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WINGS TO YOUR THOUGHTS…..

OPTIMIZATION OF IMAGE USING SKELETONIONIZATION TECHNIQUE WITH ALGORITHMS

Neetika, Dhirendra Mohan

Royal Institute of Management & Technology
Chidana, Haryana (India)
bhanwalaneetika@gmail.com

Abstract: *Digital image processing deals with manipulation of digital images through a digital computer It is a subfield of signals and systems but focus particularly on images. DIP focuses on developing a computer system that is able to perform processing on an image. The input of that system is a digital image and the system process that image using efficient algorithms, and gives an image as an output. A number of image processing and pattern recognition application demand that are raw digitized binary pattern array be normalized, so that the constituent components of that array are of uniform thickness. The Thinning process reduces such components to a thickness of one pixel or sometimes to a few pixels. The thin-line representations of elongated patterns would be more amiable to extraction of critical features such as end-points, junction-points, and connection among the components. This Paper has been proposed and implemented the thinning algorithm. The thinning equation has been optimized in the algorithm. The algorithm has been analyzed on the basis of connectivity and convergence to unit width.*

1. Introduction

A digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are referred to as pixels. The intensity of a monochrome image at any coordinates (x, y) is called the gray level (l) of the image at that point. A gray level image is composed of pixels in the gray scale defined by the interval $[L_{min}, L_{max}]$. The common practice is to shift this interval numerically to the interval [0, L-1], where I = 0 is considered black and I = L -1 is considered white on the gray scale[2] An image having only two levels namely black and white (with black denoted by 1 and white denoted by 0) is called a binary image.

1.1 Image Structure

An image consists of tiny, equal areas, or picture elements, arranged in regular rows and columns. The position of any picture element, or pixel, is determined on an x-y coordinate system; the origin is at the upper left corner of the image. Each pixel also has a numerical value, called a digital number (DN) that records the intensity of electromagnetic energy measured for the ground resolution cell represented by that pixel. Digital numbers range from zero to some higher number on a gray scale [3]. The position of a pixel P_1 at location (i, j) along with its neighboring pixels is shown in table.

P_9 (i-1, j-1)	P_2 (i-1, j)	P_3 (i-1, j+1)
P_8 (i, j-1)	P_1 (i, j)	P_4 (i, j+1)
P_7 (i+1, j-1)	P_6 (i+1, j)	P_5 (i+1, j+1)

1.2 Skeletonization

Skeletonization is a morphological operation that is used to remove selected foreground pixels from binary images [7]. It can be used for several applications, but normally only applied to binary images, and produces another binary image as output. The skeletonization operation is related to the hit-and-miss transform, and so it is helpful to have an understanding of that operator before reading on.

The term 'skeleton' has been used in general to denote a representation of a pattern by a collection of thin arcs and curves. Other nomenclatures have been used in different context. For example the term 'medial axis' is being used to denote the locus of centers of maximal blocks. Some authors also refer to a 'thinned image' as a line drawing representation of pattern[8]. In recent years, it appears that the term 'skeleton' is used to refer to the result, regardless the shape of the original pattern or the method employed [9]. Thus, skeletonization is defined as process of reducing the width of pattern to just a single pixel. This concept is shown in figure 1.

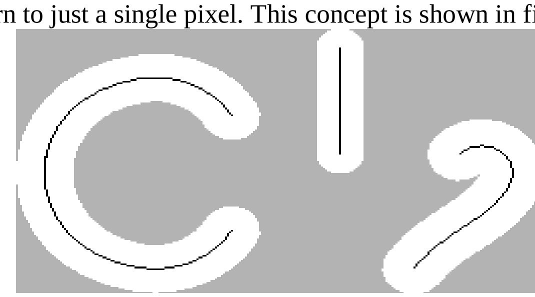

Figure 1: A set of objects with skeletons superimposed

1.3 Requirements

The skeletonization process has following requirements

1. Geometrical: The skeleton must be in the middle of the original object and must be invariant to translation, rotation, and scale change.
2. Topological: The skeleton must retain the topology of the original object.

