

A Review on an Efficient Iterative Thinning Algorithm

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ABSTRACT: Thinning is the important technique used in the image processing. The first step in the Thinning is “Pre- Processing”. This Thinning technique is used to represent the structural shape of the image. This thinning technique is used to compress the image and also to display the skeleton of the image. Skeletonization is a process of reducing foreground regions of a binary image to a skeleton form that preserves a connectivity of the original image. There are different types of thinning techniques but the most important is Iterative and Non-iterative. Iterative works on the pixels by pixel whereas non-iterative works just opposite to iterative. There are many algorithms which was developed to implement the thinning algorithm. Zhang Suen fulfils the thinning algorithm to get the maximum throughput. Zhang Suen algorithm works on various factors like execution Time and the thinning rate. The representation of the image using Zhang Suen algorithm makes the skeleton of the image smooth, clear and continuous.

KEYWORDS: Thinning, Pre-processing, Skeletonization, Iterative and Non-iterative.

I. INTRODUCTION

Digital Image processing is the routine of computer processes to achieve image processing on digital images. Digital, Image and processing are composed as Digital image processing. They take the digital image as input works on noise reduction, signal distortion and gives the output. Digital image is a matrix or an array that is represented by a finite number of bits. Analog signals do not work on Multi-Dimensional pixels. Thinning is a technique used in image processing works on an image by reducing the pixels iteratively or non-iteratively. This thinning technique works on various algorithms in which Zhang-Suen algorithm proves that the image is thinned by reducing the Thinning Rate and reduction of time. This paper also proposes a study on two algorithm techniques Canny Edge Detection Algorithm and Zhang – Suen Algorithm in which Zhang – Suen Algorithm proves that the complexity is reduced. The tool used to work on this thinning technique is VERILOG and MATLAB. The algorithm proposed in this paper is detailed and the expected output image can also be explored.

II. TYPES OF THINNING

2.1 Iteration

Iteration means repetition of a process [12]. thinning algorithm using iteration method on a pixel by pixel basis being used. this method contains two sections such as parallel and sequential. in parallel thinning the result maintains only after the previous iteration is taken, whereas in sequential thinning the process takes place in a fixed sequence [8]

2.2 Non-iteration

Non-iteration does not repeat any process [13]. Non-iteration in thinning does not work on the working on pixels by pixel. They involve in some implementations like medical transforms, distance transforms [8].

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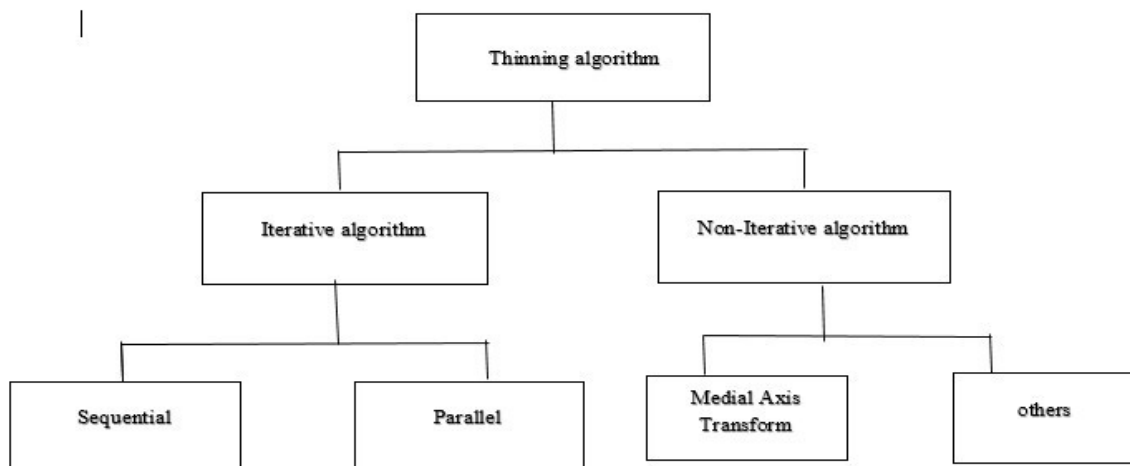


Fig 1: Types of thinning Algorithms [4]

III. SKELETONIZATION TECHNIQUE

The process of taking away the skeleton from a digital picture is called as Skeletonization. This removes the pixels in layers until only one width of the pixel are obtained. Once the pixels are removed from an object the digital picture is displayed in negligible size for the machine to identify the object [9].

