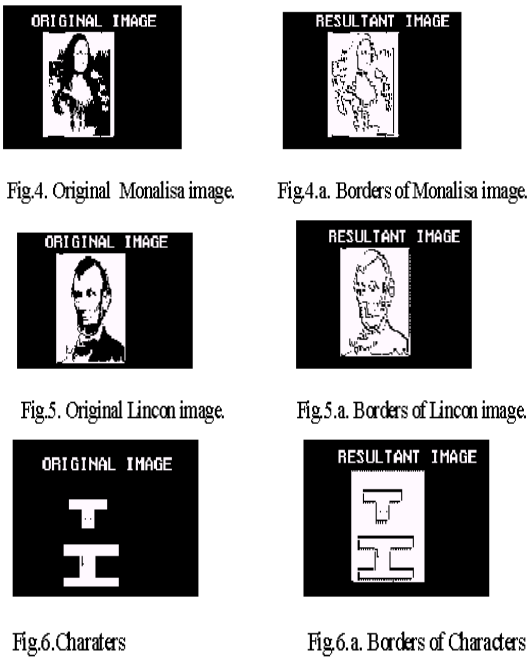

Fig.4. Original Monalisa image. Fig.4.a. Borders of Monalisa image.

Fig.5. Original Lincon image. Fig.5.a. Borders of Lincon image.

Fig.6.Charaters Fig.6.a. Borders of Characters

5. Conclusions

The proposed homotopic border algorithm does not require the choice of a family of homotopic structuring elements because implicitly, it allows for all homotopic structuring elements to be considered simultaneously. It is independent of the order in which the pixel is processed. The output is a result invariant through $\pi/2$ rotations. The proposed method is naturally adapted to a parallel implementation. The proposed algorithm has a polynomial implementation in $O(n^2)$, where n is the number of pixel of the input image. In addition, to implementation of watershed transformation, heap data structures can be used for directly accessing the pixels to process at each iteration of the order independent border detection. Since we have deliberately restricted over analysis to algorithms based on thinning, a comparison with other approaches still needs to be carried out.

References

[1] Arcelli, C., Cordella, L., Levialdi 1981. From local maxima to connected skeletons. IEEE Trans. Pattern Anal. Machine Intell.
[2] Bertrand, G., Everat, J.C., Couprie, M., 1997. Image segmentation through operators based upon topology. J. Electron.
[3] Buneman, O.,1969. A grammar for the topological analysis of plane figures, In: Meltzer, B., Mitchie D.(Eds.) machine Intelligence, Vol. 5. Edinburg University press, Edinburg.
[4] Digital Image Processing by Rafael C. Gonzalez.
[5] Lam. L. Lee., S.W.Suen. Thinning methodologies: a comprehensive survey.
[6] Kong T., Rosenfeld A : Digital Topology: introduction and survey.
[7] Iwanowski. M., Soille. P : Order independence in binary homotopic thinning.

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