1.4 Purpose of Skeletonization

The purpose of skeletonization is to reduce the amount of information in image pattern to the minimum needed for

recognition. Thinned image helps the extraction of important features such as end points, junction points, and connections from image patterns[10]. In real world there is a need for skeletonization of images due to following reasons:
To reduce the amount of data required to be processed.
To reduce the time required to be processed.
Extraction of critical features such as end-points, junction-points, and connection among the components. The vectorization algorithms often used in pattern recognition tasks also require one-pixel-wide lines as input. Shape analysis can be more easily made on line like patterns.

2. Literature Survey

T. Y. ZHANG et. al [3] in their research paper "A fast parallel algorithm for thinning digital patterns" presented a parallel algorithm for skeletonizing different types of digital patterns. The algorithm is divided into two sub iterations that remove the boundary and corner points of the digital patterns. The first sub iteration aims at deleting the south-east boundary points and the north – west corner points, the second sub iteration is aimed at deleting the north- west boundary points and the south-east corner points. After several iterations only a skeleton of the pattern remains.
Ben K. Jang et al.[5] in their paper "One pass parallel thinning : analysis, properties and quantitative evaluation" defined skeletonization as a procedure to transform a digital pattern, say, a connected component , to a connected skeleton of unit width. The one-pass parallel algorithm proposed requires only a single pass per iteration and uses a set of 5×5 templates. However, because of the limitation of the square-grid representation, resulting skeleton do not always closely approximate their corresponding medial axes. A number of other important issues, such as medial axis presentation, noise sensitivity, and over shrinking have been addressed. A set of measures to evaluate the proposed skeletonization algorithm are also discussed. The skeletonization algorithm is further extended to the derived grid for an isotropic medial axis representation.
M.V.Nagendraprasad et al. [6] in their paper "An improved algorithm for thinnng binary digital patterns" presented a parallel algorithm which yield good results with respect to speed and connectivity. However during implementation, the algorithm involves a number of time consuming steps.
Louisa Lam et al.[7] in their paper, "An evaluation of parallel thinning algorithms for character recognition" mentioned that the skeletonization algorithms have played important role in the preprocessing phase of OCR systems. They have considered the performance of different skeletonization algorithms from a number of aspects that are pertinent to OCR, from commonly measured quantities such as CPU time to the less easily quantifiable effects on the recognition process.
Samira S. Mersal et al.[8] in their paper "A new parallel thinning algorithm for gray scale image", presented a parallel algorithm, for skeletonization of gray scale images based on repeatedly conditionally eroding the gray level objects in the image until a one pixel thick pattern is obtained along the center of the high intensity region.
Y.Y.Zhang et. al. [9] in their paper, "A thinning algorithm with two- subiterations that generates one – pixel wide skeletons" have mentioned that many vectorization algorithms require one pixel-wide lines as input. One cannot use some published algorithms for vectorizing if there are redundant pixels in skeletons. They defined the skeletonization of a binary image as an application of an iterative procedure for removing locally removable points. A skeletonization algorithm is perfect if it can generate one-pixel wide skeletons. They further mentioned that in parallel skeletonization, pixels are examined for deletion based on the results of only the previous iteration. Therefore, these algorithms are suitable for implementation on parallel processors where the pixels satisfying a set of conditions can be removed simultaneously. Their algorithm used 3×3 neighborhood in which each iteration is divided into two sub iterations in which only a subset of contour pixels are considered for removal. At the end of each sub iteration, the remaining image is updated for the next sub iteration.