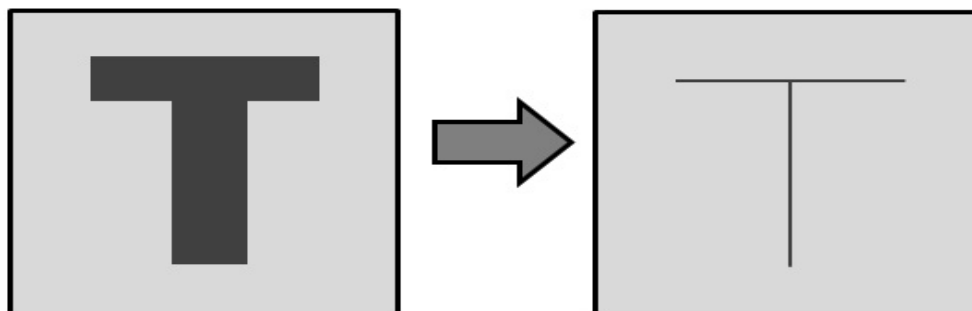


Fig 2: Concept of Skeletonization [14]

IV. VARIOUS THINNINGALGORITHMS

Currently the following algorithms using the concepts :-

- 1) Edge Based thinning algorithm.
- 2) Zhang Suen Thinning algorithm.

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- 3) Guo and Hall's parallel Thinning algorithm. Equations
- 4) Canny Edge detection.
- 5) Optimized iterative algorithm using successive erosion.

V. A STUDY ON GUO AND HALL'S PARALLEL THINNING ALGORITHM, CANNY EDGE DETECTION ALGORITHM AND ZHANG - SUEN ALGORITHM:

5.1. GUO AND HALL'S PARALLEL THINNING ALGORITHM

Zicheng Guo and Richard W. Hall used two parallel thinning algorithms (1) alternatively deleting north and east and then south and west boundary pixels and (2) alternately applying a thinning operator to one of two subfields. The speed and medial curve thinness are associated with the two-sub iterations where both produce a thin medial curve and the second attains the fastest overall parallel thinning. The local operators in this structure are focused in the support of 3*3 neighborhood which will support difficulty in connecting the image. [2].

5.1.1 A TWO-SUBITERATION THINNING ALGORITHM:(A1)

This algorithm preserves the connectivity of properties and includes 3*3 operators:

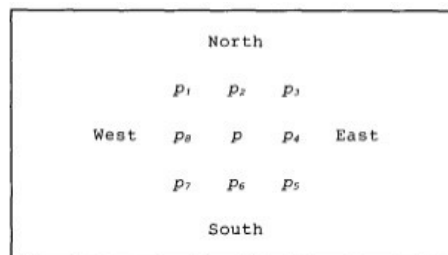


Fig 3: 3*3 neighborhood definitions of pixels [2]

This algorithm produces the smallest medial curves with the prescribed thinness under the 3*3 neighborhood. [2].

5.1.2 TWO-SUBITERATION THINNING ALGORITHM USING SUBFIELDS :(A2)

A fractional series of a parallel thinning algorithm can also be attained by separating the image into distinct subsets denoted as subfields. These subfields are activated in distinct iterations. This approach was first done in to image processing by Golay and has been subsequently applied and extended by Preston. We have separated the image space into two subfields in a checkerboard pattern. All the subfields are activated in the order 1, 2, 1, 2 . . . in consecutive iterations where only the pixels in one subfield can modify the state in any of the iteration. As a consequence, only the four diagonal neighbors of each pixel can change the state concurrently with that pixel. [2].

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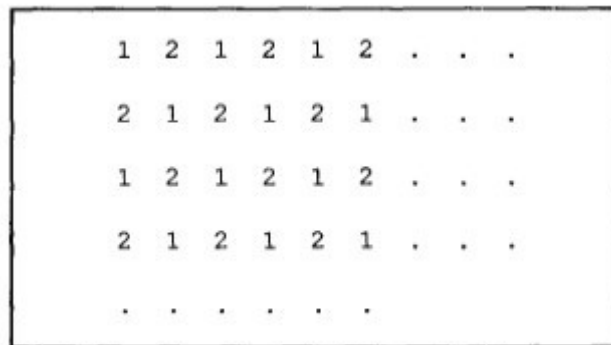


Fig 4: definition of two- sub iteration [2]

Both these algorithms preserve image connectivity's and produce the thinner results. Algorithm A1 offers the smallest medial curves with thinness when compared to Algorithm A2. A2 produces the highest parallel speed among two- sub iteration thinners and its parallel speed is also shown to be superior to a recently reported fully parallel thinning approach. Thus, the prescribed image will not be cleared when compared to Zhang-Suen Algorithm which includes two iterations. [2].

5.2 CANNY EDGE DETECTION ALGORITHM: A TRADITIONAL AND IMPROVED METHODS

Canny Edge algorithm is a weak algorithm where it is complex to noise and it will lose the edges which are weak when sorting through out of noise. The Canny detector is used in traditional method where the Canny Detector is divided into four type's Gaussian filter, Gradient Calculation, Non-maximum Suppression, and hysteresis thresholding [10]. The traditional Canny Edge algorithm is more robust to noise. To reduce this complexity an improved version of this algorithm is proposed which introduces the gravitational field intensity to substitute the image gradient. In this paper [6] the improved operation of Canny Edge Algorithm is done in 2*2 operator and stretched to 3*3 operator. But the computing speed is quite slow and it has to be further enhanced. The improved algorithm just keeps the advantages of a traditional Canny Edge Algorithm.

5.3 ZHANG - SUENALGORITHM

Zhang- Suen algorithm is a well proved algorithm where it proposes on iterative thinning algorithm working on the matrix of 3*3[7]. It is a directional algorithm which consists of two sub-iterations: the first is aimed at deleting the South-East boundary pixels and the North-West corner pixels while the second one is aimed at deleting the North-West boundary pixels and the South-East corner pixels that are the opposite orientations. [1][7]

P8	P2	P3
P7	P1	P4
P6	P1	P5

Table 2: ZS algorithm of 3*3 neighbourhood [7]

The method for taking out the skeleton of a picture contains the removing of all curve pixels of the picture except those fitting to the skeleton. In the first sub-iteration, the curve point p1 is deleted from the pattern, if it satisfies the following conditions:

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- (a) $2 \leq B(p_1) \leq 6$
- (b) $A(p_1) = 1$
- (c) $p_2 \times p_4 \times p_6 = 0$
- (d) $p_4 \times p_6 \times p_8 = 0$ [7][6]

In the second sub-iteration, the curve point p_1 is deleted from the pattern, if it satisfies the following conditions:

- (a) $2 \leq B(p_1) \leq 6$
- (b) $A(p_1) = 1$
- (c) $P_2 \times p_4 \times p_8 = 0$
- (d) $P_2 \times p_6 \times p_8 = 0$

Where: $A(p_1)$ is the number of "0-1" (white-black, in this order) pairs in the clock-wise traversal of the 8-neighborhood of p_1 , i.e. p_2, p_3, p_4, p_8, p_9 . $B(p_1)$ is the number of non-zero 8-neighbors, that is:

$$B(p_1) = \sum_{i=2}^9 P_i.$$

If any condition is not satisfied then p_1 will not be deleted from the foreground. [7]

VI. LITERATURE SURVEY

Bansal [8] proposes that the Thinning is the Pre-processing technique where the image is displayed in a skeleton form. There are many algorithms in Thinning technique but all are not much satisfiable in which all the requirements are not fulfilled. The author proposes various types of Thinning types in this paper (e.g., Iterative and Non-iterative). The software used to implement the algorithm is VERILOG and MATLAB. The thinning rate is the only factor in which all algorithms can be measured. The satisfiable algorithm is ZS algorithm where the Thinning rate, thinning speed are measured in the matrix of 3*3 neighbourhood. Hence the output for an image using the Thinning technique proposed in this paper is given as:



Fig 5: InputImage[15]

Fig 6: Thinned outputImage[15]

Kaur [9] proposes that in this paper "Enhancement of z-h algorithm to improve thinning rate: a review" the image used is binary image for thinning process. The image displayed in general way is by the deletion of the edge points layer by layer. The author has proposed the different types of Skeletonization algorithms, its needs, applications, and requirements of thinning algorithm. The algorithm used in this paper is Zhang and Suen algorithm. The future enhancement in this paper is ZH algorithm which will be applied in dynamic pixel values.