3. Present Work

The reduction of image can eliminate some counter distortions while maintaining significant topological and geometric properties. In more practical terms, thin-line representations of elongated patterns would be more suitable for extraction of critical features such as end-points, junction-points, and connection among the components. The vectorization algorithms often used in pattern recognition tasks also require one-pixel-wide lines as input.
Therefore, in real world, we have to thin the various images like BMP images to minimize the data to be handled, therefore there is need to have a software which can thin the images. There is need to study the various aspects of skeletonization concepts. Keeping in mind that our goal is to come up with a set of strokes representing our original image, it would be nice to have a way to preserve the orientation of our shapes while removing information that doesn't interest us. One possibility is to consider the skeleton of an object.
We approximate the skeleton with a skeletonization filter which gradually removes pixels from the borders of objects until something that looks a lot like the skeleton remains [15]. This skeletonization algorithm has two desirable features; the first is that it will not remove any pixel that would cause one object to become two disconnected objects. It is also sensitive enough to properly thin segments which are two pixels thick. Any good skeletonization algorithm must favor one direction over another in order to avoid removing every pixel in search of the one-true-single-pixel skeleton. The problem of connectivity has been solved in this algorithm which was present in the previous algorithms.
In real world there is a need for skeletonization of images due to following reasons:

- To reduce the amount of data required to be processed.
- To reduce the time required to be processed.

- Extraction of critical features such as end-points, junction-points, and connection among the components.
- The vectorization algorithms often used in pattern recognition tasks also require one-pixel-wide lines as input.
- Shape analysis can be more easily made on line like patterns.

Optical character recognition (OCR) is the process of converting scanned images of machine printed or handwritten text into a computer process able format. Handwritten symbol recognition has received and continues to receive much attention by many researchers. There is a wealth of papers published and studies carried on this subject.

4. Proposed Algorithm

A pixel is 8-(4-) deletable if its removal does not change the 8-(4-) connectivity of p, The pixels considered for deletion are contour pixels i.e. the pixels that have at least one white neighbor. The method for extracting the skeleton of a picture consists of removing all the contour points of the picture except those points that belong to the Skeleton. In order to preserve the connectivity of Skeleton, each iteration is divided into two sub-iterations. The pattern is scanned from left to right and from top to bottom, and pixels are marked for deletion under four additional conditions:

H1: At least one neighbor of p must be unmarked.
H2: Xh (p) =1 at the beginning of the iteration.
H3: If x3 is marked, setting x3=0 does not change Xh (p).
H4: If x5 is marked, setting x5=0 does not change Xh (p).

The above mentioned conditions are elaborated as given below:

H1: The unmarked neighbors of a pixel P1 denoted by B (P1) is the non-zero neighbors of p1, that is

$$B(p1) = p2+p3+\ldots+p9$$

The condition that we implement is that B (P1) ≥1. Condition H1 was designed to prevent excessive erosion of small "circular" subsets.

H2: In this step we calculate the crossing number, connectivity number or Hilditch number Xh (p) as described below.

It is defined as the number of times one crosses over from one white pixel to a black when points in the N(p) are traversed in order, cutting the corners between 8-adjacent black 4-neighbours where X9 =X1 therefore

$$Xh(p) = \sum_{i=1}^{4} Ci$$

Where;

$$Ci = \begin{cases} 1 \;; \text{ if } X2i\text{-}1==0 \text{ and } (X2i=1 \text{ or } X2i+1=1) \\ 0 \;; \text{otherwise} \end{cases}$$

The crossing number is equivalent to the number of 8-components of 1s in As(p) if at least one 4- neighbor is a 0.

Xh(p) is equal to the number of black components in N(p) except when p has all 4-neighbors,in which case Xh(p)=0.Obviously,crossing number for a pixel having all black 8-neighbors would be 0 as would an isolated pixel. If Xh(p) =1, deletion of p would not change the 8-connectedness of the pattern.

The deletion of p would not affect 4-connectivity if Xh (p) =2 since the black pixels in N (p) are 4-connected in these cases.

The condition H 2 is used to maintain connectivity.

The conditions H3 and H4 reflect that if X3 or X5 are marked then setting them to background does not change the connectivity number. These conditions are used to preserve two-pixel wide lines. As a result of skeletonization process, a two-pixel-width or even pixel width in horizontal or vertical direction may be deleted, which would cause the loss of connectivity of object pattern. For example, a two-pixel-width rectangular pattern will disappear completely. In order to keep up the connectivity, these pixels should not be deleted. On the other hand, if all two–pixels-width are retained, the skeleton would not be one pixel width.