Jagna [3] in this paper "New parallel binary image thinning algorithm" using parallel image thinning algorithm on

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binary images and it applies the reduction of the pixels and checks for the proper connectivity of the flow of image pattern. The author describes the non-zero pixels for objects and zero valued pixels for background. P1, P3, P5 and P7 are the relative four sections for connecting the background and P2, P4, P6, P8 are the relative eight sections for connecting objects where this section will process in two iterations.

P1	P2	P3
P8	Pi	P4
P7	P6	P5

Table 1: (3*3) Pixel mask used under consideration [3]

This above process is done by two algorithms ZS algorithm and LW algorithms which reduces the end points and the result of the proposed algorithm is also given. Hence the expected output is proposed only by the ZS algorithm, by reducing the pixels and skeletonizing the binary image.

Karnea [4] proposes in this paper “Implementation of an Image Thinning Algorithm using Verilog and MATLAB.” the implementation of thinning image is done in 128*128 pixels of a binary image using the Zhang Suen algorithm. MATLAB 7.12 is used to design the planned work and also created by charting on Virtex 5 in Xilinx ISE for considerate the hardware complication. Simulation outcomes are attained in terms of waveforms in ISim Xilinx ISE Simulator and the output text file of the hardware system is transformed to an image format using MATLAB. Performance measurement is passed out between Zhang – Suen’s thinning algorithm and MATLAB command for image thinning in relations of Thinning Rate (TR). The main advantage is it reduces the complexity and the output is clearly defined.

Abu-Ain [5] proposes in this paper. “A simple iterative thinning algorithm for text and shape binary images” that thinning is curial step in image analysis and image recognition as pre-processing period, Applications like optical script recognition (OSR), optical character recognition (OCR), and optical font recognition (OFR) accept several methods. A simple iterative thinning algorithm is proposed in the area of binary images. Then a standard dataset is planned for thinning algorithm calculation is used. Finally, the calculation experiments results are related with some other major thinning methods to proof the future method effectiveness. This paper concludes that the visual tests shows outpace for non-traditional thinning trials such as one-pixel width, rotation tolerance, tail occurrences, and topology preserving,

Zhang [1] proposes in this paper” A Fast-Parallel Algorithm for Thinning Digital Patterns” about the Zhang Suen algorithm where the two iterations are taken where one aimed at removing the south-east boundary points and the north-west corner points while the other one is intended at removing the north-west boundary points and the south-east corner points. Both pixel connections and end points are conserved. In each pattern thinned down to a skeleton by this methods. The experimental outcomes of this method are effective.

Dong [11] in this paper “A parallel thinning algorithm based on stroke continuity detection” proposes that thinning algorithm causes stroke distortion which leads to negative results in pattern recognition. To overcome this parallel thinning algorithm is used which is based on stroke continuity detection. It primarily detects the boundary points which is a reserved point to maintain stroke continuity, this can produce a good skeleton structure and immune to noise. In this paper, the comparison is done with the Zhang-Suen algorithm. The result is exposed to be similar.

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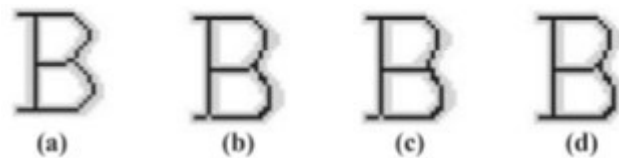


Fig 7: A sample of comparison of proposed algorithm

The proposed algorithm is to be in one iteration of scanning the image. The sequence is set from left to right and from up to down, and we get the thinning result as Zhang-Suen algorithm. The author made a comparison and presented as:

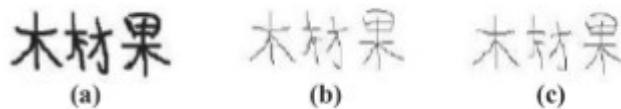


Fig 8: A comparison on a) original image, (b) result of Zhang-Suen, (c) result of Zhang-Suen with stroke continuity detection.

The main drawback in this method is it is immune to noise and the intersection of strokes mostly extinct.

VI. CONCLUSION

We have projected an effectual image parallel thinning algorithm. Thinning is the vital part which takes image as the input and give thinned image as the output. Core algorithm used is Zhang and Suen algorithm in which it works on the basis of 3*3 neighbourhood. The results indicate that the method used in the above algorithm is much faster than the other algorithms, the resulting skeletons look very much the same as the prescribed image. Thus the results designate that the projected algorithm is effective.

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