5. Conclusion

The discussion of various aspects such as convergence to unit width, connectivity and spurious branches can be taken together to compare these algorithms for regional language numerals for the purpose of skeletonization. The results obtained by applying the above discussed parallel skeletonization algorithms are shown in this paper. The differences in the outputs are very much clear from the visual inspection.

References

[1] "Fingerprint minutiae extraction based on principal curves, Pattern Recognition Letters" Volume 28, Issue 16, 1 December 2007, Pages 2184-2189.

[2] "Employing Generic Algorithms for precise Fingerprint Matching based on Line Extraction", GVIP Journal, Volume 7, Issue 1, April, 2007.

[3] M. Ahmed, R. Ward, "A Rotation Invariant Rule-Based Thinning Algorithm for Character Recognition" December 2002 (Vol. 24, No. 12) pp. 1672-1678.

[4] R. Gonzalez and R. E. Woods, "Digital Image Processing", Prentice Hall, 2002.

[5] M. Ahmad and R. Ward," An Expert system for General Symbol Recognition," Pattern Recognition, vol. 33, no. 12, pp. 1975-1988, 2000.

[6] Masoud Alghoniemy and Ahmed H. Tewfik, "Geometric Distortion Correction through Image Normalization" IEEE Trans. Vol pp. 1291-1294, 2000.

[7] L.Heutte, T. Paquet, J. V. Moreau, Y. Lecourtier, C. Olivier, "A structural/ statistical feature based vector for hand written character recognition" pattern recognition letters 19,1998, pp. 629-641

[8] M.Ahmed, R.Ward, "A Fast one pass knowledge-based system for thinning", Electronic Imaging 7(1)(1998), 111-116.

[9] N.H.Han, C. W. La, P. K. Rhee, "An efficient fully parallel thinning algorithm", IEEE transactions on pattern analysis and machine intelligence, 1997, pp. 137-141

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[10] Y.Y.Zhang, P. S. P. Wang, "A thinning algorithm with two- subiterations that generates one – pixel wide skeletons", Proceedings of ICPR, 1996, pp.457-461.

[11] Trier, O. D. Jain, A. K., Taxt T., 1996, "Feature Extraction Methods for character recognition-A Survey", Pattern Recognition 29(4), 641-662.

[12] M.V.Nagendraprasad , P. S. P. Wang, A. Gupta, "An improved algorithm for thinning binary digital patterns", IEEE transactions on pattern analysis and machine intelligence, vol. 14, no.11, September 1995, pp. 386-389.

[13] J. Starzyk, Y. Jan. "Algorithm and architecture for feature extraction in image recognition", Southeastern Symposium on System Theory, 1994, pp 448-452.

[14] A.Datta and S.K.parui, "A Robust Parellel Thinning algorithm for Binary Images." Pattern recognition, vol.27, no.9, pp 1181-1192, 1994.

[15] Srihari, S. N.,1993, "Recognition of handwritten and machine-printed text for postal address interpretation," Pattern Reconition Letters 14(4), 291-302.

[16] Ben K. Jang, Roland T Chin, "One pass parallel thinning: analysis, properties and quantitative evaluation", IEEE transactions on pattern analysis and machine intelligence, vol. 14, no.11, November 1992, pp. 1129-1140.

[17] Louisa Lam, C. Y. Suen, "An evaluation of parallel thinning algorithms for character recognition", IEEE transactions on pattern analysis and machine intelligence, vol. 17, no. 9, November 1992, pp. 914-919.

[18] G.Burel, I. Pottier, J. Cartos, "Recognition of handwritten digits by image processing and neural network", International conference on Neural Networks,vol.3,1992, pp. 666-671.

[19] C. Suen, C. Nadal, R.Legault, T. A. Mai, L.Lam, "Computer recognition of unconstrained handwritten numerals", Preceedings of IEEE 80(7)(1992) 1162-1180.

[20] Lam, L., Lee, S. W. and Suen, C. Y., "Thinning methodologies- a comprehensive survey.", IEEE Trans. Pattern Anal. Mach. Intell. 14, 9(1992) 869-885.